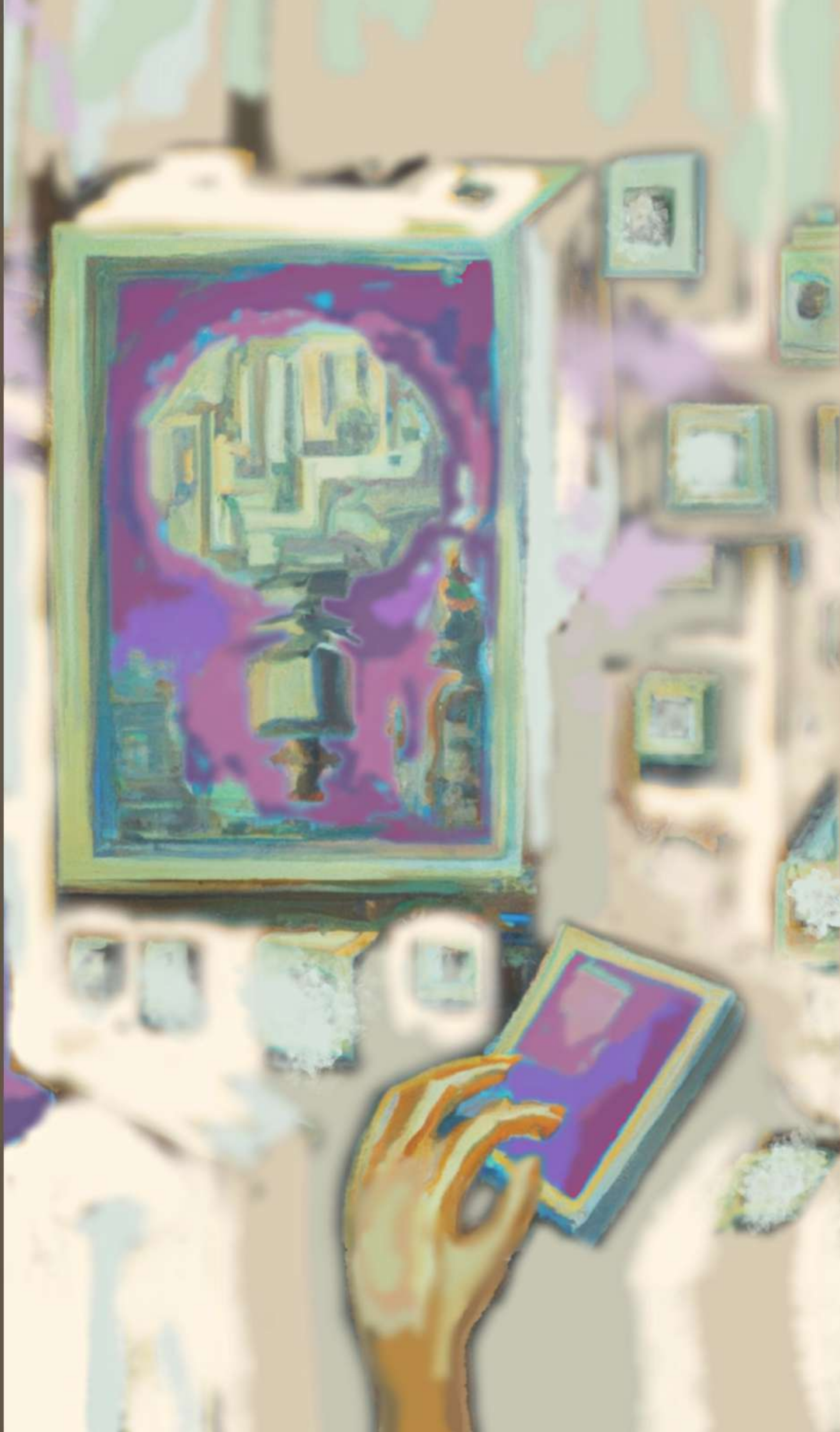
Cognitive Transformation Experience

An Interesting Adventure accompanied by CMCg.I model

Supporting Digital Transformation in the Cognitive Era



Jorge Rodas-Osollo

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Supporting Digital Transformation in the Cognitive Era.

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November 11, 2023

Zenodo & Latin American Institute of Critical Pedagogy

* A lone sailor who enjoys writing in LaTeX

The CMCg.I model book

Disclaimer
The content of this book addresses only some aspects of the *CMCg.I working model* to support *Cognitive and Digital Transformation* in the *Cognitive Era*. *Cognitive and Digital transformation* is a living area that is constantly evolving, especially nowadays, so there are many different perspectives on how to manage it. This book is not a scientific treatise, but only one of the perspectives currently working for real concrete cases, with an open mind and to be considered as an illustrative work of scientific communication and dissemination of more than 10 years of experience in this field.

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To those who have the capacity to be amazed and to face with courage what life presents to them on their timeline.

– Jorge Rodas-Osollo

To Grecia - A beacon of unwavering faith and boundless support for her father's project. Through the depths of your love and tireless efforts, you lit the path to success. Your dedication during countless hours of painstaking work on the images, coupled with your invaluable feedback and unwavering encouragement, served as the driving force that propelled this venture to unprecedented heights. Your unwavering commitment and support breathed life into every aspect of this endeavour, making it an extraordinary journey. I express my heartfelt thanks to you, my dearest chamaquita. Your presence and dedication have been invaluable to me.

– Your dad

Preface

The inspiration to write this book.

Staying alive in an ever-changing world, dynamically shaped by science, technology, nature and society, implies that people still face many challenges—in the way they do business, in the way they design, in the way they develop technologies—both individual and societal, in which *innovation* plays a *key role*. These ongoing challenges—which the *Cognitive Era* proposes—are increasingly being addressed through *Cognitive & Innovative Solutions* (both for large companies and for addressing individual problems) that often come up with *innovative schemes* on how to address the challenges. Consequently, this current technological world uses a lot of *pieces of knowledge*, that is, *high-value information*, which is useful *when solving a problem* or *satisfying a specific need* and, of course, *to drive innovation*. Thus, the satisfaction of whoever has the problem or need is achieved when the *knowledge* is *capitalised* by a *Cognitive Solution*.

Hence the requirement to find ways of using and harnessing as much *creative expertise* as possible—including imagination. Although using it *systematically* is a complex challenge, even if only to share it through traditional channels, it is required to be made explicit. Even so, mastering the challenge is a fundamental key to the advancement of the *Cognitive Era*—and its technologies of artificial intelligence, machine learning and cognitive computing—so that it can coexist with humans daily. To meet multiple needs (or problem situations) in a more "intelligent", "creative" and "human" way, they must be solved through *knowledge* (mainly *tacit*, *highly specialised*) and *distributed* throughout *collaborative networks* formed by *specialists*, *clients or beneficiaries*, *solution providers* and diverse *sources of knowledge*.

In this scenario, *knowledge capitalisation* is one of the most important factors for technological development. Consequently, appropriate *knowledge management* facilitates the ability of those requiring *specialised knowledge* to understand the quality of information and its effectiveness in reaching a proper solution. However, communicating the needs of those who have them (organisations or individuals), despite how simple it seems, is always a very complex task where a scenario of assumptions and lack of understanding between those who have the need (*the client*, *the stakeholder* or *beneficiary*) and those who satisfy it (*the solution providers*) exists. The scenario is so complex that it has been called a *hybrid cognitive ecosystem between physical space and cyberspace*, among other similar denominations; hence, it is hereafter referred to as a *Cognitive Ecosystem*. This complexity is very common and has, historically, caused *beneficiaries* to lack understanding of the scope of the impact that the conceptualisation of a *solution* demands, therefore neglecting and undervaluing the implicit hard work in this task. The consequences can be very severe; it directly affects the quality of the solution to the point of giving rise to a negligent solution or a *quasi-solution*. Consequently, it can cause *irreparable damage* to the project by providing a solution that must be given to the *beneficiary* and to the investment they are making.

From the above arises the *entity* of *Cognitive Solutions Provider* in the *Cognitive Ecosystem*. The *entity* can be understood as a *set of actors* that play at least one role: *Cognitive Architect*, *Cognitive Analyst* or *Information Technology Specialists*. This *entity* exists implicitly, since problems must be solved through *specialised knowledge* (*highly specialised information*, *expertise*, or *creative or innovative ideas*) that comes from an *ad hoc Collaborative Network*; this allows the *Solution Provider* to do a proper job even with a *touch of creativity* or *innovation*. The roles that this *entity* carries out stand out in different areas with different names—Cognitive Architect, Business Analyst, Requirements Analyst, Knowledge Engineer and Requirements Engineer—according to the context or function they perform. It is worth mentioning that there may be minor differences between these roles due to the particularities of their domains but, in essence, their core role is the same:

- Understanding the *problems or needs* of the *beneficiaries*;
- The elicitation of *knowledge requirements*, and their *representation*, through *highly specialised knowledge management*;
- The application of science and technology to *capitalise on the experience or knowledge* gained—knowledge requirements—by delivering *cognitive or innovation solutions*; and
- Concurrently, the *elicitation*, management of information and its representation through *functional requirements*; ending with
- The *implementation of the solutions*, taking into account that they have extensive experience in developing them.

In this way, a *Solution Provider*—in the role of *Cognitive Architect*, even a *Cognitive Analyst*—is an *entity* that is a *specialist and interlocutor between all the actors in the problem domain*, and is therefore able to offer *Cognitive Solutions* that satisfy the needs of the *beneficiary*. It undeniably represents a complex situation. Therefore, this situation demands a complete orchestration of the process by the *Solution Provider*, which translates into a *Cognitive Solution* that requires technological developments and changes in the processes of the organisation where the *Solution Provider* must work side by side with the *ad hoc Collaborative Network*. This hard work must be supported by a *Cognitive Ecosystem* that demands *creativity* and *innovation* to meet the challenges of the *Cognitive Era*. In congruence with what is written here, in this book, and depending on the context, the terms *Cognitive Architect*, or *Cognitive Analyst* or *Solution Provider* are used on the understanding that they are all part of the same *entity* mentioned above.

Understanding the unique characteristics of the domains delineated in the Cognitive Ecosystem and reassessing whether the requirements analysis performed in them is a necessity.

The experience leads us to affirm that the problems or needs that arise in the ecosystem, derived from the scientific and technological challenges and satisfied through the specialised knowledge of third parties, belong to *Informal Structure Domains*. These types of domains have a large amount of information that does not keep a formal structure, where the concepts and their relationships are defined by the consensus of *Domain Specialists* and those who *use large amounts of Tacit Knowledge* to develop the *Cognitive Solutions* that solve these problems. The characteristics of this type of domain increase the time for a requisite analyst to assimilate the domain of the solution, and even increase the risk that the result of using conventional methods and tools of knowledge management to obtain the *Suitable Knowledge Requirements* is unsuccessful. In fact, an *Informal Structure Domain* is a fuzzy concept—which is named in different ways (*ill-structured domains*, *ill-defined domains*, *informal domains*, *poorly defined domains*. . .) depending on the scope (e.g. *Artificial Intelligence*, *Learning Science*, *Intelligent Tutorial Systems*. . .)—because it *does not have a complete and formal definition*. Therefore, when reference needs to be made to it, convenient descriptions, and similarities, are made between those different names and their different scopes. The only common agreement is that these domains circumscribe particular needs that must be addressed as a *tailor-made suit*. Far from being frustrating, this situation strongly motivates researchers to generate more creative, interesting, adequate and focused proposals to face the challenges of the particular characteristics of these types of domains. Consequently, an induction or elicitation of *Suitable Knowledge Requirements* is of great importance for the construction of *ad hoc* solutions to problems within the context of a *Cognitive Ecosystem* that presents unique technological challenges. However, it is worth mentioning that the labelling of the different figures (concepts), mentioned above, seems to distort the value of *Requirements Analysis* and even makes a segregation related to the type of solution implemented from the elicited requirements. For example, the most common segregation of the *Requirements Analysis* process occurs when building software and non-software solutions. Curiously, it seems that this process is the exclusive property of software engineering when, in fact, it should be performed as a professional activity to ensure the quality and satisfaction of any type of solution—software or non-software—that is intended to be provided to a client, consumer or *beneficiary*.

What is the purpose of this book?

One of the purposes of this book is to raise awareness of the nature and importance of proper acquisition of *Suitable Knowledge Requirements* but, more importantly, to highlight that the risk of failure in obtaining *Cognitive Solutions* is minimised with the necessary tools and proper assessment of *Requirements Analysis*. Furthermore, the book communicates that a *Conceptual Model for Cognitive-Innovation* within a *Cognitive Ecosystem*, in line with the *real needs of the beneficiaries*, should be "open", i.e. reviewed, criticised, renewed and adapted. Another purpose is to communicate that—at a time when the environments of the *Cognitive Era* are highly dynamic—there are specific situations that need to be addressed with smart technologies and innovation processes.

Finally, why has the experience that led to the development of a *Conceptual Model for Cognitive-Innovation* served as an inspiration to write a book? Because, over several years to date, it has allowed for obtaining *Suitable Knowledge Requirements* that allow for the implementation of *Cognitive Solutions*. That is, it provides benefits to those in need in this *complex ecosystem*; therefore, it was the right time to share these experiences that are expected to inspire those who have already started to take over from us in changing the innovation that is constantly in demand in this field. In this sense, having the benefits of a working model, such as the *Conceptual Model for Cognitive-Innovation* that has formal support consisting of a *systematic process*, provides fundamental support to the *Cognitive Architect*, *Cognitive Analyst* or *Solution Provider* for the *systematic management*, *exchange*, and *formalisation* of *knowledge* in order to provide a *Cognitive Solution*.

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To my students, past and present, I offer my sincere thanks for your dedication in reading this book. I hope it provides valuable guidance for your professional and personal endeavours.

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To those who have cared for me and continue to show their appreciation, your unwavering support accompanies me in all my endeavours. Most importantly, I offer my heartfelt thanks to God, whose love, strength, guidance and boundless inspiration enable me to continue on this journey.

Contents

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1 Introduction, or the prelude to an adventure

This chapter introduces the reader to the exciting topic of the value of knowledge in providing solutions to needs in the so-called **Cognitive Era** (**CE**). It provides some background information on **Digital Transformation** (**DT**) and some of the terms involved in it. It presents a *transformation process*—and its components—that this *era* forces as an *adventure*, including the interesting **Informally Structured Domain** (**ISD**). It also mentions how these *domains* should be approached, and urges carrying out **Knowledge Management** (**KM**) *systematically* as a good practice to achieve *successful solutions*. Finally, it presents the organisation of the book.

1.1 Entering the cognitive era

The technologically developed and the mid-developed world is undergoing a major **Digital Transformation**[1], where digital technologies harness data to drive intelligent workflows, faster and smarter decision making and real-time response to environmental disruptions. . . and those who have already achieved this transformation are entering the beginning of a **Cognitive Era**[2]. Using **Artificial Intelligence**[3] and **Information Technology**[4], *knowledge* can be *elicited*, assimilated and adapted from **Big Data**[5] and even from the not so "big" to facilitate decision making and generate desirable behaviours.

The **Cognitive Era** is seen as the next step in humanity's *technological evolution*. **Figure 1.1** depicts a very condensed *technological evolution* through a short timeline where there have been very rapid changes, and two technological eras have been left behind. Implicitly, the figure communicates the relevance of knowledge use and the interaction with it. Change to the current era is already taking place in various environments, especially in technology companies. However, it is estimated that 70 per cent of **digital transformations fail**[6] in companies; therefore, those that do not adapt to these changes will disappear. . . and the question is, what ways are there to join the **CE**?

In order to understand how mankind entered the **CE**, it is necessary to go back to the previous era in the **Information Technology** (**IT**) environment. This was the time when computers were essentially giant calculators, with less capacity than the simplest smartphone, and were generally used to perform basic but tedious and laborious mathematical and statistical calculations. It is not necessary to go far back in time, because important advances came after the Second World War. Computers had to encrypt messages and perform much harder tasks than simply adding or subtracting. This need resulted in a new generation of programmable machines. It has been pointed out that many applications on a smartphone, even if they are the latest fashion trend, are still similar to earlier technologies.

1: Digital Transformation is the incorporation of information technologies into the solutions, products, processes and strategies of a public or private organisation. Such transformation enables the delivery of improved benefits.

2: The Cognitive Era is an ongoing evolution that evolves into a sweeping technological transformation. Driving this movement is the field of cognitive technology, disruptive entities and systems that can interact with unstructured data, manage knowledge, learn from this experience and naturally interact with humans. Success in the cognitive era will depend on the ability to derive knowledge from all forms of data with this technology.

3: Artificial Intelligence can be summarised as the incorporation of capabilities into a digital entity to perform tasks commonly associated with intelligent beings.

4: The Information Technology is shorthand for any computer, storage, network and other physical devices infrastructure that interacts with computers and processes to create, process, store, secure and exchange all forms of data. IT typically encompasses both information technology and telecommunications.

5: The Big Data are data sets so voluminous that traditional data processing software cannot handle them.

6: Digital transformations fail: Although most companies know how crucial it is to evolve to the CE, putting it into practice is a different story, as digital transformation has hurdles that require reviewing failed experiences so as not to repeat mistakes or misfortunes.

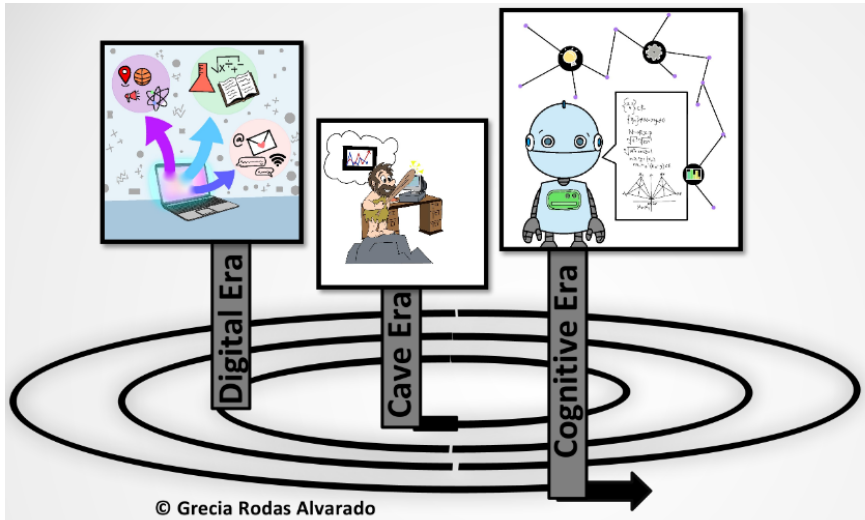


Figure 1.1: Information and knowledge use across the eras in IT. The figure shows a punctual evolution from the beginnings of digitalisation to today's cognitive development through three eras. The *Cave Era*, in which most decisions are made based on expertise or hunches; information-gathering processes are manual; Tacit Knowledge (TK) is extremely difficult to use, and common office tasks are supported by software tools for office tasks. The *Digital Era* is characterised by automation with knowledge at its core; digital information centres; most information records are already digital; strategies for extracting knowledge from human expertise are widespread; TK is better exploited, and knowledge is increasingly available in automated decision making systems. Finally, the Cognitive Era has an exponential trend in which problems, needs or decisions are addressed by knowledge managed by non-human entities.

A very important consequence of the changes in IT is the generation of data, which has grown and continues to *grow exponentially*. The data is structured in much the same way as humans process information. In other words, it is *not structured* at all. The global accumulation of data is made up of a welter of annotations, non-standardised publications, social media interactions and records from various systems. Thus, to be able to analyse a large and ever-growing amount of information and use it to solve complex problems, systems were developed to simulate human reasoning, but with infinitely greater access to data and at vastly higher speeds. And what was the result of this development? That is right: entities capable of learning.

1.2 Welcome to the transformation process

In 2011, the **IBM Watson entity**[7] was the flagship cognitive system that marked the formal start of the so-called CE, at least that was what IBM company claimed. This entity was a natural language processing machine that learnt natural language processing algorithms to analyse the meaning and syntax of human speech. IBM Watson used vast repositories of data to perform analysis and processing to answer questions proposed by humans, often in a fraction of a second. **Deep Blue**[8] was another forerunner of the CE. At the time, the world was amazed that a machine could defeat one of mankind's greatest chess champions. Today this is no longer considered astonishing at all.

To learn, you must first unlearn

Cognitive technology has been causing major ruptures in the status quo, and not just in the IT field, forcing us to abandon one mindset in favour of another. Literally, previous beliefs must be unlearned in order to understand and take advantage of the new paradigms. **Cognitive Transformation Theory**[9] addresses this *unlearning* through a system of feedback and analysis. Learning ceases to be the sum of our knowledge and becomes the creation and development of the best ways to find solutions to complex problems. If we were to compare the process to

7: In 2011, the IBM Watson entity caused great controversy by beating two all-time champions of the Jeopardy game show. If IBM Watson was already considered "smart" back then, imagine how much smarter it is now that it has had "more time to learn".

8: Deep Blue was a chess computer developed by IBM company. It is famous for defeating the world's all-time greatest chess champion, Garry Kasparov, in the 1997 match. The victory of Deep Blue was viewed as a symbolic testament to the rise of Artificial Intelligence (AI)—a victory for machine versus man.

9: Cognitive Transformation Theory, in 2006, contrasted cognitive and behavioural learning, stating that the traditional approach to learning consists of defining goals (the difference between the knowledge a person has and the knowledge they need to perform the task), setting the practice regime and providing feedback. Learning procedures and factual data is seen as a way of adding more information and skills to a person's store of knowledge. However, this warehouse metaphor is poorly suited to cognitive skills and does not address the different learning needs of novices and experts. Teaching cognitive skills requires a diagnosis of the problem in terms of defects in existing mental models, not gaps in knowledge. It requires learning objectives that are linked to the individual's current mental models. It requires practice regimes that can result in *unlearning*, which enables the individual to abandon current faulty mental models. It requires feedback that promotes awareness, as well as overcoming barriers to understanding and revising mental models.

our own cognitive development, it would be the difference between learning by rote and learning to think critically and analytically.

Computers and humans think alike

The **Cognitive Transformation**[10], linked to **Artificial Intelligence** (**AI**), like any other technological advance, will eliminate jobs and transform others. However, history has shown that technological advances also create new types of professions that can partially, or fully, replace lost jobs. Rather than replacing human intelligence, thinking or reasoning, **AI** should, or is at least expected to, enhance human cognitive abilities. At present, *cognitive entities* do not make any decisions autonomously; they simply provide knowledge and useful information, which can pave the way for human decision making. For example, **IBM Watson**, makes use of probabilities by accessing a repository of patient pathology and general health data, which can successfully make diagnoses with a much smaller margin of error than humans. With this kind of *diagnostic power*, doctors can act more assertively, adding *the cognitive power* of **IBM Watson** to their own.

10: Cognitive Transformation is the incorporation of **AI** and **IT** into the solutions, products, processes and strategies of a public or private organisation. In line with the thread of this book, it is important to note that **cognitive** and **digital transformation** are interchangeable terms.

1.2.1 Cognitive transformation is underway

AI has become transparent to the general population, who are already interacting with it without knowing. The current ability of *cognitive technology* to analyse data enables *innovations* that are truly focused on a user who wants to benefit from them. Today, many companies are in the process of *transformation* and are already reaping some of the dividends of the **CE**.

For the success of **Cognitive Transformation** (**CT**) in enterprises, **IBM** highlights three points: user experience, the data generated from observations of the experience and human interactions following intelligent analysis of the data. Each of these points—experience, data and people—brings inherent challenges that must be overcome. As noted above, those certain ways of thinking must be *unlearned* to make room for new ways of thinking.

In short, there is a need to focus on the user, to treat data as a necessary and fundamental resource and to work in an integrated way with this immense new capacity for data analysis. In this way, it will be possible to link human and technological strengths to a transformation that will allow people or companies to move into the **CE**.

Digital first

The first step in the *transformation* is to achieve the **DT**, to leave the "manual behind" and go to the automatic. It seems simple, but it is not. . . especially in countries with slower technological development. "Digital First" must therefore be a priority over **CT**. For example, in marketing, digital and mobile technologies allow companies to control the user experience, data collection, processing and decision making at the core, to turn them into captive customers.

The integration of technology into the daily operations, processes and interactions of businesses and individuals marks the beginning of **DT** and the emergence of the **CE**. To fully embrace and capitalise on this **CE**, organisations and individuals must be willing to adapt and evolve their thinking, embrace the capabilities of **AI** and harness its potential to drive innovation and growth. **CT** is now a tangible and achievable goal for those willing to embrace change and harness the power of **AI**.

A *transformation* of cognitive functions becomes urgent for individuals and companies in highly technologically—developed countries. *Digitalisation* is essential in countries with slower technological development to move into the **CE**. The *transition* to the new era begins with the adoption of tools that make it possible to take advantage of this large accumulation of unstructured, or informally structured, information to manage knowledge and obtain cognitive solutions for the evolution of routines, workflows and so on. In the **CE**, processes must be increasingly agile and optimise cost and benefits. Also, the cognitive solutions must make a true and accurate estimate in order for *the client*, *the stakeholder* or **Beneficiary**—the latter term is used in this book—to get a crucial decision that can determine a before or after in his or her particular situation.

Experience in providing cognitive solutions to individuals or companies that need to make the *transition* suggests that most of those supporting the transition process have the desire to achieve success stories. In this sense, there is an *urgent need to establish regulatory frameworks* to ensure that emerging technologies benefit humanity as a whole. Therefore, **AI** that is truly human-centred is welcome. It is mandatory that **AI**, linked to **CT**, serves the interests of citizens, and not the other way around. **CT** for all is possible with the technological part being the easiest to achieve; but, unfortunately, the most difficult part has to do with *dangerous* **human nature**[11]. It is therefore important to take care of the **ethical**[12] aspect of this transformation.

11: Human nature makes it possible for human beings to regularly act against themselves. All human beings have the potential to be cruel and destructive to each other. Why are we our own worst enemies? Is it because the human mind has a dual nature? On the one hand, a dangerous nature that regularly commits terrible atrocities against the human being itself, selfishly pursuing only its benefit; on the other hand, one that shows an aversion to acting against the human being and that, contrary to the other version, pursues its benefit but not at the expense of others or even the benefit of other human beings or any other living being.

12: Ethics refers to the set of values and moral principles that guide human actions and enable human beings to distinguish between right and wrong. Why is the ethics of AI necessary? Today, AI affects the lives of billions of people, changing them, to a greater or lesser extent, and sometimes inadvertently, but often with profound consequences, *transforming* societies and challenging what it means to be human.

1.2.2 The transformation is an adventure

To describe an **adventure**[13] derived from a **CT**, it is necessary to formalise some concepts to maintain communication under a common thread that gives continuity. An adventure of this type starts with the lead *actor*, a person or a company that has a problem or needs to integrate into the **CE**. This person is known here as the **Beneficiary**. In marketing, for instance, this *actor* is a "Customer" or "Client". However, this *transformation* is not exclusive to commercial relationships, and the term "Customer" can be confused in this sense. For this reason, **Beneficiary** is more appropriate, as the person intends to take advantage of the **CE** for his or her benefit. Thus, the problems or needs of this possessor are solved or satisfied by solutions that are known as **Cognitive Solution** (**Cg.S**).

Thus, a **Cg.S** is a consequence of the action or effect of solving a problem, or addressing a specific difficulty or need of the **Beneficiary** using **specialised knowledge**[14], which is usually *tacit* and must be made *explicit* through **Knowledge Management**[15] techniques. To provide a **Cg.S** that meets **Beneficiary** expectations, it must be developed according to a set of **Suitable Knowledge Requirements** (**SKReqs**). In this respect, a **requirement**[16] is a necessary condition that a solution must meet to satisfy a problem or reach an objective within a *specific domain* [**sharma2011**]. A **SKReqs** is a *requirement* derived from *specialised knowledge* that defines a **Cg.S**. Thus, a *domain* is a *well-defined area* in which the *needs* and

13: An adventure is an exciting and probably risky trip, effort or undertaking that often involves unknown dangers and risks.

14: Specialised knowledge is knowledge that allows for understanding parts of a *domain* or models in great depth. This type of knowledge solves very complicated problems or supports the performance of unusual tasks. It includes in-depth knowledge in one or more areas related to parts of the *domain* and usually has no (or very limited) examples.

15: Knowledge Management is the process of capturing, storing, sharing and effectively managing the knowledge and expertise of human beings in order to increase overall knowledge. Its main objective is to improve efficiency and productivity, and to preserve critical and useful information.

16: The Requirement is a specification of an idea, or need or want. Sets of requirements are used to collect information necessary to plan, build and test a process, service, product or system.
sharma2011

expectations of the **Beneficiary**, the experience in developing the **Cg.S**—restrictions, additional information—and other experiences linked to the *need* and *possible solution* are delimited by it.

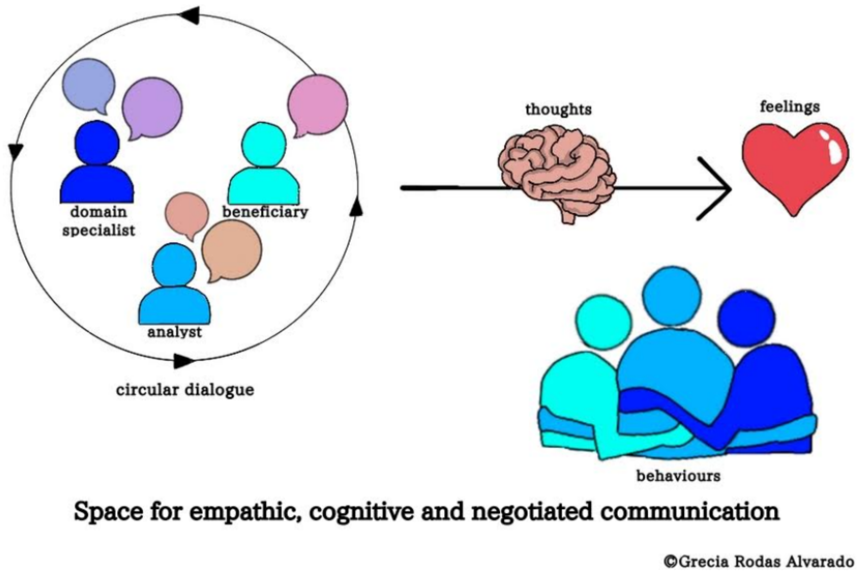


Figure 1.2: Space for empathic, cognitive and negotiated communication. According to this illustration, this space allows for a *circular dialogue* between all *actors* in the **ad hoc Collaborative Network** orchestrated by the **Cg.S Architect**. Nonetheless, this process becomes more complex for the **Cognitive Analysts** team because he/she is often not a member of **Domain Specialists**, and/or when the **Beneficiary** has no idea how the solution he/she needs should work and if he/she has some idea about it, he/she is not able to communicate it. In addition, the **Beneficiary** does not know the techniques or tools for the implementation of the solution; as a result, the **Beneficiary** is often reluctant to accept that it will have to make a significant investment to solve the problem. It is also unable to engage in a "negotiation dialogue" with the **Cognitive Analysts**.

The efficient and effective functioning of the **Cg.S** depends on the *discovery*, *specification*, *verification* and *validation* of its **SKReqs**. These *requirements* are fundamental to designing and developing solutions for areas such as industrial, software, graphic, instructional, business processes, decision making. . . These variants of the development of products or solutions present serious difficulties inherent to the induction and obtaining of the correct and appropriate **SKReqs** due to the complexity of the process, and the intricate interaction between the **Cg.S Provider** (**Cg.S-P**) and the **Beneficiary**. Thus, the *specification*, *design* and *development* of a **Cg.S** are complex and cannot be carried out by a single person. It requires the collaboration, active and conscious participation of a group—called **ad hoc Collaborative Network** (**ahCN**)—including the **specialists**[17], who possess *knowledge of the possible solution*, **Cg.S-P**, **Cognitive Analysts** (**Cg.An**), and the **Beneficiary**. Consequently, the provision of a **Cg.S** is an intense, non-trivial, often tortuous process, requiring great discipline and creativity, especially on the part of the **Cg.An**. The greatest difficulty faced by the **Cg.An** during the process, especially when unfamiliar with the domain, is to induce and elicit the **knowledge necessary to implement the solution**[18]. Because this *knowledge* belongs to the **Domain Specialists** (**DS**), **Cg.An** must establish a *space* that allows for an *empathic, cognitive and negotiated dialogue of communication*, as shown in **Figure 1.2**.

17: Specialists are people—one or several—with a solid theoretical background in a *specific domain from which they elicit knowledge*.

18: **Knowledge necessary to implement the solution** concerning the *problem or need* comes from the **Beneficiary** and, concerning the *possible solution*, comes from the **DS**.

This process is far from *trivial* generally, as a **Beneficiary** does not have a clear idea of what they need; even when they have it, he or she is usually unable to describe it. In addition, it is common that they do not know the techniques or tools for the development of the solution, so they are unable to establish a negotiation dialogue with the **Cg.An**. On the other hand, the **DS** are usually so immersed in the *knowledge of this domain* that they overlook important information that allows them to conceive the appropriate solution. Consequently, the **Cg.An** must reconcile the needs of the different **DS**, and have the ability to negotiate on a domain where they are often neophytes, and therefore must learn, as soon as possible, the necessary knowledge about the domain. Nowadays, this process is even more arduous and complex because the **Cg.S-P** must dominate *emerging technologies* and give the **Beneficiary** efficient solutions as soon as possible. To address these challenges, it is necessary for the **Cg.S-P** to use *strategies*, *techniques*, *formal languages*, *processes*, and *methods* to minimise the intuitive works; it is necessary to move from *informal work*, done through *sensation*, to a *formal* and *systematic engineering process*. In this regard, as mentioned before, to carry out the activity of inducing and obtaining the **SKReqs**, it is not enough to establish simple dialogues with the **Beneficiary** or to ask direct questions about his or her expectations or needs. The **Cg.S-P** knows that any need implies the existence of a good amount of implicit **SKReqs**. Thus, the **requirements engineering**[19] is, through the **Requirements Analysis Process**[20], who aims to *obtain*, *analyse*, *evaluate*, *consolidate* and *manage* the **SKReqs** for the implementation of **Cg.S**, and it only remains to state that this *process* is intrinsically linked to **Knowledge Engineering**[21]. Therefore, in terms of *solution design*, the **Requirements Analysis Process** (**RAP**) delineates functions and scopes concerning real-world objectives and the relationship of these objectives to precise specifications of the behaviour of the possible solution and how it might evolve. The **RAP** participates in all the processes of implementation of solutions for problems or needs of the **CE** framed in an **ISD** (more details in Subsection 2.2.1 on page 17). They are present in a wide variety of domains where non-**IT** solutions are expected; not software solutions, but *knowledge solutions*. This implies that **SKReqs** elicitation is a very relevant process for constructing *ad hoc* solutions to the problems—regardless of their scope—posed by technological challenges linked to **CE** and often involving unknown risks. Hence, go out and explore the jungle! Do not be afraid, because if you do things professionally, it will be a good adventure!

19: Requirements engineering is the process of eliciting the needs and wants of stakeholders and developing them into an agreed set of detailed *requirements* that can serve as the basis for all subsequent development activities. The purpose of *requirements engineering* is to make the problem at hand clear and complete, and to ensure that the solution is correct, reasonable and effective.

20: The Requirements Analysis Process consists of a series of steps to determine the needs and expectations of a person or company that has a problem or need. The importance of the inclusion of the *all domain knowledge and experiences* in the RAP is emphasised. The RAP involves frequent communication with all stakeholders and end-beneficiaries of the solution to define expectations, resolve conflicts, and document all key requirements.

21: Knowledge Engineering is an area of AI that designs rules from information to—together with other data—mimic the thought process of a *human specialist*.

Why is getting a Cg.S for a problem or need in an ISD considered an adventure?

Linked to the above, and just as in an adventure, a **Cg.S** must adequately address the challenges offered by an **ISD** because it will never be the same as any other, especially as scenarios in this era change rapidly. In fact, in parallel, an **ISD** could be seen as a complex interconnected environment of entities, i.e. a **Cognitive Ecosystem**[22] (all details in Chapter 2 on page 15); thus, each implementation of a **Cg.S** project offers risks in terms of how the domain is addressed. In this sense, a lot of work has been done on the development of tools and methods, but a very small percentage has focused on understanding the nature of an **ISD** and being able to obtain the **SKReqs** for the design of a **Cg.S**. Thus, a **RAP** should be oriented to the *knowledge elicitation and management* in the context of **ISD**, and it is highly desirable to work under a *model* that includes:

- *a dynamic, repeatable and flexible systemic process*;
- *belonging to the intersection of* **RAP** & **Knowledge Engineering** (**KE**);
- *operating in the context of* **ISD**; and
- *orienting towards knowledge transfer or transformation*.

It is worth mentioning that the authors of the book urge against neglecting the importance of **ethics**[23] in this transformation, and it is worth noting that this book addresses a relevant part of the technical aspect of it. It also communicates

22: A Cognitive Ecosystem is a complex interconnected environment of functional cognitive entities operating in complex, distributed linkages with emergent systemic and behavioural capabilities. They may include learning and knowledge processing functions at all levels, including humans, but not all of their functions are subservient to humans.

23: Ethics refers to the set of values and moral principles that guide human actions and enable human beings to distinguish between right and wrong. Why is the ethics of AI necessary? Today, AI affects the lives of billions of people, changing them, to a greater or lesser extent, and sometimes inadvertently, but often with profound consequences, *transforming* societies and challenging what it means to be human.

both successful experiences and a **Conceptual Model for Cognitive-Innovation** (**CMCg.I**) in support of the **CT**.

That is, a *model* oriented to support those who will make the transition to **CE** or for those who need to design or implement a **Cg.S** or simply make **Tacit Knowledge** as *explicit and formalised as possible*. Where **KM** includes **RAP** to enable the generation and construction of a knowledge structure that can be incorporated into a **Cg.S**, faithful to the needs and expectations of the **Beneficiary**. Without forgetting the great importance that *ethics* must have in this transformation. The most complex aspect of the implementation of any **Cg.S** is not necessarily the technical aspect, but the human aspect.

In short, it must be aware that the needs or problems of the **Beneficiary** are framed in an **ISD**, embedded in a **Cognitive Ecosystem** (**Cg.Eco**), characterised by a *high degree of informality*, where *knowledge is mostly tacit* and *lacks a defined structure*.

Finally, it should be clarified that this book deals only with the technical aspects and communicates experiences with the use of a model such as the **CMCg.I**. It has proven to offer great competitive advantages to any company or organisation.

1.3 What will you find in this book?

The book is organised into eight chapters and four appendices, including an introductory chapter and subsequent chapters that address the following:

Chapter 1: Introduction or the prelude to an adventure This chapter aims to convey the importance of knowledge in the **Cognitive Era**, inspiring readers to grasp its significance and recognise its central role in shaping the future. It encourages the exploration of digital transformation by delving into relevant terms and concepts that define this phenomenon. The chapter initiates the transformation process by shedding light on the **Informally Structured Domain** and its potential. Finally, it highlights the importance of systematic knowledge management, emphasising its role in capturing useful information and using it effectively in this era.

Chapter 2: Understanding the Cognitive Era This chapter explores the intricate architecture of the **Cognitive Ecosystem**, revealing its functions, relationships and actions. It provides essential insights for readers, equipping them with valuable information to consider when implementing **Cognitive Solution**.

Chapter 3: Cognitive Analysis and Requirements In this chapter, the link between requirements analysis and **Cognitive Analysis** is explored. Furthermore, the four stages of **Cognitive Analysis** are discussed and the advantages of using a model for the realisation of **Cognitive Solution** are highlighted.

Chapter 4: Conceptual Model for Cognitive-Innovation In this chapter, the model is introduced as a versatile tool to support the representation, illustration and communication of the theoretical **Cognitive Architecture** within the **Informally Structured Domain**, which is directly related to a **Cognitive Solution**. It encompasses all the activities involved in the realisation of a **Cognitive Solution**. In addition, real-world experience is included to provide a better perspective on the use of the model.

Chapter 5: Developing Cognitive Solutions using the model This chapter explores how the model was used to facilitate the organisation and understanding of the **Informally Structured Domain**, with the aim of providing a **Cognitive Solution** for the **Electroconvulsive therapy** (ECT) domain. It describes the actions, activities and processes involved in achieving this **Cognitive Solution**, and communicates the possibility of optimising the delivery of ECT and thereby reducing negative side effects.

Chapter 6: Orchestrating Actions for Quality Cognitive Solutions In this chapter, the model was used to streamline the organisation and understanding of the informal structure, pertaining to the Training domain. In addition, it communicates the orchestration of actions and activities, which ensured quality and customer satisfaction in the development of their **Cognitive Solution** which incorporated the use of virtual reality.

Chapter 7: Success Stories in the Cognitive Era This chapter summarises two success stories where the model was used, with the aim of highlighting some experiences in the fields of industry and healthcare, emphasising the exciting potential of the **Cognitive Era** and cognitive technology.

Chapter 8: Afterword The concluding chapter provides further insights, additional information and thoughtful reflections on the issues explored in the book. While it serves as a culmination of the content presented, it is important to note that it does not serve as a definitive conclusion to previous and ongoing work related to the topics covered in the book.

Appendix A: Supporting Information on KM and RAP This appendix includes additional details related to **Knowledge Management** and the **Requirements Analysis Process**.

Appendix B: KMoS-RE: A systematic process This appendix looks at the systematic process within the working model, exploring how knowledge is generated, structured and shared to effectively meet the needs of beneficiaries.

Appendix C: The KDEL and Ontology Processes Key considerations for the development of the **Knowledge of Domain on an Extended Lexicon** and ontology processes are outlined in this appendix.

Appendix D: Agile Prototyping Basics The final appendix of the book serves as an introduction to agile prototyping and provides an overview of its importance in the **Cognitive Solution** development process.

Part I

A decade of work: Exploring the basics

List of Figures in Part I

2 Describing a Basic Cognitive Ecosystem

This chapter is addressed to a reader who is deciding to act, or who has already decided to be an *actor*, in the **Cognitive Era** (**CE**). Therefore, it is necessary to lead him/her to appreciate the **Cognitive Ecosystem** (**Cg.Eco**). It has an *architecture* with a *suitable stage* for the participation of *actors*, in their *different roles*, and it is supported by a *scenography*, *terms and relationships between them*, to sustain *the production* of *a benefit*, direct or indirect, for all involved in a **CE** project. The following sections identify the concepts, terms, actions and relationships that aim to provide the background behind the implementation of a **Cognitive Solution** (**Cg.S**).

2.1 Setting the stage

Setting up a **stage**[1] is a relatively straightforward matter as long as all the structural components are in place and the relationships between them are well understood, as can be seen below.

1: The stage is a designated space for *actors or performers* to perform *a production* for *an audience*. Viewed within the *architecture* of a *building*, the stage may consist of one platform or several. In some cases, these may be temporary or adjustable, but the stage is usually a permanent element. For the realisation of the production, the *actors* are supported by a set design. This is the set of elements to set the scene and thematise a given environment. The scenography must be the reflection of the message and the concept to be communicated, an *ad hoc message*, *created for the audience*. In production, everything starts from a concept and an idea. The aim is to immerse the audience in a universe to achieve the objectives of the event: entertainment, communication and reflection.

Cognitive ecosystem scenario

Definitions of **cognition**[2] and the processes and functions related to it, to date, include different terms, which are often defined according to the *domain* in question and its context. Human cognition is generally regarded as the *sine qua non* of any kind of intelligence or high-level mental function, because human decision making relies on heuristics, unconscious rules of thumb, bungling and shortcuts. In contrast, non-human cognitive systems do not use emotion, which can provide convenient shortcuts to decision making, reducing the need to rely on applied rationality. Although **Artificial Intelligence** (**AI**) entities can make many decisions faster than humans, this does not mean that human cognition will be left out of the underlying techno-human structures of the **Cognitive Ecosystem**, on the contrary, it will assume different roles in the future. The very well-established tradition of human cognition includes many types of repositories, cultural practices, books and other technologies in the form of "static cognition", which systematically increases the scope, power and creativity of human cognition in real-time. Thus, human cognition at the individual, institutional and cultural levels has never been, and never will be, outside of the **Cg.Eco**. Moreover, a tipping point has been reached, where "dynamic cognition" and collaborative techno-human cognitive processes evolve and operate in a **Cg.Eco** with *complex domains*, such as an **Informally Structured Domain** (**ISD**), where information has to be acquired from deep within the human brain, spiced with explicit information from *static cognition* and translated into a product or service that addresses a

2: Cognition is the set of mental processes involved in acquiring knowledge and understanding. Cognitive processes include thinking, knowing, remembering, judging and problem solving. The processes involve high-level brain functions encompassing language, imagination, perception and planning. Cognition can be categorised into hot and cold cognition. Where hot includes processes in which emotion plays a very important role, such as reward-based learning; in contrast, cold cognition includes mental processes that do not involve feelings or emotions, such as a memorised work routine.

current need of the **Cognitive Era**. *Domains* in which cognitive functions operate, such as: perception, learning, differentiation, reasoning, calculation, problem solving, decision making, memory, information processing and communication with other cognitive systems (language, media, video. . .). Although the definitive set of elements that constitute cognition cannot be defined, the presence of some elements does offer a way of looking at a **Cg.Eco**, especially if it is bounded by an **ISD** or *set of these domains*. For a quick tour of a **Cg.Eco**, three spheres of *actors* or *entities* can be distinguished:

- *those that contain explicit information found in various sources, such as data repositories, is referred to as static knowledge*,
- *those that perform cognitive functions*, and
- *those who use this approach are able to make informed decisions based on constantly changing market conditions. In other words, the analysis and interpretation of market behaviour is called dynamic cognition. . .*

In practice, of course, these spheres overlap, but this map provides a relatively easy way of identifying *actors* or *entities*.

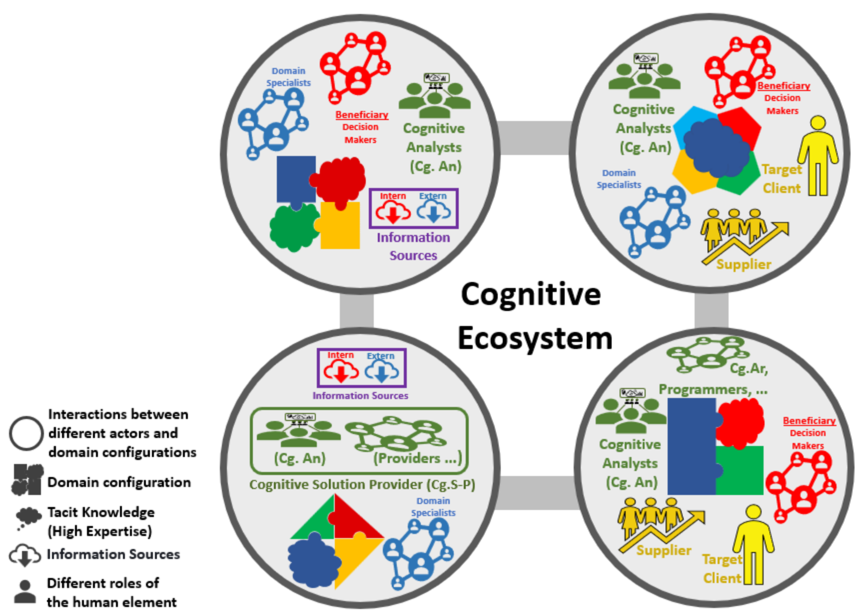


Figure 2.1: Cognitive Ecosystem. The figure shows a *cognitive ecosystem* where different *actors* and *cognitive entities* interact under complex, distributed linkages with emergent systemic and behavioural capabilities according to the *domain(s)* in which they act to provide a solution to a problem or satisfaction of a need. Four spheres can be seen in the figure, each of which represents different configurations depending on the domain in which they act. An ecosystem can have at least two domains, one referring to the problem or need to be addressed, and the other linked to the possible solution. The number will depend on the domains present in the ecosystem. Within each sphere, the domains are represented by puzzle pieces, where the cloud-shaped piece is the **Tacit Knowledge** and the others are the **Explicit Knowledge**. The cloud icon with the flow arrow represents the various sources of information. The several configurations of half body icons represent the different roles of the human being: **Cognitive Analysts**, **Cg.S Provider**. . . It is important to note that there are *external entities*, market information or customers, that affect the ecosystem, as represented by full body icons, corresponding to the "Supplier" and the "Target Client".

The upper left sphere, *Information Sources* (cloud icon with flow arrow in **Figure 2.1**), represents any source from which a **Cg.S Provider** (**Cg.S-P**) can be informed of aspects of the problem, the need, its possible solution or its domain. They include data collection services ranging from Internet of Things devices to social media platforms. . . The upper right sphere corresponds to *different roles played by human actors*—working collaboratively—in providing solutions to problems or needs of the main *actor*, the **Beneficiary**. Such *actors* must form a cognitive infrastructure, and through technologies, provide services and products via the functional elements of cognition. Among the most important roles are the **Domain Specialists** (**DS**) and, above all, the set of **Cognitive Analysts** (**Cg.An**) who manage the cognitive functions—from perception to intelligibility constructs and applications such as problem solving—necessary to acquire, manage and represent knowledge (several configurations of half body icons in **Figure 2.1**). The latter sphere includes *various and diverse forms of marketing information*—dynamic cognition—coming from specific markets or clients (Target Client and Supplier icons in **Figure 2.1**). As in every scenario, the **Cg.Eco**, has some *essences* that will be dealt with next.

2.2 Essences in the scenario

The essences that stand out in a **Cg.Eco** are given by the concepts—**ISD**, **Cognitive Architecture** (**Cg.Arch**), **Knowledge Management** (**KM**), **Tacit Knowledge** and **Explicit Knowledge**, **Cognitive Analysis**—and the relationships between them. These essences give rise to one configuration, among many possible ones, that can serve as a systemic, dynamic, repeatable and flexible working model to provide a **Cg.S** in general, and in particular to enhance the transfer or transformation of knowledge.

2.2.1 Informal structured domain: the most important essence of the scenario

The intrinsic, fundamental and ever-present nature of the **Cg.Eco** *scenario* is the **ISD**, whose characteristics make it somewhat abstract but provide the certainty that it can be worked with. The previous section communicates that an **ISD** is the essence present in the *actors*, their cognitive processes, their behaviours and the entities they interact with. . . It also communicates that these components, of the **Cg.Eco**, have an intricate interconnectedness between the need to be addressed, and the different knowledge and experience levels where the boundaries are blurred. Therefore, it implies that they work in a collaborative and consensual way. **Figure 2.2** shows the conceptual model of this interconnection of explicit information that is *well structured* and knowledge with *little or no structure*, which both inform the nature of the problem or need. Thus, a conceptualisation and one or more solutions are obtained, which may or may not have an algorithmic solution.

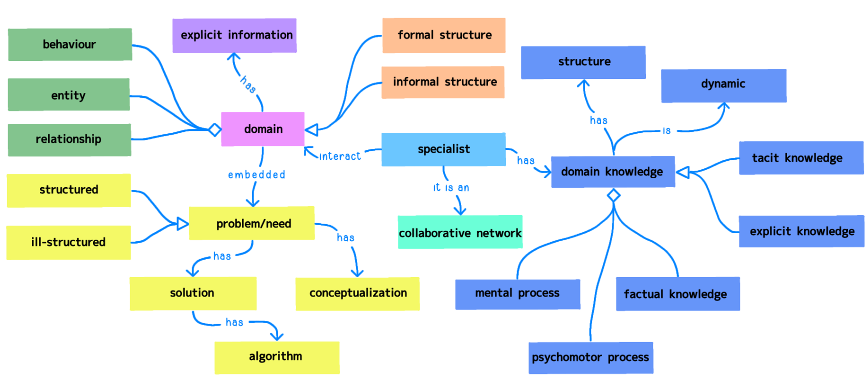


Figure 2.2: Conceptual-model schema of a domain. The schema shows a conceptual model that describes the intricate relationship that interconnects the problem, knowledge and experiences, and how they allow for delimitation of the domain. It shows the domain's main elements, such as the problems and the relationships they have concerning their conceptualisation and solution. A domain composed of entities, relations and behaviours is appreciated; and finally, it describes the characteristics of the knowledge.

As derived from the conceptual model (**Figure 2.2**), it can be foreseen that the adaptation challenge for those who have "the obligation" to adapt to the **CE** is not simple, and that there are many factors to be taken into account. Generally, **who suffers**[3] from a situation, problem or need, belonging to the **CE**, is aware of this situation but does not have the time, ability or knowledge to determine the nature of the problem or give the appropriate treatment or implement actions to resolve it because the activities related to the dynamics and environment of the problem are constantly changing, which implies that the problem cannot be prevented. The organisation and processes of such activities could be carried out in acceptable conditions, but to survive in the current environment, innovation is required. This innovation must start from the fact that there is no knowledge base where *knowledge* is formal and explicit, which generates gaps between the dynamics of processes, and even the communication between them. The knowledge of the environment is uncertain, ambiguous and only some *decision makers*, especially the **Beneficiary** and **DS**, have it, but the knowledge is incomplete and has different degrees of specificity. Chapter 4 on page 51 details a general model to address the situations or needs, mentioned above, through particular treatments for dynamic **ISD** environments. An **ISD** is a complex domain that can be described by characteristics such as the state of its data, information and knowledge, and the representation and communication between them in the following way:

3: **Who suffers** is an individual or company that has to face the adaptive challenge of the **CE**. An adaptation that requires a process of transformation and that includes the incorporation of **Information Technology**, to a greater or lesser extent depending on the nature of the need. In the end, if **who suffers** decides to act and commit to the transformation, this will be the *actor* known as the **Beneficiary**.

- *heterogeneous data and information*;
- *specialised knowledge with a high degree of informality*;
- *the knowledge is partially explicit with a very poor information structure*;
- *it possesses non-homogeneous implicit knowledge*, and
- *knowledge is mostly tacit, non-homogeneous and without structure*.

In addition, the **ISD** involves a *set of actors working collaboratively* to understand the problem, need or business, identify weaknesses, convert them into opportunities and *obtain the knowledge requirements* of this intricate **Cg.Eco** to propose a suitable, viable and valuable **Cg.S**. **Figure 2.3** characterises the essence of an **ISD**, to get an idea of the environment of a **Cg.S**. The core part of the domain, *knowledge*, is represented by an amorphous puzzle structure.

In parallel, it is worth mentioning how the **CE** is changing business and marketing perspectives when developing any kind of project. The biggest impact stems from the accelerating pace at which the amount of data and detailed information about customers is increasing, and the need to translate this into knowledge that will differentiate one business from its competitors, or at least enable that business to survive. While many businesses still focus on traditional strategic planning, there is now a need to insist on a more adaptive approach. For example, *business-to-customer marketing* (**B2C**[4]) or *business-to-business marketing* (**B2B**[5]) perspective management are good approaches. However—under **AI**, *machine learning*, *cognitive technologies* and **IT**—it is necessary to evolve to the *Business-to-Business-to-Customer* (**B2B2C**[6]) perspective. In this sense, it is necessary to understand the biometric profiles, not necessarily of a **Beneficiary**, but of the end consumer. This additional element gives great power to the company by allowing the development of more effective predictive or **KM** models; therefore, it insists on the proper management of data or information coming from external *actors*, i.e. external sources of information (see **Figure 2.3**). Companies that supply goods and services to other companies must insist on, and collaborate by, understanding the factors that motivate the choice of one company's offer or another. In other words, to add value to a value

4: The B2C refers to the tactics and strategies in which a company promotes its products and services to individual people, and creating, advertising and selling products for customers to use in their everyday lives.

5: The B2B is a marketing strategy in which businesses focus on selling goods or services directly to other businesses.

6: The B2B2C is a marketing approach which implies that companies can sell to a business or to the end consumer. This approach, supported by the technology of the **CE**, empowers their sales and marketing chains to make mass sales and keep customer acquisition costs low. It also simplifies logistics and offers a range of products suited to customer profiles to attract them and keep them loyal to its offerings.

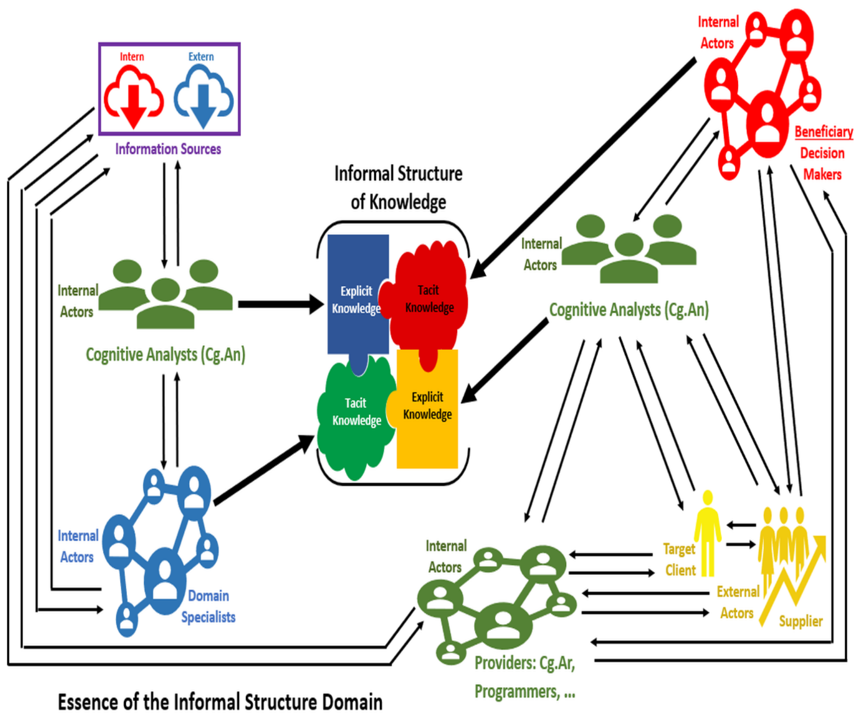


Figure 2.3: An overview of the Informal Structured Domain essence of Cognitive Ecosystem scenario. The figure shows the *actors*, *entities* and *their relationships*, who make up the *essence of ISD*. In the upper left corner, *static cognitive entities*—labelled as "Information Sources"—can be seen. The information entities can be *external* or *internal*. The internal entities belong to the **Beneficiary**. The external entities are databases or repositories with free or paid access. Occupying most of the graph, are the different *human actors*: the **Cg.An** who performs the most important role (**KM**), the **DS** who possesses the *expertise* and *high-level knowledge* about the *domain*, the **Cg.S-P** who has *different technical specialities* that they *offer as a service* for the *implementation of the solution* and, the most important *actor*, the **Beneficiary**, who *has the need* to address, *possess information about* and *make vital decisions* about *the solution*. In the bottom right, *dynamic cognitive entities* are visible, labelled as "Target Client" and "Supplier" (marketing information). The information—provided by these external actors—changes at every instant, communicating the "pulse" of the *targeted client* or *niche*. Finally, at the heart of the essence is *domain knowledge*. Represented as a puzzle where *the clouds* are *pieces of* **TK** held by the **DS** and the **Beneficiary**. The other *pieces* correspond to the **EK** elicited and managed by the **Cg.An**.

chain, it is now necessary not only to understand the dynamics of the firms being served, but also the drivers of their respective market niches.

2.2.2 The Cg.Arch essence

An interesting essence of this **Cg.Eco** is the **Cg.Arch**. It is important to comment on this because there are *many cognitive architectures*, and while most of them belong to general **AI**, the *component architecture* of this **Conceptual Model for Cognitive-Innovation** (**CMCg.I**) does not. From the general **AI** approach, it is stated that *cognitive architectures* have always tried to model the human mind. To this end, they attempt to establish concrete mechanisms to produce intelligent behaviour and thus contribute to cognitive science. In this sense, **Cg.Arch** is a hypothesis about the fixed structures that constitute a mind, whether in natural or artificial systems and how these structures work together—along with the knowledge and skills embodied in the architecture—to produce intelligent behaviour in a variety of complex domains. To do this, an *architecture* must integrate higher-level thought processes, especially symbolic ones, plus any other aspects critical, albeit sub-symbolic, to successful behaviour in human-like domains such as perception, motor control and emotion. **Cg.Arch** encompasses both the creation of **AI** and the modelling of natural intelligence, at an appropriate level of abstraction. However, each **Cg.Arch** is built on a particular set of premises and assumptions, which makes it difficult to compare, evaluate and, above all, unify them. A glance at existing *cognitive architectures* [1] reveals that disagreements persist regarding their research objectives, structure, operation and application. Faced with such a diversity of existing *architectures* and their objectives, the question arises as to

[1]: Kotseruba et al. (2020)

which hypothesis can be considered a **Cg.Arch**. For example, *cognitive architectures* that are inspired by *psychology* should facilitate the study of the human mind by modelling not only human behaviour but also the underlying cognitive processes. **IT**-oriented *cognitive architectures*, on the other hand, are explicit representations of what is known about general human cognitive mechanisms, which are essential for understanding the mind. It is convenient to comment that the homogenisation of concepts or paradigms (related to the cognitive field and the hypotheses about the nature of the mind), among those who work in this area, has not been possible to date, especially because something new emerges on the subject of cognition every day. Therefore, the definition of a **Cg.Arch**, and its main function, is open, dynamic and adjustable. Although there is little agreement, in practice, the term "cognitive architecture" is not so restrictive. Most definitions can agree that *cognitive architectures* are simply a blueprint for intelligence or, more precisely, a proposal about representations and their mental, computational and other procedures, which operate on these representations to explain a series of cognitive behaviours. Even **IT**-oriented architectures have a set of structures for perception, reasoning and action, and model the interactions between them. However, when it comes to less common or new projects—or, as in this case, being part of the adventure of the **CE**—how to distinguish them, to consider them, is less clear. Consequently, this book formalises the **Cg.Arch** as an effort to establish it in a sufficiently efficient, functionally elegant and generic way in support of the interacting *actors* in it (be they natural or artificial). An *architecture* that, although closer to the psychological than to the engineering base, is the basis for the beginning of the innovative implementation of a **Cg.S**. More details on a **Cg.Arch** that supports the transition to the **CE** are available in Section 4.2 on page 53.

2.2.3 Knowledge management: from tacit to explicit

Why is it important for the **Cg.Eco** scenario to manage **TK** in a way that allows it to be expressed clearly, i.e. **EK**?

This **CE** already requires effective communication of knowledge, but this knowledge is mostly **TK**. **Tacit Knowledge** is sometimes referred to as *tribal knowledge*, as members of a *tribe* often *absorb* knowledge simply by experimenting through activities within the context of the *tribe*. The idea is interesting as it evokes a time when writing did not exist but, somehow, without getting into the debate of whether or not there was organised knowledge at that time, experiences were accumulated and generally assessed by trial and error. However, relying on this kind of experience transfer, similar to osmosis, leaves whether or not it happens to chance. Unfortunately, even highly experienced people may not be able to acquire the **TK** necessary to perform a specialised job even better. Worse, the *tribe* may not be aware of what it does not know. Essentially, this implies that the *tribe* will continue to **use an inferior approach to their functions**[7] simply because they are not aware that there is a better way to conduct them.

7: Impact of the pandemic on knowledge sharing. A very real danger in, and derived from, times in the pandemic—forcing physical isolation and working at a distance—as those involved in *distance learning* have minimal interactions with each other; consequently, fewer opportunities to exchange and absorb knowledge. This confirms that the transfer of **TK** requires physical human interaction.

That said, **TK** must be elicited, managed and codified into **EK** so that it is *visible* and accessible to all those who need it to *solve their problem or satisfy their need*, personally or as a business. It also clarifies any confusion or uncertainty between those who are a **Beneficiary** and those who are a **Cg.S-P**, allowing them to drill down into the *nitty-gritty* details to consolidate their understanding for good. The transformation and management of **TK** enables the learning curve of those who need the knowledge to be made more efficient. In the same way, the transformation of **TK** **adds value**[8] to the current **EK** content. In general, **TK** is only *useful and valuable* to others when it is shared by those who possess it. Therefore, documenting it correctly and formally will allow knowledge to be shared easily and show a big difference between those who use the *knowledge* and those who do not because it is assumed that this *knowledge solves* an *existing cognitive problem or need*. In other words, good management that provides the ability to store and share **TK** should impact the **Beneficiary**, even allowing them to solve their problems as they wish. In this sense, for example, with a comprehensive **KM** process, full of *know-what* and *know-how* information, any **Beneficiary** could always find what they need to overcome the problem at hand. In addition, if a **Beneficiary** can always get the *knowledge* he/she needs from the **Cg.S-P**, there will be a common benefit and welfare. For any organisation that wants to stay competitive and adaptable, effective **KM** is essential. By documenting and capturing **TK**, an organisation can preserve and build upon the expertise and experience of its employees. This can provide valuable insight and understanding that can be used to inform decision making and problem solving. It can also increase the organisation's ability to deal with change. It also facilitates the *assimilation of knowledge* for those who do not have it, allowing for the preservation of *prior knowledge* for *posterity*. This has an impact on saving time in dealing with new situations—similar to others previously resolved—by learning from past experiences and mistakes and avoiding spending time and energy on ideas that do not work. *Knowledge transformation and management* does require a lot of effort, but it is always worth doing. Of course, as long as this process is approached strategically and systematically. Additional information regarding **KM**, **TK**, and **EK** can be found in Appendix A.

8: An example of **added value** is to complement the documents with videos of procedures of a specialist performing his/her function, as the visual example has an impact, greatly shortening the learning curve.

What exactly is knowledge?

For a long time, there have been many attemps to answer this question, and nowadays for several areas—such as *philosophy*, *science*, *technology* and even **AI**—the question remains open and without a complete and satisfactory answer. Despite this, *knowledge* is recognised as one of the main assets of modern society. Thus, this term continues to be the subject of analysis, reflection and revision due to its varied meanings and utilities. However, it is clear that to work with *knowledge*, one must first understand its nature and what it is based on, as each meaning leads to different positions in the process of **KM**. This book will not answer the question, but it does use some answers to give a common thread to enable a coherent reading of the book. The oldest and best-known definition of the concept of *knowledge* that this book takes into consideration belongs to Plato, who stated simply that *knowledge* is justified and true belief, without any distinction between *knowledge* of that and *knowledge* of how. Although there is no single or agreed definition of the concept of *knowledge*, different authors (i.e., Nonaka, Alavi and Leidner, Spiegler, Blair, Marzano. . .) have defined their version in congruence with their areas of *knowledge*. Just to give a small example of the various definitions, and because they are directly related to the content covered in this book, the following are listed:

[2]: Farnese et al. (2019)

- In [2] reference is made to the concept of *knowledge*, from Nonaka's perspective, and it is defined as a *personal belief* that justifies a capacity of an individual for physical action or thought.

[3]: Diab (2021)

- In [3], *knowledge*, as perceived by Alavi and Leidner, is the result of the *processing of information* that a person performs. Therefore, *knowledge* has a *subjective* and *personal quality*, which does not have the information. According to this point of view, in a knowledge transfer process, *people cannot provide* their *knowledge*, only inform it. In the same sense, the person *who receives* the information *must assimilate* it to build their *own knowledge*.

[4]: Siakas et al. (2016)

- In [4], *knowledge*, according to Spiegler, is the process of knowing, reflecting, acquiring data and information in a social context, and generating new data, information or knowledge. Even though the *knowledge* of culture is composed of context, experience, basic truths, best practices, common sense, judgement, rules of the game, values, beliefs, needs, emotions and desires.

[5]: Ho et al. (2012)

- In [5], *knowledge*, according to Blair in the context of **KM**, is linked to experience through the nature of the data, the information and the development of a **KM** process. Therefore, data and information are necessary, but not sufficient to exercise the experience.

[6]: Azizah et al. (2019)

- In [6], *knowledge*, according to Marzano's perspective, has *structure*, is *dynamic* and consists of *information*, *mental processes* and *psychomotor processes*, and that it is presented at different *cognitive levels*; therefore, they propose a *knowledge taxonomy*.

9: Knowledge is the relevant, useful and objective information that helps in drawing conclusions.

- And for **AI** and all the areas to which it is linked, **knowledge**[9] is generally the *relevant and objective information* that helps in concluding, in few words, *useful information*.

[7]: Grandinetti (2014)

In particular, experience in **KM** requires pointing out that human knowledge is dynamic, context-specific, deeply rooted in the value system of individuals and created from the social interactions between them, and therefore has an important subjective and personal charge. In this sense, Polanyi communicated that *knowledge* depends on the experiences and learning achieved by individuals and that it has a dual nature: *tacit* and *explicit* (addressed in this way in [7]). The *tacit component* is highly personal, context-dependent and gained through experience. It is thus an ability or skill that is used, most often, to solve a problem or perform something of value, consciously or unconsciously. That is, one knows *how to do things without knowing how to communicate it*, without being able to articulate to others how to achieve the good results that are being achieved. The *explicit component* is that which can be expressed clearly, in detail, completely and unambiguously. It is practical knowledge that is conveyed through any language or formal representation, from written text in natural language to the complex formalism of ontologies. Polanyi suggests that the *tacit* cooperates with the *explicit*, along a *knowledge continuum*, and argues that the appropriate use of a mutually agreed language is an important tool for establishing a communication channel between human beings and sharing knowledge through it. However, when communication is dominated by knowledge, it becomes complex, although this does not prevent **knowledge from being transmitted by other means such as observation or repetition of tasks**[10]. Along this *knowledge continuum*, the **TK** can be seen as two possibilities: that of *being expressed* and that of *not being expressed*. Accordingly,

10: **Knowledge transmitted by observation or repetition of tasks** is, for example, what people do when they learn to ride a bicycle or when a master craftsman transfers knowledge to his apprentice disciples.

- The first possibility: when *knowledge can be expressed*, the *knowledge* remains **hidden**[11] for one of the following three reasons:
  1. concern for *secrecy and power*,
  2. because no one has *bothered to acknowledge the knowledge or try to explain it*, and
  3. because it *refers to assumptions that everyone uses in general*.

  In the first reason, keeping *knowledge hidden* is *conscious*, but in the other two, it is *usually unconscious* and not possible to determine whether or not there are insurmountable obstacles to making this kind of knowledge *explicit*; and
- The second possibility: when the *knowledge acquired through familiarity and practice is inexpressible*, this is when the **knowledge is acquired by the perception of sight, or smell or know-how**[12].

11: **Hidden or implicit knowledge** is the *knowledge* that can be described but has not been done for some reason. In fact, most of the *knowledge* between the extremes of **Figure 2.4**.

12: A **knowledge acquired by a perception** could be when a *sommelier* (a trained and knowledgeable wine professional), tastes wine and classifies it; or the identification of a special musical chord when a *virtuoso* (a person highly skilled in music) is listening to a complex musical piece.

A graphical representation (**Figure 2.4**) of this *Polanyi perspective* shows that each *piece of knowledge* has a dual knowledge nature (*tacit* and *explicit*).

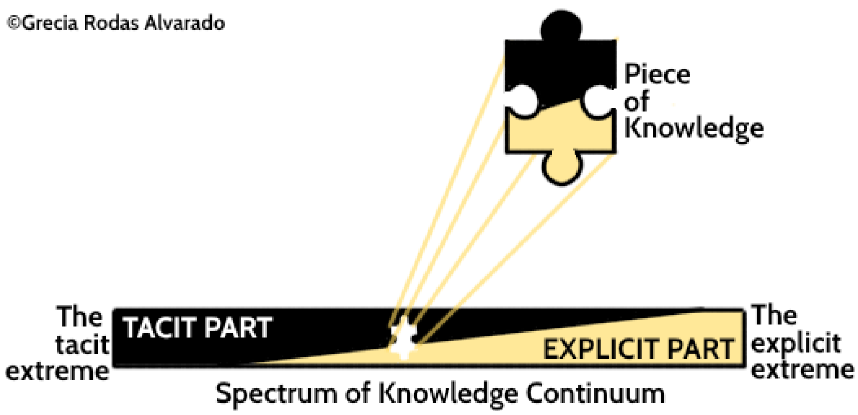


Figure 2.4: Knowledge is seen as a continuum. According to this view, there are *adjacent states of knowledge* in a *continuum* and they are not perceptibly different from each other, but the *extremes* are very different. Indeed, any *piece of knowledge* has a *tacit* and an *explicit part*; unless the *piece* is located at one extreme. That is, at the right extreme, the EK, is the *simple knowledge* that can be easily described. At the other extreme, the TK, is the *complex knowledge* which may not be susceptible to analysis and decomposition; therefore, it will never be possible to represent it.

It is worth noting that in this book, *management* of TK, the *knowledge* from DS, always aims to achieve a manageable EK, as far as possible, by dealing with the reasons why it remains *hidden*.

In summary, the concept of TK seems straightforward but provides ambiguity and even inconsistency instead of certainty. It has been used in several areas, including *psychology*, *epistemology*, KM, AI, and Cognitive Analysis. Today, the importance of KM to improve cognitive problem solving processes and, even, for companies, to gain a competitive advantage in the CE, is undeniable. For example, Zenati [8] points out that many of the medical breakthroughs of the CE are due to proper KM.

[8]: Zenati MA et al. (2019)

It is important to be aware that it will never be possible to obtain and transform all the TK of DS. However, it is imperative to attempt transformation through a systematic process so that the set Suitable Knowledge Requirements (SKReqs) be of good quality and allows the implementation of an adequate Cg.S that satisfies all the real needs of the Beneficiary.

2.2.4 The Cg.Anlys essence

A **Cognitive Analysis** consists of *empathising* with *who suffers*—person, or company: a group of people—and that has a problem or need in the framework of the so-called **CE**. The **Cognitive Analysis** allows for understanding of the feelings and emotions, trying to experience objectively and rationally what the entity, called in this book the **Beneficiary**, feels. Once empathising with the **Beneficiary** has been achieved, a process of elicitation of **requirements**[13] will be initiated to form a set, which in this book is called **SKReqs** and includes activities of induction, elicitation, modelling, validation and management. From the set of **SKReqs**, the implementation of the **Cg.S** can be carried out to properly address the problem or need of a **Beneficiary**. Before starting the implementation, a classification of the requirements must be made, and a distinction must be made between which requirements are functional and which are not. Functional requirements express how a **Cg.S** behaves; that is, the functions and actions it provides to those who interact with it. In contrast, non-functional requirements are used to express the attributes of the **Cg.S** and specify the following aspects:

13: A requirement is a condition necessary for something to happen. The IEEE defines it as a condition or capability necessary to solve a problem or achieve a goal. It must be met, or present, to satisfy specifications and be properly documented.

- *Usability.* The extent to which it is easy for the **Cg.S** to meet the capabilities and knowledge conditions required by the problem of the **Beneficiary**.
- *Reliability.* Probability of failure-free operation of the **Cg.S** for a predetermined period for a given environment.
- *Performance.* Determination of how quickly the **Cg.S** works and adapts, concerning a given workload.
- *Support.* The inherent ability of the **Cg.S** to enable the diagnosis of any problem and subsequent treatment to be adequate, correct and clear.

Therefore, carrying out a proper **Cognitive Analysis** minimises the risk of delivering a *quasi-solution* or the cost of implementation exceeding the budget.

Will Cg.Anlys influence the quality of the solution?

From the above discussion, —regarding a *subjectivity of knowledge*, a complexity that includes *empathy between* the **Cg.An**, the **Beneficiary** and **Domain Specialists**, and the *elicitation of suitable knowledge* to provide a solution—perfect satisfaction of the problem or need by a **Cg.S** is practically impossible. However, by *transforming knowledge from tacit to explicit*, the best approximation to perfection can be achieved. This is possible because **EK** is incorporated into the *requirements* and, in this book, is defined as **SKReqs**. Furthermore, thanks to the challenging work of the **Cg.An**—through empathy—that achieves communication and feedback with the **Beneficiary** which goes beyond simple talks; it allows the *acceptance of the solution thanks to the quality achieved to be a success*. Consequently, the **SKReqs** must be:

- *Correct*: Define the desired cognitive and functional capabilities of the real-world operating environment, its interface and its interaction with it.
- *Complete*: Describe adequately and provide full coverage of the entire solution.
- *Unambiguous*: Avoid ambiguity; have only one possible interpretation.
- *Precise*: Define, exactly, every aspect of the behaviour of the **Cg.S**.

- *Traceable*: Ability to follow the life of a requirement in both directions to its origins or its implementation through the specifications generated during the development process. A requirement is traceable if all parts of the **Cg.S** related to that requirement can be identified.
- *Understandable*: They must accurately convey the wishes, needs and problems of the **Beneficiary**.
- *Verifiable*: Provided they relate to a quantifiable or observable aspect of the solution.
- *Prioritised*: The priority they have is given by the degree of stability or by the degree of functional need. The degree of stability refers to the number of expected modifications of a requirement during the development process. A functional need may be based on a hierarchy containing qualifying attributes such as: essential, conditional and optional, or on some classification scheme that seems appropriate.
- *Precise*: Appropriate and attached, in a possible world, to the desires, needs and problems of the **Beneficiary**.

The IEENSVR process for handling requirements

A **basic systematic process**[14] for handling requirements for cognitive and non-cognitive solutions consists of a set of well-defined activities, as described below:

14: A systematic requirements engineering process enables a formal connection between the modelling, analysis, design and construction of any professional product through tasks—collectively identified by their acronym "IEENSVR"—that define, identify, manage and develop the requirements for its design.

1. *Initiation:* At the beginning of the **Cg.S**, fundamental questions are asked that provide information about the domain, the *actors* and actions within the domain. These *actors* and actions should be described in detail. A basic understanding of the problem or need must be achieved to *delimit the domain*. Effective communication is very important here, as it is the basis for what needs to be done next. In general, the **Cg.An** must gain an understanding of the cognitive need and the problem, the *cognitive need* of the **Beneficiary**, the *specific domain* and the scope of the **Cg.S** among others. In addition to establishing empathetic communication and collaboration between the **Beneficiary** and the **Cg.An**.
2. *Elicitation:* The requirements of the **Beneficiary** are gathered. The *requirements establish* the *key objective* of a *solution*. Understand the type of requirements the solution needs to meet. Mistakes are likely to be made in terms of not describing the requirements correctly, or forgetting some parts. It is essential to involve all the people affected by the problem and those who will ultimately interact with, and benefit from, the solution. It is common to encounter problems of scope because the requirements are not properly detailed, poorly defined or not possible to implement. In addition, there may not be a clear understanding between the **Cg.S-P** and the **Beneficiary** when it comes to the requirements. Sometimes, the **Beneficiary** may not know what it wants, or the **Cg.S-P** may confuse one requirement with another. Finally, if the project is lengthy, volatility may occur as requirements change over time, which can make it difficult to manage a project, ultimately leading to a loss and waste of resources and time.
3. *Elaboration:* This takes the requirements that have been established and gathered in the first two phases and refines them. They are also expanded and deepened. The *main task* is to engage in *modelling activities and develop a*

prototype that elaborates the features and constraints using the necessary tools and functions.

4. *Negotiation:* A discussion and exchange of conversations about what is needed and what needs to be eliminated. Negotiation takes place between the **Cg.S-P** and the **Beneficiary**, and focuses on how to carry out the project with limited resources. The **Beneficiary** is asked to prioritise requirements and make estimates of conflicts that may arise. The risks of all requirements are taken into account and negotiated in such a way that both the **Beneficiary** and the **Cg.S-P** are satisfied concerning subsequent implementation. The negotiation phase looks at the availability of resources, delivery times, the scope of the requirements, the cost of the project of the requirements, the cost of the project and estimates on the development of the solution.
5. *Specification:* Digital documents, a set of models, a collection of use cases and a prototype must be achieved. The **Cg.An** gathers all the requirements (both knowledge and functional) and starts prototyping to observe the basic functions, features or constraints. Models that can be used in this phase include: ER (Entity Relationship) diagrams, DFD (Data Flow Diagram), FDD (Function Decomposition Diagrams) and Data Dictionaries. In addition, a *specification document* is presented to the **Beneficiary** in a language he/she understands, to give an idea of the working model.
6. *Validation:* A formal technical review where error checking and debugging is done. The **Cg.An** examines the *specification document* and checks for the following: all requirements have been correctly established and fulfilled, and errors have been debugged and corrected to build a prototype according to the standards. The review team works together and validates the requirements; it includes the **Cg.An**, the **Beneficiary**, and all other potential users of the solution. All **ISD** *actors* participate in the testing of the specification, examining whether there are errors, missing information or additions to be made, or checking for unrealistic and problematic errors. Some of the *validation techniques* as follows: requirements review/inspection, prototyping, test case generation and automated consistency analysis.
7. *Requirements management:* This is a set of activities in which all **ISD** *actors* participate in the identification, control, monitoring and establishment of requirements for the successful and smooth implementation of the project. In this phase, the *actors*, especially the **Cg.An**, is responsible for managing changes that may occur during the project. If new requirements arise, it is at this stage that responsibility must be taken to manage and prioritise where the solution lies, how this new change will affect the overall process and how to approach and cope with the change. The working model will be carefully analysed from this phase and ready to be handed over to the **Beneficiary**.

Digital documentation of suitable knowledge requirements

In the **CE**, **digital documentation**[15] is an indispensable reality for all scientific, cultural and economic activities in our society today, bringing with it remarkable changes in the approaches and tools it provides. Some digital documents are digital versions of printed originals and printouts of originally digital documents. It is worth mentioning that, in all meetings, from the first interview with the

15: **Digital documentation** is the production of dynamic and interactive information and communication, using the resources offered by **IT** for the **Cg.An** to develop his/her *cognitive process* of *in vivo* interviewing, reading, analysing, understanding, linking to previous processes, as well as locating and retrieving new thematically associated documents.

Beneficiary, all interviews should be recorded, and the cognitive and functional requirements of the **Cg.S** should be described and specified in detail and with clarity, to avoid ambiguities or lack of information. Therefore, one of the first digital documents to be obtained will be the recordings of the interviews. In addition to the first generic version of the *knowledge (non functional) requirements* and *functional requirements* of the **Cg.S**, and the initial version of the identified use cases.

Generally, to document the requirements, a process is carried out that starts with:

- *Delimiting the domain*: The delimitation starts by establishing an overview of the problem or need, and identifying and describing the possible **Cg.S**. As the progresses, the *knowledge and functional requirements* will emerge and transform from vague to specific, and the *use cases* that are deemed appropriate will evolve towards their detailed form.
- *Domain detailing*: The development of a **Cg.S** is *framing* by an **ISD** and must be detailed with a special focus on the requirements of the **Cg.S**. Starting from the general requirements—knowledge and functional types—and use cases in their initial version, and considering the objectives of the **Beneficiary** and the *model* of what the **Beneficiary** wants as a *solution*, everything is communicated and discussed with the **Beneficiary**. Those use cases in which it is considered necessary are reformulated and completed with additional information. In the same way, the *knowledge requirements are particularised and enriched*, and the functional requirements are indicated and detailed. This work is a *two-way process* between the **Beneficiary** and all *actors* and *entities* in the **ISD**. It is expected that the use cases of the **Cg.S** will form a highly detailed version; that the functional requirements already allow starting the implementation of the **Cg.S**, and that the *knowledge requirements fully describe what is expected* from the **Cg.S**.
- *Analysis and refinement of knowledge requirements*: The *knowledge requirements* of the **Cg.S** should be analysed and refined through *modelling* to identify potential problems and to further detail the proposed **Cg.S** to solve the needs of the **Beneficiary**, including the *logical* and **Cg.Arch** of the **Cg.S** and its interfaces to all its users and the services to be offered by it. It is expected to obtain a **Cg.Arch** of the **Cg.S**, comprising all models supporting the solution and defining an interface for all possible users of the solution.
- *Quality of the knowledge requirements*: The quality of the *knowledge requirements* of the **Cg.S** is then verified. Its main objective is to verify that the **Cg.S Requirements Specification** meets the quality model of the proposed set of *cognitive requirements*, which should be made known to the **Cg.An** in order to be considered during the elaboration of the *cognitive requirements*. The output expected of this task is the identification of problems in the *knowledge requirements* by verifying the *quality of the requirements, especially non-conformance or non-satisfaction defects*.
- *Validation of requirements*: Its main objective is to check that the **Cg.S** described by the **Cg.S Requirements Specification** corresponds to the needs of the **Beneficiary**, obtaining its approval and allowing the generation of a basis for *supporting the requirements* of the **Cg.S**. This is done based on meetings, analysis of recordings, modifications to models and requirements and further meetings with the **Beneficiary** and persons linked to the **Beneficiary**.

It is important to keep detailed minutes of the meetings and to point out problems with the requirements, which should be recorded in a digital medium.

- *Traceability*: A traceability exercise continues by recording all those problems in the *cognitive requirements* identified in any of the tasks of the **Cg.S**, and which meet the needs of the **Beneficiary**. Finally, the **Cg.S** requirements are specified (traceability matrices of *recorded cognitive requirements*). The output of this task is the traceability matrices that reflect the dependencies between the requirements and other elements that constitute the **Cg.S Requirements Specification**.

All of the above is concentrated in at least **one particular digital document**[16]. Consequently, a **Cg.S Requirements Specification** is considered to be of quality if it is complete, coherent, organised, convenient, correct, accurate and unambiguous:

16: This **particular digital document** contains a *complete description of the cognitive and functional requirements*, denominated as the **Cg.S Requirements Specification**, i.e. the relevant information that enables the **Cg.S-P** to design and deliver *a suitable* **Cg.S**.

- *Complete*: The document contains all the information necessary for a description of the **Cg.S** design, and no more.
- *Consistent*: The specification of the **Cg.S** is consistent if there are no contradictory statements between the requirements contained in it.
- *Organised*: The document is well-organised if its content is arranged in such a way that the **Cg.S-P** can easily locate the information.
- *Convenient, correct, accurate and unambiguous*: The document maintains, at all times, an *open set of requirements* that will always contain the necessary number of requirements to provide a **Cg.S** that guarantees the *satisfaction* and the quality of the desires of the **Beneficiary**.

How is the quality of the Cg.S measured?

The benefits of the **CE** and the effects of the **IT** that underpins it, are *extremely difficult to measure*, which has influenced its acceptance by preventing effective communication and allowing detractors to minimise the potential impact of the benefits. As a result, most of these **benefits are considered intangible**[17]. Although there are several methods, there is no single method and, in general, it behaves as a closed-loop model in which inputs are presented, in which there are one or more rules and in which an output is given that is compared to the inputs. The input consists of a set of preset or expected benefits. The rules define a model of each domain in question, and the output is the set of benefits obtained—financial or otherwise—and their continuous comparison with the input.

17: Intangible benefits are the advantages or profits derived from the **CE**, which can be extremely difficult to measure; and this difficulty makes the benefits and the quality of these benefits difficult to compare and communicate, for example, for the decision making and strategic development that the **Beneficiary** decides to undertake. Assessing the benefits a **Beneficiary** receives from a *technology solution* can be achieved through different strategies. With **Cg.S**, satisfaction is determined by the extent to which the solution meets the needs of the **Beneficiary**, leading to greater trust and acceptance.

In this sense, all **Cg.S** include tangible effects but, primarily, intangible effects. The intangible effects are the benefits—or detriments—caused by the **Cg.S** and, since they cannot be appreciated by the human senses, they cannot be credibly converted into monetary values, much less after having consumed a reasonable amount of resources. However, even if they are not converted into monetary values, they still represent the most important part of the evaluation process because they are responsible for satisfying the problem or needs of the **Beneficiary**.

There are several measures of intangibles, but because of the very different nature of each *cognitive* project, there is no single best measure of intangibles to quantify (or to qualify) the consequences of intangibles. This is not to say that these effects can never be measured or converted into monetary values. However, in *cognitive* projects, it is common to consider the subjective valuation that the **Beneficiary** has and, after each cycle of implementation and valuation, or each time it is necessary, to check what and how the solution satisfies the **Beneficiary**, and to continue until all his/her expectations are met.

To summarise, foremost, as regards the part derived from functional requirements, there is no great complexity to determine the quality, and there are several proven and already established measures for this. For example, if the **Cg.S** is implemented by software, its quality will be regulated by an **ISO/IEC 9126 standard**[18]. However, from the above, it is established that a **Cg.S** will always have a *cognitive component that is intangible*, and that *this intangible part is "valuable"* and *is responsible for satisfying the needs or problems* of the **Beneficiary**. Consequently, the quality of the **Cg.S** is associated with the *satisfaction* of the **Beneficiary**. Therefore, the minimum that must be done to guarantee the quality of the **Cg.S**, as a whole, is to perform a checklist of the *knowledge requirements* contained in the **Cg.S Requirements Specification**, elicited through a *systematised and knowledge-based process*, which will finally guarantee the *completeness* and *quality* of the **Cg.S**.

18: ISO/IEC 9126 is the international standard to ensure the quality of all software-intensive products, including safety-critical systems where lives are at risk, if software components fail.

2.3 Spheres: actors & entities

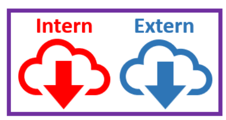


Figure 2.5: The figure shows the **Information Sources** represented by two cloud icons with a flow arrow. They are any source—internal or external—from which a **Cg.S-P** can be informed about aspects of the problem, the need, its possible solution or its domain.

Earlier, it was mentioned that a simple way to approach a **Cg.Eco** is from *three spheres* of *actors or entities* (Section 2.1 on page 15). They essentially provide explicit information, perform cognitive functions and report on market behaviour (see **Figure 2.1**).

First sphere: explicit information sources

In this context, an information source (**Figure 2.5**) is an entity, thing, person or place from which information is obtained. This information is obtained by an *actor* working on the implementation of a **Cg.S**; that is, any source from which a **Cg.S-P** can be informed of aspects of the problem, the need, its possible solution or its domain. Consequently, the choice of the source of information and how to search for it are issues of great importance. In particular, the sources of information include all those from which the **Cg.An** can obtain information to perform an effective **Cognitive Analysis**, especially to support him/her in obtaining the **SKReqs**.

The information obtained has a well-defined structure, is explicit, and comes from an information infrastructure that can be **internal or external**[19] and is composed of:

- Components **interacting**[20] to collect, organise, filter, process, generate, store, distribute and communicate information. Repositories, databases, documents, images, observations, speeches of people, organisations...

19: **Internal information sources** are those that belong to at least one of the *internal actors* of the *domain*. Generally, the *internal information* belongs to the **Beneficiary** and is stored in its databases, files and specialised human resources... The **Beneficiary** itself is one of the main sources of *internal information*. **External information sources** are those that do not belong to the **Beneficiary** or its context. Information obtained from them is generally in the cloud and belongs to some formal and verified site, or could be queried to information services.

20: **Interacting** occurs between *actors*, processors, storage media, inputs, outputs and communication networks with access to clouds, databases or domain-specific repositories to implement a **Cg.S**. It is important to remember that *external data and information sources* are largely autonomous, geographically distributed and heterogeneous in terms of the operating environment, culture, social capital or objectives. However, it is possible to work with them collaboratively so that the *knowledge or experience*, which belongs to the **DS**, is capitalised in the **Cg.S**.

- Data generation and services range from the devices and networks of the Internet of Things and drones to social media platforms, payment systems and facial recognition technologies.
- Technologies and products that provide information flows. Mobile phone sensors, IoT products, point-of-sale, facial recognition cameras, drones and other devices.
- Institutions and services that provide information elements. Platforms of global social media companies such as YouTube, Facebook, VK, Telegram, Twitter, Weibo, WeChat, TikTok and others.

In summary, the *explicit information sources*, be they entities, things, people, or places, are consulted only for the implementation of a **Cg.S** by the **Cg.S-P**.

Second sphere: cognitive functions performed by the actors

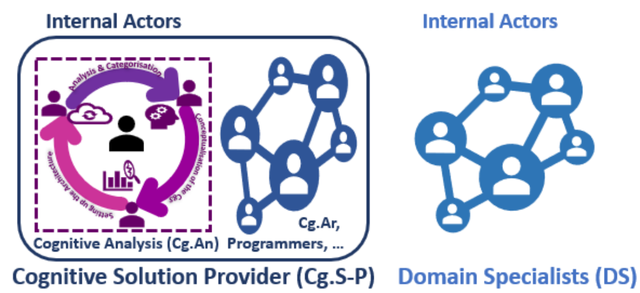


Figure 2.6: The figure shows the **Tech-Sci actors** represented by several configurations of half body icons. The left side represents **Cg.S-P**: **Cg.An**, **Cg.S Architect** and others. The right side represents **DS**. **Tech-Sci actors** must implement a **Cg.S**, using, as a starting point, their knowledge and experiences configured in the *informal structure of the domain knowledge*.

This sphere has a set of *actors* playing different roles or functions. *Actors* that—working collaboratively—provide solutions to the problems or needs of the main *actor*, the **Beneficiary**. These *actors* must form an "infrastructure of cognitive functions" and, through **IT**, provide the expected service or product. Such an infrastructure must support the *actors* in performing the following activities:

1. Information analysis, intelligent data analytics and cognitive analytics.
2. Systematic processes for knowledge elicitation and **KM**.
3. Implementation of cognitive and innovative solutions.
4. Decision making.
5. Retrieving and follow-up on market information, or of the target client if the implementation of the solution demands it.

Actors who perform as **technologists or scientists**[21] (**Figure 2.6**) must implement a **Cg.S**, using, as a starting point, their *knowledge* and *experiences* related to existing solutions for cases similar to the one they are dealing with. Thus, the process of implementing a new solution may include new ways of designing or producing goods or services to make a positive change that alters what is already established to obtain something new. This implies that, specifically, these *actors* are *highly trained* to *respond to problems* in *any domain* and provide *innovative solutions* that are generally *situation-specific*. In addition, the interaction between them must take advantage of all the knowledge and information that exists in the domain, together with the application of science and technology to achieve the capitalisation of experience or knowledge providing a **Cg.S**.

21: Activities 1, 2 and 3, of the second sphere, are carried out by *actors* performing as **technologists and scientists**: **DS**, **Cg.An**, and other providers.

Regarding these *actors*, there are three essential roles: the **DS**, the **Cg.An**, and the **Cg.S Architect**. The **DS** is the one who possesses the *knowledge and expertise*—both of which are *tacit*—that are represented by *puzzle pieces* in the *Informal Structure of Knowledge* (see **Figure 2.3**). The **Cg.An**, or set of them, manage the cognitive functions necessary to acquire, manage and represent knowledge. This knowledge is configured in the *Informal Structure of Knowledge*. The **Cg.S Architect** establishes the infrastructure necessary to deliver solutions based on any combination of technologies, processes, analytics, marketing, internal organisational environment or consulting. These solutions can be **tailor-made suits**[22] for the **Beneficiary**, or innovations based on existing products or services for a target market or client. The profile for either the **Cg.An** or **Cg.S Architect** should be characterised by a balanced combination of empathetic and effective communication, conflict resolution, and psychological, technical, social and business skills.

22: A Tailor-made suit is an established phrase to communicate that a solution is specially designed for a specific domain, task, purpose or need, underlining that this solution is perfectly suited for its purpose.

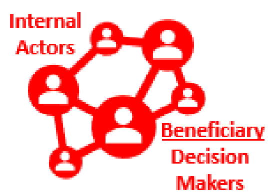


Figure 2.7: The figure shows the **Beneficiary** represented by a network of half body icons. The **Beneficiary** is the main *actor* and it has the power to decide, at any time, whether the project to get the **Cg.S** that it needs should start, pause, continue, or end. In other words, the **Beneficiary** has the economic resource to invest in obtaining the solution to its problem or need.

Finally, the main *actor*, the **Beneficiary** (**Figure 2.7**) is the one who performs the decision making activity. This is the main *actor* and has the power to make decisions; it has the need and, to satisfy it, it will have to make an economic investment to finance the necessary infrastructure, and all that this implies, for the implementation of the **Cg.S**.

Third sphere: external passive informative actors and entities report market or customer behaviours

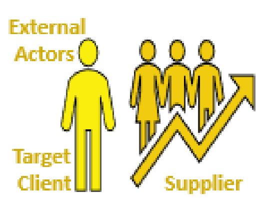


Figure 2.8: The figure shows the **passive informative actors** represented by two configurations of human figures. These *passive actors* interact with the others, as long as necessary, *giving information* about the *market* and *the target client*.

The latter sphere includes passive *actors* (**Figure 2.8**) who *report* various and diverse forms of *marketing information coming from target clients or specific markets*. This information can be present in the interaction with the other *actors* whenever the need to be satisfied demands it.

2.4 Chapter summary and reminders

In this chapter, the *basic essence* of a **Cg.Eco** was described using an *analogy* of a *theatre stage*. The *analogy* included the preparation of the stage, starting from its essence, where the most important essence of the stage, the **Informally**

Structured Domain (**ISD**), was highlighted. It continued with a series of concepts that introduced the *actors* on stage to communicate the central idea:

Making a **Cognitive Analysis**, appropriate to the **ISD**, is very important to successfully implement a **Cognitive Solution** that reflects all the *available domain knowledge* for the **Beneficiary** to be able to easily "cross the line" between surviving, or not, in the **Cognitive Era**.

3 Cognitive Analysis, Beyond the Requirements Analysis

The previous chapter, mentioned how important it is to perform a proper **Cognitive Analysis** of the **Informally Structured Domain** (**ISD**) to successfully achieve a **Cognitive Solution** (**Cg.S**) and, perhaps at this point, the **Cognitive Analysis** looks like a *standard requirements analysis*. This chapter makes it clear that the *requirements analysis* is a part of the **Cognitive Analysis**. It also communicates the objectives of its the four stages of the **Cognitive Analysis**, and the convenience of working on a **Cg.S** project through a *model*.

A **Cognitive Analysis** must interact with the **Domain Specialists** (**DS**) to obtain *domain knowledge*, to elicit the **Suitable Knowledge Requirements** (**SKReqs**) set and to be able to specify, in detail, the **Cg.S** for its subsequent implementation. A **Cg.S** does not use "masses of bits" to give information, rather the **Cg.S** bases its operation on the *accessible knowledge*. Therefore, the **Cg.S** must reflect all the *available domain knowledge* so that the **Beneficiary** can easily "cross the line" between surviving in the **Cognitive Era** (**CE**) or not.

And, a question emerges: how is that knowledge harnessed?

In essence, it is harnessed through the **Cognitive Analysis**, which takes into account the characteristics of the problem or need, the high-level knowledge and expertise of the **DS**, the experience of the **Cognitive Analysts** (**Cg.An**) themselves—and other actors involved in obtaining the solution—as well as their knowledge of **Information Technology** (**IT**) to implement a **Cg.S**. This is not trivial; for example, the simple illustration, **Figure 3.1**, highlights the importance of **Cognitive Analysis** as a connector for the “dialogue” between knowledge in a real case related to Cognitive Neuroscience. The **Cg.S** obtained was a software tool that manages this domain knowledge through neurological cognitive tests, and assesses the level of a person’s cognitive impairment.

The implementation of **Cg.S** has shown that **Cognitive Analysis** is complex and requires a lot of concentration and dedication from all the actors involved in the implementation of the solution, especially the **Cg.An**, the **DS** and the **Beneficiary**. Essentially, the software tool mentioned above would not have been possible without the close collaboration between these actors. In addition, it has been shown that the process of integration between different knowledge, expertise and experiences do modify the domain, and this process is known as **cognition**[1], which is where the human brain receives data from diverse sources—internal or external—and, after its analysis and interpretation, the brain reaches a conclusion that modifies its reality [9].

Solving problems or needs embedded in the **ISD** requires a complex and dynamic social interaction between all actors, especially the **DS**, **Cg.An** and **Beneficiary**. Fortunately, this hard work *modifies the knowledge of all actors*, evolving as the project progresses, *modifying the domain*, and *improving the detail* and *characterisation*

1: Cognition is a process that occurs in the biological machine known as the human brain. This process consists of receiving, analysing and interpreting data from various sources before drawing a conclusion that is stored in the memory. This conclusion directly modifies the reality that the human being perceives by provoking the creation of new neuronal synapses, altering the current perception and generating a new one. Increasingly, as a result of the stored experiences and the addition of new experience after experience, a unique and unrepeatable reality is constructed.

[9]: McDowell (2011)

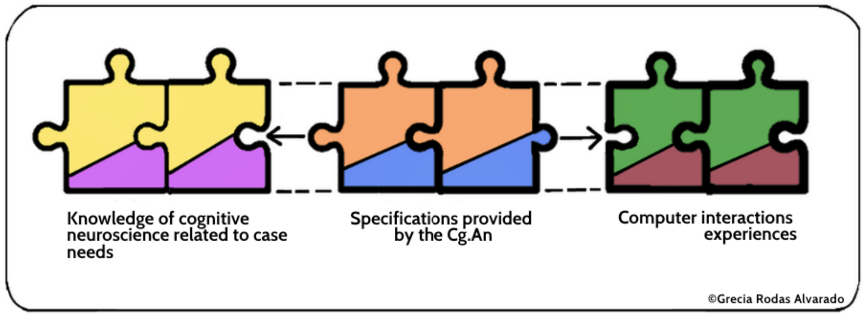


Figure 3.1: Schema of Cognitive Analysis Importance. The schema shows the central importance of proper specifications of a problem domain for the integration of knowledge to enable **Cg.S** functionality. On the far left, the *cognitive requirements* detail the knowledge of the area—in which the **Cg.S** will operate—of cognitive neuroscience. On the far right, the *functional requirements* detail the interfaces and other features, properties and functionalities that the implementation of the software tool must accommodate. In the middle are *connector specifications* provided by the **Cg.An** that show his/her experience in *connecting knowledge* of the neuroscience area *with the functionalities* that must be present in the software tool. These specifications are not trivial and, as can be seen, are the pieces that put together the puzzle of knowledge and functional expertise for the implementation of the application solution.

of *both the problem* and *the solution*. **Cognitive Analysis** must explore the problem from different angles to find a *suitable solution*. These cycles of exploration modify knowledge progressively and do not rule out a return to earlier stages to change the direction of exploration. Even if a return is made, the knowledge, expertise and experience remain as added knowledge that allows new paths to possible solutions to be explored. This "dialogue" between knowledge, expertise and experience—which occurs through a *process of knowledge modification and transformation*—is called *cognitive dialogue*.

[10]: Bjørner (2011)

From the above information, a **domain** [10][2] can be summarised as a *well-defined area of human activity*, that has *formal and informal aspects*, which requires is a *dialogue between all the actors* involved in obtaining the solution and, after a series of actions or events, a *change in knowledge* is established that impacts the specifications or knowledge requirements of the solution. The domain must be formally described, and the **Cg.An** must validate its description together with *all those involved in obtaining the solution* (this must be done with the **DS** and the **Beneficiary**). This validation will be done repeatedly until everything necessary for the implementation of the solution is established.

2: A **domain** is a space in which a dialogue of one or more areas of human knowledge is established. The formal description of the *domain* is usually done through an informal narrative text that uses natural but specialised language specific to the *domain* and describes the *domain* as it is. In addition, it is strongly recommended that the above is accompanied by a mathematical text—a formal, precise, and unambiguous definition—which together with the narrative formalises the description. Including a model of the *domain*, which is a schematic description of the space in which the dialogue takes place.

Based on experience, the characteristics of the **ISD** generate an *implicit cognitive and social space*, referred to as an **ad hoc Collaborative Network** (**ahCN**), which allows the *connection of knowledge*, *expertise* and *experiences*, and the *collaboration between all the actors* directly involved in obtaining the solution.

It is worth bearing in mind that these domains have large amounts of **Tacit Knowledge** (**TK**) that cannot all be transformed into **Explicit Knowledge** (**EK**), and not all **EK** can be formalised (related information in Section 2.2 on page 17). Linked to this situation are informal aspects that depend on context in order to be correctly interpreted and managed. Experience in real-world situations—domains ranging from medicine, industrial design, architecture and education—indicates that these informal aspects are resolved by consensus and without formal verification of their processes. Thus, it is the responsibility of the **Cg.An** to use his/her experience and skills to solve everyday situations that are not usually in his/her domain. If an **ISD** is predominantly **TK**, it does not mean that cognitive analysis is impossible and that the **ahCN** will not be able to give a

Cg.S. To offer these solutions, one has to be aware of the fact that one depends on context, distributed knowledge in **ahCN** and consensus. In this scenario, it is of the utmost importance that the **Beneficiary** is aware of the nature of its problem, as vital decisions for the solution will depend on it.

On the other hand, if a domain is quasi-formal, this means there are minimal pieces of **TK** to be used, the **Cognitive Analysis** will be straightforward and the **ahCN** will be able to implement the **Cg.S** that responds to the problem or need of the recipient. However, experience in the **CE** indicates that there is a hard price for a "day of leisure in the strawberry field".

An interesting question that remains "in the dark" is how to decide whether the nature of a problem identifies it as belonging to an **ISD**, or whether more information is needed to formally define it.

3.1 Why beyond the requirements analysis?

Requirements analysis[3] involves frequent communication with all actors involved in the solution, especially the **Beneficiary**, to determine the expectations of the specific characteristics that the solution should have. To elicit and induce the expectations of the **Beneficiary**, techniques such as interviews including observations, scenario building and focus groups must be carried out very carefully and with all the time necessary for this *arduous work* to be completed successfully. Resolving conflicts or ambiguities in the requirements demanded by the various actors, avoiding feature proliferation and documenting all aspects of the project development process are activities that requirements analysis requires from start to finish. In addition, the analysis must ensure that the solution fits the needs of the **Beneficiary** rather than trying to mould the expectations of it to fit the requirements. Consequently, requirements analysis is a team effort which requires activities—for requirements elicitation—that combine knowledge and skills about the technologies that will be used to implement the solution, psychology, empathy and effective communication. These activities are vital for the realisation of projects that will design tailor-made solutions to the needs of the **Beneficiary**. The experience, in these **vital activities to develop projects**[4], indicates that approximately 30 per cent of projects deliver solutions on time and meet all the expectations of the **Beneficiary**. Fifty per cent of projects experience changes in budget, functionality or extended development time, and 20 per cent are cancelled.

3: Requirements analysis (also called *requirements engineering*), is the process of inducing, analysing, evaluating and determining the expectations of a **Beneficiary** to manage them and *provide a new or modified solution to satisfy their need*. These characteristics, called *requirements*, must be quantifiable, relevant and detailed. Requirements analysis is an important aspect of project management. In software engineering, in particular, these requirements are often referred to as functional specifications.

4: Vital activities to develop projects (CHAOS report). The report focuses on the human factor by highlighting the *vital activities to develop projects* and their effects, and provides a good overview of areas for improvement as well as opportunity in project management skills for organisations. It even provides excellent insight into the root causes of project failure or success.

The main reason a **Cg.S Provider** (**Cg.S-P**) finds itself in the undesirable 70 per cent has to do with poor execution of requirements elicitation, selection and implementation of tasks, which is often due to the *analyst's inability* to make explicit, and empathise with, the expectations of the **Beneficiary**. In other situations, they are so immersed in the *domain knowledge* that they omit important information because they unconsciously take it for granted. In general, they do not sufficiently understand the domain and are unable to maintain empathetic communication between all project actors. In addition, the *analyst* must reconcile differences with the **Beneficiary** and the **DS**, and must have the ability to collaborate and commit to working hard in a domain in which they are often neophytes; they need to grasp, as quickly as possible, the *knowledge* and *expertise necessary* to deliver the *solution*. Experience teaches that, as requirements are not tangible, the knowledge possessed by the **DS** and **Beneficiary** needs to be made explicit through means (especially graphical ones) that, together with talks in *everyday language*, can be communicated in a working session with the **Beneficiary** and the other *actors*. Requirements analysis becomes even more important to carry out an "excellent" increase when the problem or need is embedded in an **ISD** (more details in Subsection 2.2.1 on page 17) because the characteristics of the **ISD**, present in the needs or problems, require a **Cg.S**. The *analysis of requirements becomes more complex* since the **Cg.S** is developed according to the specific demands of **Beneficiary**; they are *convenient solutions* that force the implementation to include *knowledge or expertise distributed* throughout the **ahCN**, especially the knowledge of the **DS**. Consequently, the *analyst* must employ *cognitive processes* and will therefore be the **Cg.An**. Now, the requirements analysis is the **Cognitive Analysis** that will elicit **SKReqs** and identify the necessary *pieces of knowledge* to integrate them into the **Cg.S**.

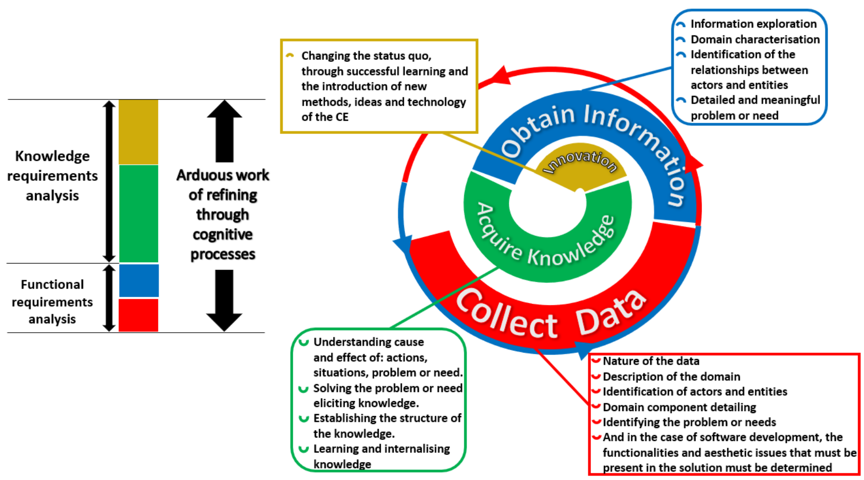


Figure 3.2: Cognitive Analysis spiral. The spiral communicates how **Cognitive Analysis** is carried out in different cycles that continue until the objectives of each stage are achieved or until the **Cg.An** determines the completion of the stage (Collect Data, Obtain Information, Acquire Knowledge and Innovation). In addition, all the cycles must be integrated, and reaching the innovation stage involves refining each of the previous stages. The left-hand side communicates that working out the knowledge requirements is really hard and involves the greatest investment of time in the **Cognitive Analysis**.

In **Figure 3.2**, the hard work of **Cognitive Analysis** is depicted as a four-stage spiral, and in the outermost section there is a ring of arrows indicating that this work is a series of cycles, back-and-forth, as many times as necessary until the goals of each stage are achieved. And obtaining the *pieces of knowledge* needed to shape the **Cg.S** is a work of refinement, moving from the outer stage (collect data) to the inner stage (innovation). Although this looks like a data mining process, it is not. However, it is not excluded that, in the stages of obtaining information and acquiring knowledge, data mining is carried out, although it is not mandatory. When a **Cg.S** is to be developed, it is because the need to be addressed is embedded in a **ISD**; therefore, the primary *pieces of knowledge* for the **Cg.S** come from the **DS**. This requires the use of techniques, including psychology, to elicit this knowledge by making as much **TK** as explicit as possible.

3.2 Objectives of the Cognitive Analysis through the four stages

As mentioned above, a **Cg.S** is a tailor-made suit for the **Beneficiary**; therefore, the objectives outlined for each of the stages are not unique. Each stage will have to meet the necessary objectives for each particular project. With this in mind, the objectives indicated here are illustrative and general, and are based on the experience of implementing **Cg.S** for several **ISD**. It can be pointed out that the general objectives of a conventional need are achieved through a *standard functional requirements analysis*, which is completed in the first two stages of the **Cognitive Analysis** (*Collect Data* and *Obtain Information*). However, when it comes to a need that is embedded in an **ISD** and that requires knowledge, then the four stages (*Collect Data*, *Obtain Information*, *Acquire Knowledge* and *Innovation*) must be carried out, which are the *Acquire Knowledge* and *Innovation* stages, the core of the **Cognitive Analysis**, where the **SKReqs** are obtained.

The objectives for the *standard requirements analysis*—*Collect Data* and *Obtain Information* stages—are:

- *Collect Data*: Nature of the data, description of the domain, identification of *actors* and *entities*, domain component detailing, identifying the problem or need. . . , and in the case of software development, the functionalities and aesthetic issues that must be present in the solution must be determined.
- *Obtain Information*: Information exploration, domain characterisation, identification of the relationships between *actors* and *entities*. . . , and detailed and meaningful problem or need.

The objectives for the **Cognitive Analysis** that will elicit the **SKReqs**—four stages—are completed with the stages:

- *Acquire Knowledge*: Understanding cause and effect of: actions, situations, problem or need, solving the problem or need, eliciting knowledge, establishing the structure of the knowledge. . . , and learning and internalising knowledge.
- *Innovation*: Change the status quo, through acquired learning, for the introduction of new methods, ideas and technology of the **CE**.

3.2.1 Collect Data stage

The data collection stage is a set of objectives that relate to gathering information from all relevant sources to find answers to the problem that needs to be solved. When the problem or need is studied, essential data is collected to understand the events and conditions in the domain in which it is embedded. As events and conditions are understood, models are generated with the data to generate ideas from them and make decisions based on them.

The identification of *actors* and *entities* is one of the first steps in this stage, which includes identifying and describing them according to the functions or activities they perform in the domain. Entities do not necessarily represent specific physical entities, but simply particular facets (i.e. "roles") of some entities that are relevant to the specification of *knowledge* or *functional requirements*.

The description and detailing of a domain are carried out using models that provide an abstraction of the possible world in which the problem is embedded, for which a solution will be implemented. Creating explicit models of the domain offers two key advantages: it allows for detailed reasoning—and hence validation—of what is assumed about the domain, and it offers opportunities for the reuse of requirements within a domain.

Finally, functionality must go hand-in-hand with aesthetics. Experience has shown that the **Beneficiary** is more empathetic as the implementation of the solution is perceived as functional and aesthetic as much, or more, as he/she imagined it would be possible, especially if it is an software. Therefore, all solution designs must include the pleasant qualities that the **Beneficiary** imagines. In visual terms, aesthetics include factors such as balance, colour, movement, pattern, scale, shape and visual weight. The **Cg.S-P** uses aesthetics to complement the usability of their designs, thus enhancing the functionality of the **Cg.S** with attractive designs, which is especially important as it supports the empathy that has to be achieved in the **Cognitive Analysis**.

The *Collect Data stage* is the beginning stage of the spiral in which data will be refined into the *pieces of knowledge*. First, it must be determined what data are to be collected, and how and where they are to be found. The determination of the type of data needed, and the accuracy and correctness of these data, significantly affects the quality and accuracy of the subsequent pieces of knowledge. Therefore, this step has to be done very well.

In summary, *collect data* is the initial *stage* of the spiral in which data will be refined and linked to knowledge to form the *pieces of knowledge* that will underpin the **Cg.S**. First, this *stage* determines what data will be collected, and how and where it will be found. The determination of the type of data needed, and the accuracy and correctness of the data, significantly affects the quality and accuracy of the subsequent *knowledge pieces*. Thus, this stage has to be carried out properly and as professionally as possible.

For details of techniques and tools to achieve these goals, see [11] and [12].

[11]: Laplante et al. (2022)

[12]: Tractinsky et al. (2012)

3.2.2 Obtain Information stage

Obtain Information is an inquiry that goes beyond data collection. This *stage* must find relationships between concrete facts to achieve a set of objectives: to explore the information in the domain, to establish its characteristics and the relationships between all its *actors* and *entities* and to detail the problem or need. This information is communicated through tables and graphs in multiple forms. Recurring patterns are sought that can be considered as new characteristics or new knowledge. It is possible that, at the previous stage, the state of the data is unorganised. Therefore, the **Cg.An** must have the experience and ability to reorder the data and use statistical, or even intelligent, data analysis methods to obtain information from it. This *stage* is mainly done together with the **Beneficiary** through interviews and targeted exercises: questionnaires, observation of behaviour and interpersonal skills, social methods and social issues. . . The *Obtain Information* stage aims to capture all relevant information about how "the one with the problem or need" currently does things. This information includes information flow, business processes (or a lack thereof), data used in these processes, external and internal data, handling of exceptions, problems of the current situation, including existing systems, desirable and undesirable scenarios. . . It is worth noting that, at this *stage*, the **Cg.An**'s most frequently used skill is to seek or "break through" an **ISD** about which he/she is often quickly ignorant. The term "obtain information" should not suggest that the information that the **Cg.An** needs is explicitly available somewhere—a document, someone's head. . . —and that all the **Cg.An** has to do is find the source and obtain it—by reading or asking—as this is often wrong. The necessary information may have to be extracted through **Cognitive Analysis**, interpretation and synthesis from several sources. For example, consider the decision-making that takes place in a bank regarding loan approvals. The **Cg.An** must find out the rule(s) for loan approval; these may not exist anywhere—in documents from, or in the heads of the people who work in, the loan department—and may even have contradictory statements within the same department. It is the "counting-doing problem": people know how to do many things that they normally never describe (**TK**); thus, when they are required to make descriptions of these activities, the descriptions may be inaccurate or impossible. This is very relevant, as the lack of access to *expertise* can mean that the critical expectations, experiences and needs of the **Beneficiary**'s project stay hidden and unperceived, causing the set of knowledge requirements and, consequently, the possible resulting solution to be inadequate.

The four basic aspects of the domain describe the following:

- *Thematic*: *Actors* and *entities* of the expected solution. Description of what exists and what is the future.
- *Use*: The environment in which the expected solution will operate.
- *Solution*: What the solution should do within its operating environment, what information it contains and what functions it should perform.
- *Development*: The development process, the development team, schedule and required qualities: security, performance. . .

Experience has shown that a useful way to obtain information is to collect sequences of desirable or undesirable events. For example, for admission to a hospital, the following assumption is made: "I am admitted to a hospital, and what happens during my admission?" The answer could be: "You, or the person accompanying you, will talk to the admission person; you will be asked to show your insurance card or disclose the medical service to which you are affiliated, and explain why you have been referred to the hospital. . . " It is also possible that some scenarios describe undesired sequences of events, such as: "You will not be admitted if you do not present your insurance card. . . " However, from the scenarios, the general processes used in the organisation of the study can be constructed, as well as the use-cases of the possible solution.

Who are the persons to be consulted during the information gathering? They are all *actors*—all those who have some kind of relationship with the implementation of the solution:

- *Users*, who care about the features and functionality of the solution.

- *Designers*, who want to provide a perfect solution or modernise the existing one.
- *Cognitive analysts*, who want to "meet all requirements".
- *People who interact with, and support, the user*, as they want to make sure the solution is functional and user-friendly.
- *Those who look after the business*, as they want to make sure they "do better than the competition".
- *The technical people* who will prepare the information to communicate the solution's framework in the form of manuals. . .
- *The beneficiary of the project*, as they want to have solutions that are on time, on budget and with all objectives met.

Finally, here are some techniques that are commonly used to obtain information:

- *Sampling of hard data*: Forms, applications. . .
- *Background reading*: Reports, memos. . .
- *Interviews*: Meeting with people and asking them questions.
- *Questionnaires*: Distributing a questionnaire to the relevant people, collecting their answers and analysing them.
- *Observation*: Spending some time observing the organisation in which the new system is to be implemented.

Detailed information on the aspects and techniques for the *Obtain Information* stage can be found in [13] and [14].

[13]: Anwar et al. (2012)

[14]: Hathaway (2016)

3.2.3 Acquire Knowledge stage

This stage is very interesting because it will pursue knowledge wherever it is within the **ISD**. It will use statistics, and analyse patterns and concepts to understand the cause and effect of actions, situations, problems or needs. It will select knowledge to solve the problem or need of the **Beneficiary** and, through managing this knowledge, set up a structure for the knowledge to be the foundation of the **Cg.S**.

To meet the objectives of this stage, the previously mentioned stages should have met their objectives, at least in the first round. Accordingly, a sequence through the stages of a process that achieves knowledge acquisition could be summarised as follows:

1. Data Collection (from *Collect Data* stage)
2. Organising the data (from *Collect Data* & *Obtain Information* stages)
3. Summarising (from *Obtain Information* stage)
4. Analysing (from *Obtain Information* & *Acquire Knowledge* stages)
5. Synthesising (from *Acquire Knowledge* stage)

The **Cg.An** will use the information coming from the previous stages, as a **initial insight**[5], and starting point for the work of *eliciting knowledge and expertise* from the **DS**. The **Cg.An** will first evaluate the domain and check if it has the characteristics of an **ISD**. Then, he/she will *elicit the knowledge*, and identify and evaluate the *pieces of knowledge* to make sure that they offer the knowledge required by the **Cg.S**. It must be stressed that the most complex and strenuous part of the work for the

5: Occasionally, **initial insight** can be used by the **Beneficiary** to make decisions related to its current situation or decisions about the process of implementing the **Cg.S**.

Cognitive Analysis is the process of extracting, making explicit, and organising the knowledge so that it can be used to carry out the solution. Thus, the most important aim at this stage is to give the *pieces of knowledge* necessary in order to ensure the correct functioning of the **Cg.S**.

Some considerations to keep in mind at this stage, before Cg.S implementation

The **Cg.S** may or may not be a software tool, this does not matter; what matters are the *pieces of knowledge* for the implementation and proper functioning of the **Cg.S**. The *pieces of knowledge* must reflect the knowledge and expertise of **distinguished**[6] **DS** who possess unique knowledge and specialised skills. In addition, it is useful to keep in mind the following considerations:

- *About domains*. The characteristics of the **ISD** (Subsection 2.2.1 on page 17) must be taken into account to achieve proper implementation of the **Cg.S**. These characteristics are linked to the acquisition of domain knowledge. Firstly, there must be bona fide **DS**, i.e. people with generally recognised expertise in the required domain. Secondly, there must be a consensus among the **DS** about the possible solutions to a problem or need embedded in the domain. Thirdly, the **DS** must be able to communicate the details of their modus operandi. Finally, the domain must be well delimited, and solutions within the domain must avoid relying on common sense.
- *About Domain Specialists*. There are **Cg.S** that are software and can manage a knowledge base that can be developed from several sources, such as books, manuals and simulation models, but the knowledge at their core comes from human specialists. Although multiple specialists can be used, as a recommendation the **Cg.S** should be based on the knowledge of a single specialist. This **DS** must agree with the objectives of the **Cg.S**, and must be a cooperative and easy person to work with. In addition, he/she needs to have good verbal communication skills and be willing and able to devote the necessary time to the work.
- *About the knowledge acquisition technique*. The topic of knowledge obtainment was discussed earlier, and it is worth remembering that the interview cycle is one of the most important techniques used by all the actors involved in the implementation of the **Cg.S**. As the interview cycle progresses, models of the **Cg.S** are generated and evolve, enriched by the activities of each stage. As a result, these interview cycles are intensive and systematic, often lasting several months. It should be borne in mind that, the deeper the knowledge of the **DS**, the less they will be able to describe it. Moreover, in their efforts to describe it, **DS** tend to rationalise their knowledge, which can be misleading. It is worth remembering that, because the main and most important source of domain knowledge comes from human beings, the **Cg.An** must be a specialist in specific knowledge acquisition techniques, and select the most appropriate ones to work with those who will be involved in the implementation of the solution. Nevertheless, although there are many good methods for the *acquisition of knowledge requirements*, such as introspection, questionnaires, interviews, focus groups and protocol analysis, to name but a few, they are all limited when dealing with **TK**.

6: **DS** have been **distinguished** because they are the *actors* who are often the most reluctant to collaborate, and working with them often generates "headaches". Despite this, it should be emphasised that the *knowledge pieces* are integrated not only with knowledge coming from the **DS**, but from all of the *actors* involved in the implementation of the **Cg.S**, especially the **Beneficiary**.

Therefore, the **Cognitive Analysis** must include a psychosocial perspective—cognitive psychology, anthropology, sociology and linguistics—in parallel to the analysis of dialogue, conversation and interaction.

Summary of the knowledge acquisition process of the actors involved in the Cg.S

Given the above considerations, it is possible to summarise the process of acquiring the *pieces of knowledge* coming from the *actors* involved in the **Cg.S**. First, observe—as far as possible—all *actors* who possess the skills and knowledge that they currently use to address the problem, even if they are not used in a satisfactory manner, as this is knowledge that can serve as a starting point. Then, elicit as much knowledge as possible that the **DS** possess and believe can be useful for implementing the **Cg.S**. This is done through discussions to identify the knowledge and procedures needed to solve different types of circumstances presented by the problem. Next, scenarios that can be associated with different types of circumstances linked to the problem or need are constructed with all the actors involved in the **Cg.S**. **DS** are asked for suggestions on how to solve the previous scenarios, making sure that they communicate the reason for the suggestion. Subsequently, **SKReqs** and supporting models are elicited and expressed in the most appropriate knowledge representation for the **Cg.S**. Meetings should be held to review these with all actors, especially the **DS** and the **Beneficiary**. There are bound to be changes, adjustments and adaptations that include the experience and knowledge of the **DS** and, most importantly, the decision-making that would have to be done by the **Beneficiary**. As can be seen, all of the above activities require a close working relationship between the **Cg.An** and all the actors involved in the implementation of the solution. Consequently, the **Beneficiary** must be fully aware that he/she needs to invest time from all the *actors* who are usually under his/her command, as well as from himself/herself.

In summary, the experience of implementing a **Cg.S**, of what is involved in acquiring knowledge and how it relates to the solution, was communicated earlier. But it must be remembered that working with an **ISD** and its characteristics makes the **Cg.S** a tailor-made suit for each situation and its domain. Consequently, everything this book mentions is based on experiences, which have worked, but which are perfectly adaptable to the project to be dealt with, and can be communicated as practical considerations regarding the following aspects:

- *Operational objectives*. After an assessment of the problem and the domain, it can be perceived whether a **Cg.S** is appropriate and feasible. Therefore, realistic operational objectives can be formulated for a **Cg.S** and, consequently, **SKReqs** for its functionality should be defined, taking into account who the intended user is and how the solution should be delivered. If the actors do not have a unified concept of the operational objectives of the project, the definition of **SKReqs** will be hampered and the necessary *pieces of knowledge* for the **Cg.S** will not be identified. It is the responsibility of the **Cg.An** to make sure that the objectives are consistent with the resources available for a project. At an early stage of the interview process, the purpose of the project and the roles of the *actors* involved in the interviews should be carefully discussed. The discussion should lead to a consensus on what the

Cg.S is expected to be, who its users should be, and how the solution should be delivered. As the project develops, the operational objectives should be reconsidered regularly. Also, detailed and careful planning should be carried out, in line with the agenda of the *actors*, especially the **Beneficiary** and the **DS**.

- *Prior training*. Prior training for the **Cg.An** on the **ISD** is very important. In general, an **Cg.An** is not familiar with the domain and, as a result, the development process slows down. If an **Cg.An** has limited knowledge of the problem domain, then training in the domain is important and can accelerate the development of the **Cg.S**.
- *Knowledge document*. Simplistically, models, their explanations, lexicons, knowledge requirements, pieces of knowledge and the processes to get them—all of this is knowledge. . . and all knowledge should always be kept up-to-date and be properly documented. It is even desirable to establish conventions to decide how it should be documented, in what language, and what jargon to use, to give descriptive names to each important part, especially those essential for the implementation of the solution.
- *Scenarios*. A series of scenarios should be developed that fully describe the types of procedures that all *actors* involved in the problem, and hence the solution, should go through. If reasonably complete case studies do not exist, the **Cg.An** should be able to compose realistic scenarios. Anecdotal stories can become scenarios, and are especially useful because they are often examples of unusual interactions between *actors* in the domain. Familiarity with several realistic scenarios can be essential for understanding the actions and decisions of all *actors* in early interviews, for structuring later interviews and for validating each model until the solution is reached.
- *Interviews*. **DS** and the **Beneficiary** are often very busy people, and interviews held in their work environment are likely to be often interrupted. To maximise access to them and avoid interruptions, it may be useful to hold meetings away from the workplace. Alternatively, meetings can be held outside working hours and on weekends. Regardless, interviews should always be recorded because it is necessary to extract the lexicon and find keywords that state the actions or decisions of the *actors*. Also, notes taken during the interview may often be incomplete or suggest inconsistencies that can be clarified by listening to the recording. The **Cg.An** must also be aware of fatigue and manage interview times accordingly. In the first interviews, the format should not be rigid, in the sense that the discussion can take its course. The **Cg.An** should resist the temptation to impose personal bias on what the *actors* express. During the first conversations, *actors* are often asked to describe the tasks encountered in the domain and to walk through the example tasks explaining each step. An alternative or complementary approach is to simply see actors at work, especially the **DS** solving problems without interruption, or to have *actors* speak aloud during the performance of a task. These procedures are variations of the *protocol analysis*, and are only useful with **DS** or *decision-makers* who primarily use verbal thought processes to solve action-demanding situations. Regarding the need for *agile prototyping* (more information on prototyping can be found in Appendix D), initial interviews can be formalised to support this process. One such technique is a *structured interview* in which the *actors*, especially the **Beneficiary**, are asked to list aspects to be taken into

account when making a decision. Next, the **Beneficiary** is asked to list the possible outcomes of the decision-making. Finally, he/she is asked to find connections between aspects and outcomes with each other, so that rules, requirements or even patterns, i.e. knowledge, can be found. A second technique is called *twenty questions*, where the **Cg.An** develops domain-typical scenarios during the interview. At the beginning of the interview, the *actors* participating in the interview ask the questions necessary to understand the scenario well enough to allow them to decide the sequence and to notice the consequences. Each time they ask questions, they are asked to explain why each question is being asked. When the **Cg.An** perceives that he/she has uncovered or identified something that could be knowledge, he/she interrupts and reiterates to make sure that what he/she perceives is correct. A third technique is *solution ranking*. In this procedure, the **Cg.An** prepares a set of typical solutions to problems in the domain. The *actors* are asked to rank them according to the characteristics they consider important for finding possible solutions to the problem. After each ranking, the *actors* are asked to explain how they decide on each classification. Subsequent interviews should generally be structured and follow a cyclical pattern in which *pieces of knowledge* are elicited, documented and tested. During this phase of *acquiring and integrating pieces of knowledge*, the **Cg.An** must begin to methodically uncover the finer aspects of the knowledge. Typically, this process is scenario-based. By modifying the scenarios in different ways, the **Cg.An** can probe the sensitivity of the *actors* to change. During interviews, it is desirable to work with means that allow for the exact phrasing of any participating *actor* to be flexibly displayed, recorded and organised. It may also be useful to adopt conventions for recording any comments from the sessions, e.g. colour-coding the different aspects discussed. Structured interviews should steer the course of a meeting to achieve specific predefined objectives. For example, once the *set of knowledge pieces* has been established, an *ontology* can be developed and the *actors* can be asked to evaluate the knowledge it communicates. However, be aware that the **Beneficiary** is the *decision-maker* and has power over the project; it is common for interviews to deviate from the **Cg.An**'s intended objectives for the session, so the **Cg.An** should be able to steer the session back on track.

- *Questionnaires*. Where specific information is needed, a questionnaire can be used effectively. Questionnaires are often used in combination with other techniques, such as interviews.
- *Ontologies*. The **ontology**[7] can establish the general scheme of representation of the domain being analysed, detailed and characterised. With it, the logic of the actions and decisions carried out by the *actors* involved in the implementation of the solution can be validated. It also allows for verification of the hierarchy of the knowledge related to their actions and decisions.
- *Knowledge Pieces*. Although complex representation techniques may eventually be used, the identified *pieces of knowledge* should be represented as the interview cycles progress. They may initially be represented as rules, as they are often easier to use for the purpose of characterising knowledge during knowledge acquisition. The *first set of knowledge pieces* can be developed from written materials or example cases described by *actors* during the first unstructured interviews. The *initial pieces* should be treated as

7: An **ontology** is a catalogue of the kinds of things that are assumed to exist in a domain. This catalogue is constructed from the perspective of the *actors* in the domain, and uses their language to explain the domain clearly and familiarly. Thus, ontologies have elements that represent predicates, constants, concepts and relations belonging to that language. From this perspective, ontology can set up a general scheme of representation that is based on the logic of the actions or reasoning of the *actors* involved. It is also a hierarchical representation of knowledge and complex reasoning mechanisms.

approximations, and their wording should be kept simple for the clarity of all those participating in the meetings. As more cases are described during the interviews, the *pieces* can and should be expanded, modified, updated and corrected. Once a stable *set of knowledge pieces* starts to be integrated, it can offer information for structuring the interviews.

From the above, it is clear that this *stage* is the one that requires the most time, work and even creativity. That is because, in this *stage*, the causes and effects of the actions carried out by the *actors in the domain*, as well as the situations they face, must be known. Also, this *stage* must sufficiently detail the problem or need, in order to empathise with the **Beneficiary** and, consequently, determine how the situation should be resolved. In this sense, the *stage* will provide the knowledge and if this knowledge is properly managed, learning and internalisation should be achieved, which will allow the final stage of the spiral to be reached: the innovative implementation of the **Cg.S**. Thus, if the domains are well identified, detailed, and characterised and if the *actors* are chosen with this in mind, the chances of success in achieving the right **Cg.S** will increase considerably. Then, all, or almost all, of the practical aspects of the *knowledge acquisition stage* described above should help.

Detailed information on the *knowledge acquisition* can be found in [15] and [16].

[15]: Milton (2007)

[16]: Mohammad et al. (2010)

3.2.4 Innovation stage

The innovation stage is interesting because it involves not only work but also creativity. It is the stage where the change—or series of changes—takes place, and however minimal, it will always improve and add value to a product, process or service. Innovation can be presented through inventions—or creative interventions—which can be incremental or disruptive, and they have to be tangible in the process itself or, in the resulting product or service. Therefore, an *innovation process* is important due to:

- *Opportunities for problem-solving*: When innovation is fostered, brainstorming arises from attempts to solve existing problems or needs.
- *Adapting to change*: In the technological world, where the environment changes drastically, change is inevitable and innovation is the means, not only to keep a company afloat but also to ensure that it remains relevant and profitable.
- *Maximising of globalisation*: Innovation is a necessity to solve the needs and challenges and take advantage of the opportunities that open up markets around the world.
- *Being in competition*: Innovation can help establish or maintain the vanguard of a company, compete strategically within a dynamic world and make strategic moves to overcome the competition.
- *Evolution of the dynamics of the workplace*: Innovation is essential for the use of demographic data in the workplace, which constantly changes, and ensures the proper functioning of the product, service or process.
- *Knowing the changing desires and preferences of target clients*: Currently, clients have a wide variety of products, services or processes at their disposal, and

are well-informed to make their choices. Therefore, it is imperative to keep up with changing tastes and also forge new ways to satisfy the target clients.

Cognitive Analysis, carried out in organisations, companies and institutions, implicitly categorises *possible solutions* into two types: the *engineering type*, especially focused on IT, and the *non-engineering type*; but, because they arise from **Cognitive Analysis**, they must be considered as a **Cg.S**. In short, a **Cg.S** is any proposal that derives from the **Cognitive Analysis**. Moreover, by focusing the analysis on organisational knowledge, it involves groups of *actors* with different expertise, objectives and skills in a *conscious and collective innovation process*. A transformation of organisational dynamics has always been accomplished with this stage, to a greater or lesser extent. Therefore, this stage of innovation is also known as *cognitive innovation*. The *Digital Era* has provided organisations with the technology to manage their information properly. In the CE this information is refined by extracting *useful information* to provide *highly structured knowledge*. In developed countries, most organisations have already incorporated digital technology, which facilitates their transition to the CE. However, in countries with little or slower development, organisations have not yet succeeded in incorporating the *Digital Era*, let alone the CE. Therefore, for organisations to implement an adequate, viable *cognitive innovation*, they need to rely on a *model* that provides the necessary components to accompany the organisations in a transition to obtain an appropriate **Cg.S**. Interesting information on the *innovation* process for this era can be found in [17], [18] and [19].

[17]: Gummerum et al. (2014)

[18]: Brocke et al. (2015)

[19]: Ceci et al. (2021)

3.2.5 Corollary

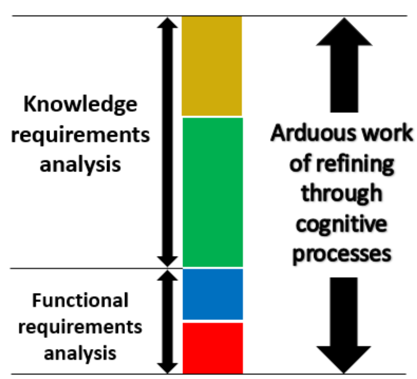


Figure 3.3: Arduous work of refining. The bar chart shows an approximate distribution of the time spent performing the *arduous work* of the **Cognitive Analysis**. The chart also distinguishes between two parts of the **Cognitive Analysis**: the functional, and the knowledge requirements. The arrows give an idea of the time spent on each part of the **Cognitive Analysis**, and the coloured secondary divisions distinguish each of the four *stages*.

The corollary of the four stages is that they are all equally important for good analysis. However, some involve more activities than others, and therefore the investment of work for each of these is different (see **Figure 3.3**). The spiral starts with the outer stage until the inner stage is completed; however, they are not sequential, i.e. it is not necessary to finish the outer stage before starting the next one. Each stage will be carrying out its activities until it achieves its objectives and, between all of them, it is possible to distinguish the *pieces of knowledge* necessary to implement the **Cg.S**.

Finally, as a result of the hard work carried out in each of the *stages*, it can be concluded that, the way **TK** is approached may be causing various problems in meeting the objectives of each of the *stages*, therefore jeopardising the correct implementation of the solution. Consequently, transforming as much **TK** as possible into **EK** is necessary to minimise the risk of project failure or increase development time and cost. It is worth noting that some of this knowledge will not be transformable and will stay *tacit*, but, it is necessary to attempt as much transformation as possible through a systematic process with the necessary mechanisms to integrate, structure and synthesise specialised knowledge. By way of encouragement, experience in this type of project allows us to report that, in fields such as medicine and business management, the proper management of **TK** has brought great benefits, and it is undeniable that, in these cases, a convenient transformation was possible.

3.3 The strategy to face these challenges, including a model

The main goal of the **Cg.S-P** is to give a **Cg.S** that meets the needs and expectations of the **Beneficiary**. To achieve this goal, it is necessary to set up the *theoric architecture* that identifies, links and formalises the existing relationships between terms, concepts, activities, *entities* and *actors* embedded in the **ISD**. Such a **Cognitive Architecture** (**Cg.Arch**) must have ways of representing knowledge in ways that assimilate and codify it by an unambiguous and convenient set of **SKReqs**, which guide the design and development activities of the **Cg.S**. In order to integrate such a set, the **Cognitive Analysis**, which is carried out with the whole **ahCN**, must find clear and proper *pieces of knowledge*. This requires a good process of cognitive dialogue and effective **Knowledge Management** (**KM**) that reduces ignorance and improves the assimilation, communication and use of knowledge. Consequently, and based on experience of such situations, it is argued that the *main activity* involved in **Cg.Arch** has to be a systematic process that enhances the use and evolution of existing knowledge throughout the whole **ahCN**, and the strategy for *scaffolding the* **Cg.Arch** has to be through a **model**[8].

8: A theoretical-methodological model is a simplification of the theoric architecture because it includes only the relevant aspects to a given domain, and does not pretend to represent the totality of the problem to be solved.

3.3.1 Why a model?

Experience affirms that the particular characteristics of the problems or needs embedded in an **ISD** increase the assimilation time of the domain itself, and the problems must be addressed by utilising a *tailor-made suit* (Section 3.2 on page 37). Moreover, even using conventional **KM** methods and tools to obtain a set of **SKReqs**—correct, adequate and unambiguous—could be a fruitless task without due care and without carrying out the assimilation in a *systematic* way. Thus, a *model* is ideal for this situation, as it would provide a framework that:

- Formalises and delimits the elements necessary to establish an **Cg.Arch** that structures the study process, and plans how to approach a specific **ISD**.
- Frames the reasoning process and supports the interpretation of *knowledge*.
- Integrates the *elicited pieces of knowledge* and links them to the *entities*, *actors* and activities leading to the implementation of the *solution*.
- Provides the *semantic bases*, i.e. the *cognitive foundations*, to initiate the conceptualisation of the **Cg.S**.

- Sets in motion a *cyclical* and *systematic process* to conceptualise, propose and validate the possible **Cg.S** that should satisfy the need.
- Feeds back to all the *actors* and *entities* participating in the *process* after each cycle; and
- Modifies and "evolves" the organisation.

In summary, to establish the framework that supports such activities successfully, there must be a *model* that configures them and formalises the interaction between all the elements to establish the **Cognitive Ecosystem**, which enables *innovation* in the search for a viable **Cg.S** to address the need of the **Beneficiary**.

Be aware when deciding to work on the model

There is a part of the world, somewhere, where there is a **CE** now, which is current, and that it is difficult to characterise in detail on a day-to-day basis due to the accelerated and constant change, which in this *era* generates the technology connected to it. However, one knows that one is obliged to participate in the **CE** if, and when, the future of one—personally or as an organisation—is determined by a dependence or desire to lead a life in society linked to this technology. In short, there are many positive aspects of *digital life* in the **CE**, and the authors of this book are confident that they outweigh the negatives. . . but will this always be the case? History reveals that every revolution has at least two aspects, one positive and one negative, and that these aspects are not absolute and depend on the perspective of the evaluator. In this sense, there are times when it seems that the damage to the well-being of humanity, living beings and our planet will outweigh the positive aspects so quickly that, in a decade—or less—a tally of the damage will be made and a more realistic perspective will be taken. There are undeniable benefits of *digital life*—e.g. access to knowledge and culture—these are a daily reality for a good part of humanity. However, it is undeniable that some harm has arisen in recent years, and this trend continues with a steady acceleration in a negative direction. The growing strength of **the powers that be**[9] is worrying, as this could be an era that, instead of offering prosperity for humanity, could become one of *extreme control*, an era of *totalitarian rule* that would immediately and directly affect the freedom, privacy and security of society and those who live in it. Today, life is lived in a corporatism that does not care about maintaining democratic governance, where there is a technological displacement of work and, which, as a social tranquilliser, offers an addictive technological leisure that captures the attention and mental space, that dictates what to do and how to do it to the general population, with particular emphasis on the younger generations and those still in education. Yes, *digital life* threatens the hitherto psychological, economic and political well-being. . . a real and heartbreakingly bleak possibility. Despite all of the above, the authors of this book believe that it is always best to think positively and to see the good that is *around us*. While remaining realistic and knowing that evil and problems will continue to exist, there is a firm hope that there is a greater population living with hope for good and positive thinking, which always helps to explore ways of dealing with problems and adverse situations that arise every day.

9: The powers that be refers to the entities in command, or in a position of authority. These entities may be part of a government, a corporation or in some other position of leadership. It generally has a negative connotation for most people, implying that one is under the domination of the powers that be, and that one resignedly accepts their decisions, even arbitrary ones, usually unconsciously or despite being consciously in an agreement or not.

In short, life is not easy or fair, but it is interesting. And, if one does not have the means to be a *modern-day Robinson Crusoe*—to be able to survive in this **CE**, surviving on an isolated island with food, water, shelter and everything that be considered necessary, optimal and desirable, including certain comforts, with self-confidence to survive without wanting to be rescued—consequently, one should participate in this **CE** as well being as prepared as possible by remembering that the technology implicit in it uses knowledge derived from experience to offer us tools that improve the well-being of all human beings.

This scenario shows the importance of having an adequate and timely *model* to establish the **Cg.Arch** that provides the **Cg.S**.

3.4 Chapter summary and reminders

This chapter revealed that the **Cognitive Analysis** must fulfil a series of objectives that are divided into *four stages* and that go beyond the attainment of *functional requirements*. The stages of analysis covered, were: data collection, information gathering, knowledge acquisition and innovation. In addition, the strategy for implementing a **Cg.S** as a *model* was reported.

Finally, it is worth stressing the need to:

- Identify and consider the particular characteristics of an **ISD**;
- Carry out good **KM**, which enhances *cognitive dialogue*, minimises the *symmetry of ignorance* and facilitates the *transfer and explanation of the greatest possible amount of knowledge*; and
- Improve and update all the activities and processes for the *elicitation and compound of the pieces of knowledge set*.

The next chapter presents a **Conceptual Model for Cognitive-Innovation**, not as the only one but as one of several, and one that has proven to work well in dealing with situations—embedded in an **ISD**—avoiding the elicitation of incorrect, inappropriate or ambiguous knowledge requirements. It also takes into account the importance of human nature, its capabilities and limitations, and thus provides the best *solution tailored to the needs* of the **Beneficiary**.

4 Conceptual Model for Cognitive-Innovation: One Way

This book has demonstrates that there are individuals or companies (the **Beneficiary**), that face the challenge of adapting to the **Cognitive Era** (**CE**). This challenge is a need that can range from how the **Beneficiary** works, and its processes, to the incorporation of technologies. In general, whoever suffers when facing this type of problem, which is very present in this *era*, will be aware of the situation but does not have the time, capacity or knowledge to analyse the nature of the situation, and has even less time, capacity or knowledge to carry out the adequate treatment or implementation of the actions needed to solve it.

Unfortunately, the environment that the **CE** poses for the situation is constantly changing; addressing it is not simple and, even if such actions could be carried out under acceptable conditions to survive in the current environment, it is desirable to innovate. An innovation, in this situation, must assume that the knowledge (formal and explicit) to support it does not exist or is not available. When the knowledge of most of the domains of the **CE** is uncertain and ambiguous, it is difficult for the **Beneficiary** to renew its way of working or its activities. It is no longer enough for the **Beneficiary** to go to a *human specialist*—a specialist in the specific need—for knowledge because it is incomplete and of varying degrees of specificity, and often not even available because the specialist is not even able to distinguish it himself/herself. Therefore, obtaining the knowledge that the **Beneficiary** needs is not an easy undertaking and requires professional support.

This chapter communicates the convenience of having a *model* for both the representation and communication of the *components*, *entities*, *actors*, *processes* and *activities* that participate—moving forward systematically—in reaching a *proposed solution* for its subsequent *implementation*. In this sense, the **Conceptual Model for Cognitive-Innovation** (**CMCg.I**) was built by establishing a compromise between analogies and differences with a reality that has already been addressed by accompanying those who have needs and problems to continue interacting with the challenges posed by the **CE**. Therefore, the **model**[1] can be expanded and corrected as it has been developed over the success stories of accompaniment, and it is kept under a permanent iterative process of revision to accommodate new situations and experiences. This chapter will also show how the **CMCg.I** integrates the concepts discussed above to address the situations or needs—embedded in an **Informally Structured Domain** (**ISD**)—that are presented to the **Beneficiary**, to establish the *theoretical cognitive architecture*, which underpins a **Cg.S** and makes the linkage between *all those involved* in the *proposed solution* and *its implementation* possible through the **CMCg.I**. It is in this **Cognitive Architecture** (**Cg.Arch**) that experiences, behaviours, collectively shared ways of thinking and relationships between all components of the given **ISD** are defined. Consequently, the **Cg.Arch** connects the *necessary components* and supports a *particular* and *innovative treatment* to the situation of the **Beneficiary**, i.e. the production of a *tangible or intangible* **Cg.S**.

1: Notably, the **model** (**CMCg.I**) is open, constantly revised, enriched, updated and now used as a *modus operandi* by a set of **Cognitive Analysts** (**Cg.An**) to implement a **Cognitive Solution** (**Cg.S**).

Figure 4.1 shows a general outline of the model, and the following subsections give an overview of the parts of the model.

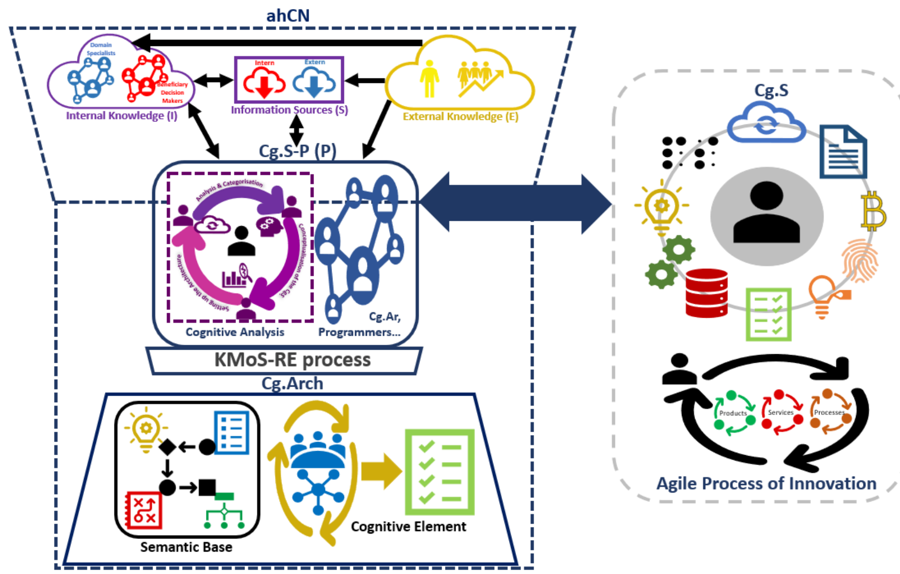


Figure 4.1: **Schema of the Conceptual Model for Cognitive-Innovation.** The image shows the general schema of the CMCg.I. It represents all its components and the relationships between them. For the sake of readability, it has been divided into four parts, corresponding to the ad hoc Collaborative Network (ahCN) (top: trapezium with dashed lines), Cg.Arch (bottom: trapezium with continuous lines), Cg.S Provider (Cg.S-P) (centre: rectangle with round corners and continuous lines) and the Cg.S (right: rectangle with round corners and dashed lines).

4.1 ad hoc Collaborative Network

Definition 4.1.1 *Let the ad hoc Collaborative Network (ahCN) be an implicit cognitive and social space. An ahCN is a finite set of four-tuple sets of actors or entities* $\{I, S, E, P\}$*, where* $I, P \neq \{\}$*. In a CMCg.I model, Internal Knowledge (I) and External Knowledge (E) are sets of pieces of knowledge derived from human expertise and experience. The Information Sources (S) is a set of pieces of information coming, arising or obtained from a person, thing or place. The Cognitive Solution Provider (P) is a set of entities that conceive and develop a Cg.S.*

It is important to note that:

- Information Sources are entities that interact to collect, organise, filter, process, generate, store, distribute and communicate data and information. Interaction occurs between users, processors, storage media and communication networks. The information usually comes from data clouds, repositories, databases. . .
- All *entities* and *actors* in the ahCN can be autonomous, geographically distributed and heterogeneous.
- The *entities* and *actors* work collaboratively to achieve the best common, compatible objectives, which guarantees the smooth functioning of the ahCN.
- The knowledge or expertise belonging to the actors, from different fields, are capitalised in the Cg.S after an *Agile Process of Innovation* (see Subsection 3.2.4 on page 45).
- The *Internal Knowledge* is considered as the basis of the solution and the *External Knowledge* is considered as the feedback of the solution and the influence, motivating the supplier to provide the best solution.

Figure 4.2 shows a general schema of the **ahCN**. More details about the *actors* and *entities* are provided in Section 2.3 on page 29.

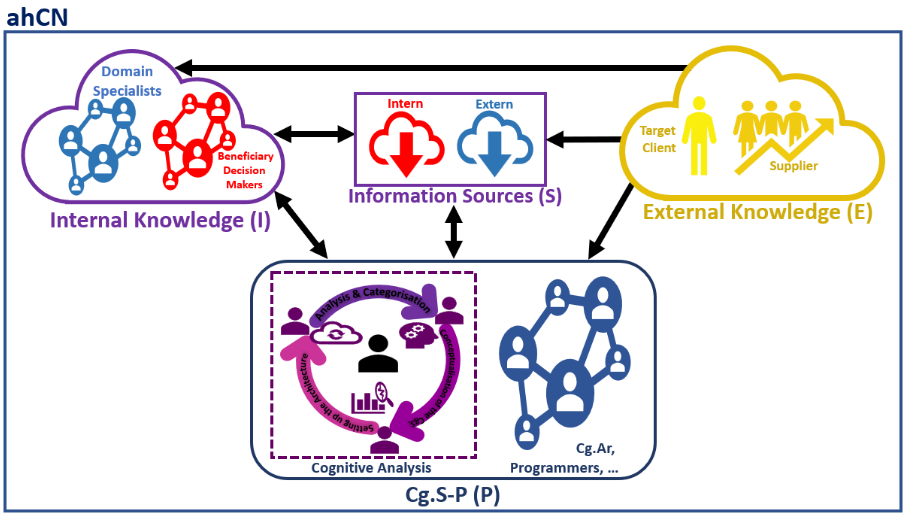


Figure 4.2: Schema of the Cg.Arch. The schematic shows the four-tuple sets of *actors* and *entities* that compose an **ahCN**: the *Internal Knowledge* (cloud on the left), the *External Knowledge* (cloud on the right), the *Information Sources* (rectangle in the centre), and the **Cg.S-P** (rectangle at the bottom in the centre with round corners).

4.2 Cognitive Architecture

An important component in the **CMCg.I** is the **Cg.Arch** itself, which has an **essential function**[2] in the **Cognitive Ecosystem** (**Cg.Eco**) (see Subsection 2.2.2 on page 19). **Cg.Arch** is a space for hypotheses that "form structures" employing the *actors*, *entities* and their interactions, which are embedded in the **Cg.Eco**. Such "structures" reflect the planning, designing and construction of knowledge, and the cognitive and functional structure that reflect behaviours which are considered intelligent. The core of the **Cg.Arch**, according to [20], is a *Semantic Base* established after a **Cognitive Analysis**, which, in turn, is the essential components set to design or enhance the **cognitive element set**[3] that should be present in the implementation of the **Cg.S**. **Figure 4.3** shows a general schema of the **Cg.Arch**, and its definition is as follows:

2: In short, the **essential function** of a **Cg.Arch** is to *design the cognitive blueprints* that are the firm basis for the implementation of the **Cg.S**.

[20]: Rosenbloom et al. (2016)

3: **Cognitive element** is an irreducible set of interrelated entities, definitions, rules or principles that contribute to the formalisation of a cognitive process.

> **Definition 4.2.1** *Let **Cognitive Architecture** (**Cg.Arch**) be an implicit space to fix the theoretical structure reflecting the planning, design and knowledge to support the **Cg.S**. A **Cg.Arch** is a finite two-tuple set of two sets one of semantic elements and another of cognitive elements $\{R, U\}$. In the **Cg.Arch**, part of the **CMCg.I** model, **Semantic Base** (R), is the set that contains the most significant partial or complete representations of relationships, knowledge requirements. . . , to assist in the definition of the components needed to support the solution and complement the Cognitive Element set. The **Cognitive Element set** (U), is a set of interrelated entities, definitions, rules or principles that contribute to implementing the **Cg.S**.*

It is worth noting that the *Semantic Base* set formalises the relationships between the concepts or terms and their attributes belonging to the **ISD** related to *the need* and its **Cg.S**. This knowledge must be made explicit by means of registration in some media, thus constituting **Explicit Knowledge** (**EK**). This allows for the *externalisation* of this *knowledge*, with the aim of achieving a consensus among

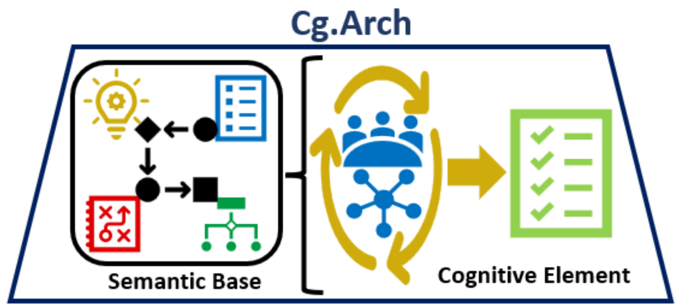


Figure 4.3: **Schema of the Cg.Arch.** The schematic shows a simple representation of the two main components of the Cg.Arch: a *Semantic Base* set (left square with round corners), which is the essential component to design or improve the set; and a *Cognitive Element*, of interrelated entities, definitions, rules or principles (list on the right representing the interrelation of the set elements).

the Cg.Eco *actors* and, consequently, minimising the *asymmetry* of the *lack of knowledge*. Therefore, this exercise allows *for the formalisation of the concepts* and *their relationships* as *pieces of knowledge*, and represents them as *convenient* and *useful* for the process of *obtaining solutions*. At the same time, it enhances the *representation of knowledge* as it facilitates the communication—by means of *graphical conceptual models*—of the *Semantic Base* set of the *domain*, as well as its validation. In cognitive transformation projects, it is common to encounter ambiguous and inconsistent domain terms, even after the *Semantic Base* set has been communicated. While **Domain Specialists** (DS) validate the concepts, a graphical conceptual model provides a comprehensive description of the domain knowledge, allowing errors to be identified and corrections to be made for a *functional* Cg.Arch design. This is essential for the successful implementation of a Cg.S. Drawing on more than a decade of experience supporting these projects, this book provides valuable insights for organisations moving into the CE.

4.3 Cognitive Solution Provider

The entry of the CE has caused this largely "digital world"—especially the world of organisations—to continually transform, demanding the provision of technology to enable timely adaptation or, at least, **survival adaptation**[4]. Therefore, the challenge for organisations to achieve a successful transformation is to integrate an innovative process that includes different analyses, studies, activities, services and solutions. The Cg.S-P facilitates this type of process by advising and accompanying those *who have a need for transformation* in the best possible way, making use of all available technologies, but always within the reach of its client (the Beneficiary). Therefore, the Cg.S-P offers advice, information and recommendations, which allows the Beneficiary to make the most appropriate decision in moments of indecision. Thus, the Cg.S-P is a *set of tech-sci actors* that include the Cg.An, the Cg.S Architect and *all the actors* involved in the Cg.S proposals that are offered to the Beneficiary. Figure 4.4 symbolises the Cg.S-P, and its definition is as follows:

4: For example, concerning the survival adaptation of companies, according to McKinsey, only 30 per cent of business transformations are successful, meaning that 70 per cent fail due to different situations that often occur during technology implementation.

Definition 4.3.1 *Let the Cognitive Solution Provider (Cg.S-P) be the one who proposes, designs, develops and implements the Cg.S proposals through a set of tech-sci actors (P) such that* $P = \{\text{Cognitive Solution Provider}\}, P \neq \{\}$. *In addition, some actors (or at least one) form the Cg.An team (set T) such that* $T = \{\text{Cognitive Analyst team}\}, T \neq \{\}$. *And, one of the Cg.An will perform the role of* *the Cg.S Architect (set A) such that $A = \{Cognitive\ Architect\}, A \neq \{\}$. Then, $A \subset T \subset P \lor A \subseteq T \subset P$. Such as $\exists!_x \in A \rightarrow x \in T \land x \in P, \exists_x \in T \land x \in P$.*

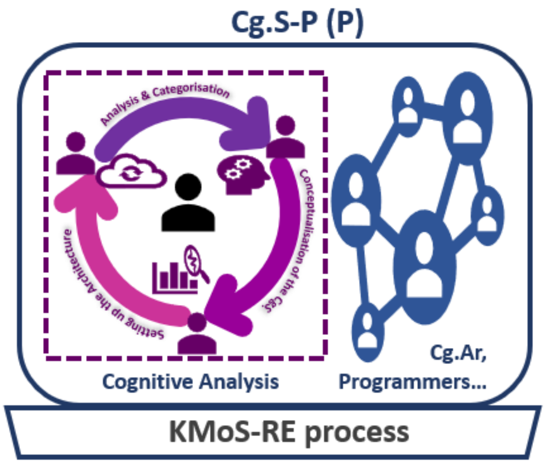


Figure 4.4: Image of the Cg.S-P. The Cg.S-P image symbolises the *set of tech-sci actors* with different specialisations playing different roles. On the left, the image highlights those who carry out one of its most important activities: the Cognitive Analysis. The right side shows all the *actors* as a whole. The lower part displays, as its main support, the systematic process for the support of knowledge requirements management performed by the Cg.S-P, called KMoS-RE, which will be introduced in Subsection 4.3.1 on the following page.

In general, the support strategy implemented by the Cg.S-P should enable all *actors* involved to understand the full picture of the situation of the person with a need or problem. First, the Cg.S-P must know the problem and assess the Beneficiary's state of digitalisation, as one is "more digital" than the other. Then, the Cg.S-P must orientate and propose *possible solutions* that the Beneficiary could take on to enable it to obtain better performance and productivity, or to at least survive. At this point, the whole process of achieving a Cg.S depends on the decision of the Beneficiary; therefore, the project can either end there or continue. The Cg.S-P must be aware that it does not have control or power over the Beneficiary at any point. However, regardless of its decision, the Cg.S-P must be able to count on all the necessary *actors* to cover a broad panorama of the situation. This can range from an analysis of the security and communication systems to more specific studies, such as the analysis of new technological resources and consequently implementing the solutions and integrating them into the service of the Beneficiary to solve its situation.

In brief, the mission of the Cg.S-P is to maximise the performance of the Beneficiary by using the Information Technology (IT) of the CE, and helping the Beneficiary to achieve its objectives through knowledge, automation and intelligent management of time and resources. The consultancy of the Cg.S-P must indicate the best way to carry out a transformation to the CE, and provide those who need to do so with the confidence that they will be accompanied in this transformation by a Cg.S-P who knows how to *innovate* and who has the following *knowledge*:

- *Conceptual*, i.e. the knowledge that sustains the domain—formal, theoretical and practical—design of theories, design of experiments, solution models. . .
- *Procedural*, i.e., knowing how. Knowing and having experience in procedures, processes, tools, technological implementations. . .
- *Strategic*, especially the one oriented to business success. To know and have experience in the tactics and tools to redesign a business, to set new strategic goals and to know how to work to achieve them.

Therefore, the Cg.S-P must engage in a good **cognitive dialogue**[5] to acquire

5: On the right side of **Figure 4.6** is the **cognitive dialogue** that the Cg.S-P (through the Cg.S Architect) orchestrates with the ahCN (especially with the Beneficiary), with those who have the expertise to implement solutions and with the DS.

knowledge, to be **well-informed**[6] and to carry out the professional work of assisting the **Beneficiary**.

6: **Figure 4.2** shows the sources of information that allow the **Cg.S-P** to enrich its knowledge and to keep itself **well-informed**.

Why support those who are facing a transformation that is so crucial to their future?

Many organisations in the most digitised countries already use a **Cg.S** to manage all aspects of their processes, from financial operations to procurement and security. But do these technologies not erect invisible barriers that prevent other businesses in less digitised locations from doing basic things like paying online and so on? Imagine a company that was founded before the Cave Era (see Section 1.1 on page 3) and never invested in modernising its processes and the technology that goes with them. This company is increasingly left alone, complaining that "all other companies are digitising, evolving and adapting at an ever faster pace" to the detriment of those that "cannot keep up". In short, this company is already part of an underclass that believes that, because the other companies have the latest computers and computer systems to do their daily payroll, they are in the modern age. They do not understand why it is increasingly difficult for them to perform the basic day-to-day functions of a company in a world which assumes that every company already has intelligent connectivity, and this leads to frustration.

As the last 5 years have passed, it has become increasingly difficult for organisations with technical problems to function normally. It is a fundamental question of fair competition and even technological discrimination—why has it come to a point where it is almost impossible to carry out common operations from a corporate mobile phone? In fact, more and more companies are becoming isolated from the digital revolution and, as time goes by, they will have to invest more and more resources, particularly financial resources, to join it. Sadly for them, they are finding it increasingly difficult to cope with the cognitive options that are becoming the new normal. A very clear example of this is the experience of financial institutions during the 2019–2021 pandemic, as they were forced to perform strong authentication controls on those banking or even shopping online, which excluded both businesses and individuals from a world they used to participate in daily.

This shows the vulnerability of many institutions with regard to the forced changes they will have to make to participate fully in the **CE**. So, how can they be helped? In order to achieve the mission and objectives of the **Cg.S-P** with a high probability of success, the **Cg.S-P** concentrates on the delivery of a good **Cognitive Analysis** supported by a *systematic process*, as communicated in the following subsection.

4.3.1 Knowledge management through a systematic process

To carry out **Knowledge Management** (**KM**) in an **ISD** environment, the **Cg.An** can be supported by the **Knowledge Management on a Systematic process for Requirements Engineering** (**KMoS-RE**) process to *elicit*, *analyse* and *knowledge-requirements representation*. In addition, it supports the configuration of the **Cg.Arch**, underpins the proposals of the **Cg.S** and is a facilitator of both the *innovation* and the *transition process* that would be performed by the **Beneficiary**. The **KMoS-RE** process can even be used intentionally to *enrich* the *collective knowledge*, i.e. that of all the *actors* involved in the development of the *proposed solution* and its subsequent implementation.

To provide the afore mentioned support, the **KMoS-RE** process fulfils *two series of actions*: the **Cognitive Analysis** and the **Knowledge Evolution Cycles** (**KE-Cycles**), which provide four specific outputs: a set of *Pieces of Knowledge*, a *Matrix of Expertise*, a *Belief Registry* and the *Solution Proposal* (see **Figure 4.5**).

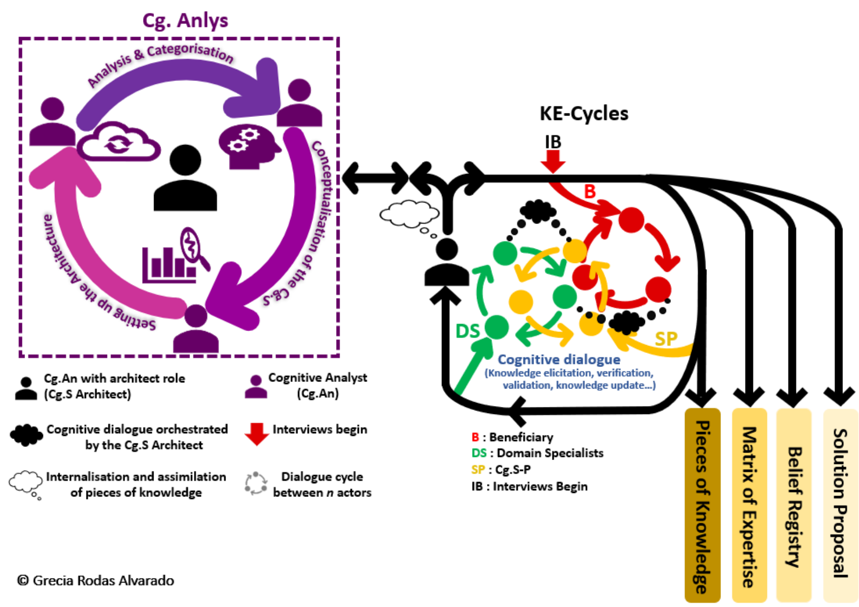


Figure 4.5: **Image of the KMoS-RE process.** The image of the **KMoS-RE** symbolises the *two sets of actions* that it performs: in the upper-left corner, the **Cognitive Analysis**, where knowledge is analysed to support the **Cg.S**; and on the right side, the **KE-Cycles**, where *knowledge* is emitted, *expertise* is monitored and *beliefs* are recorded.

The Knowledge Evolution Cycles

KM, driven by the **KMoS-RE** process, focuses on the **KE-Cycles**. This cycle contemplates the four iterative modes of knowledge conversion within the *SECI model* of knowledge dimensions [**nonaka1995**]:

nonaka1995

- *Socialisation* is the process of transferring **Tacit Knowledge** (**TK**) between individuals through the exchange of mental models and technical skills.
- *Externalisation* is the process of transferring **TK** to **EK** through the development of models, protocols, activities. . .
- *Combination* is the process of recombining or reconfiguring *existing* **EK** to create *new* **EK**.
- *Internalisation* is the process of learning through the repetition of tasks that make use of **EK**, and individuals internalise the experience by converting it into **TK** again.

However, these modes are adapted to work in an **ISD**, and to identify the *pieces of knowledge* necessary for the implementation of the **Cg.S**. The **KE-Cycles** (**Figure 4.6**), "in tune" with the **Cognitive Analysis**, can use the following types of knowledge processing:

- *Elicitation*: *Pieces of knowledge* are obtained especially from **DS**, as part of a process in which *socialisation* predominates, i.e. there is a *cognitive dialogue*.
- *Verification*: The *pieces of knowledge* are verified with all of the *actors* involved in obtaining the solution. It is mandatory to verify them with the **DS** and the one *who has the need or problem*. Moreover, all communication is used to distinguish if there are more needs, or if adjustments have to be made to the identified needs. This activity is complex since it *externalises the knowledge*, trying to find *agreement*, and if there is *agreement*, a process of *assimilation of the domain knowledge* takes place.
- *Validation*: All of the *actors* involved in the implementation of the solution validate the models and proposals generated. By carrying out this activity, everyone *assimilates the knowledge* behind the models and, consequently, the *collective knowledge is increased*.
- *Knowledge update*: All of the activities of each *cycle of dialogue* between all of the *actors* promote the *exchange and updating of knowledge*.

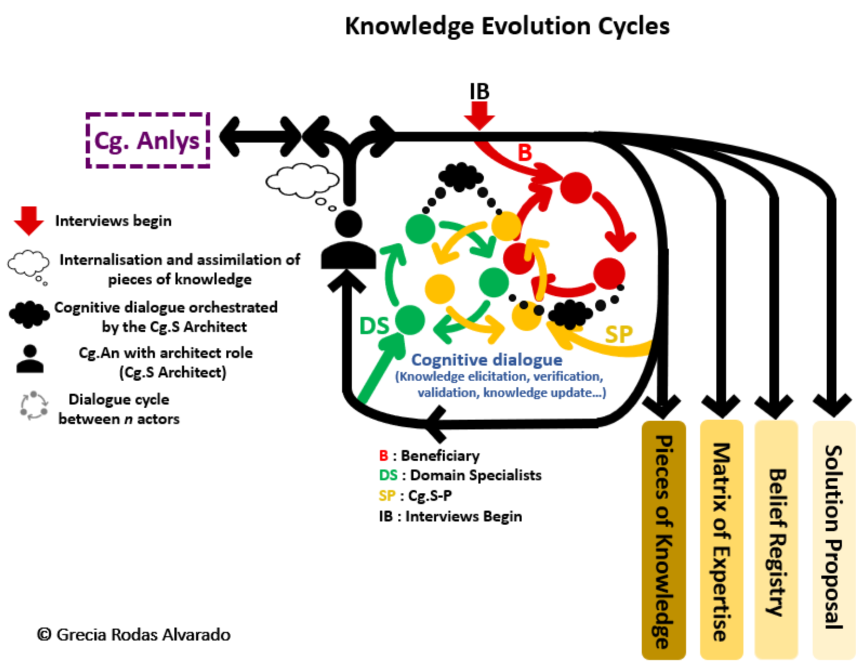


Figure 4.6: **Figure of the KE-Cycles.** The **KE-Cycles** figure communicates that activities can take place in an empathetic environment during each cycle. These activities, focused on the transformation from **TK** to **EK** and vice versa, are orchestrated by the architect (human icon in black) in order for the *actors* involved to obtain the **Cg.S**, therefore, these cycles (arcs in a closed circle) correspond to the *cognitive dialogues* (clouds in black). The **KE-Cycles** produce at least four outputs: knowledge, expertise relationships, belief registry, and solution proposals. The **KE-Cycles** formally start with the first recorded interview with the **Beneficiary**. Cycle work is carried out until a solution proposal is validated by the **Beneficiary** for implementation.

The Cognitive Analysis

In Subsection 2.2.4 on page 24, it was reported that, in order to carry out a good **Cognitive Analysis** (as shown in **Figure 4.7**), it is necessary to achieve empathy with the *person who suffers* and who has a problem or need within the framework of the so-called **CE**. In the **KMoS-RE** process, empathy must be achieved by working through the **KE-Cycles**. Once empathy with the **Beneficiary** has been achieved, a process of elicitation of requirements is initiated. These are classified into functional and non-functional requirements, and the non-functional requirements will be integrated into the set of **Suitable Knowledge Requirements** to subsequently propose and, if necessary, carry out the implementation of the **Cg.S**. It is convenient to bear in mind that functional requirements express the functions and actions that the Cg.S provides to those who interact with it, and that the non-functional requirements are used to express the attributes of the Cg.S. Therefore, performing a good Cognitive Analysis minimises the risk of delivering a *quasi-solution* or the risk that the cost of implementation exceeds the budget.

Figure 4.7: Image of the Cognitive Analysis. The image of the Cognitive Analysis symbolises the various activities linked to the analysis, architecture and conceptualisation. These activities are carried out in work cycles with each Cg.An, and orchestrated by the Cg.S Architect.

The main objective of the work carried out in the Cognitive Analysis is to define *proposals* for a Cg.S. In other words, in the Cognitive Analysis, the needs of, for example, a company are compiled in order to provide solutions. For this purpose, an internal study of the company's current situation and the problems it is already facing has to be carried out. The study starts with a direct interview with the person who has the problem or needs. Subsequently, there will be as many interview sessions as necessary with all of the *actors* involved in the search for the Cg.S and its implementation, especially the DS. As shown in Figure 4.5, all interviews are activities of the KE-Cycles. All information collected is recorded and analysed by a team of Cg.An led by the Cg.S Architect. Using *categorisation* tools, *pieces of knowledge* are identified and used to build explanatory models of the company's current situation, which are then validated in the KE-Cycles. Working on the solution of problems or needs that belong to the ISD implies that this will be arduous and complex; therefore, the Cognitive Analysis requires discipline, constancy, formality and patience. Each time a model is communicated for validation, the company assimilates what needs to be improved and what needs to be solved. The feedback gathered by the Cg.S Architect comes from all of the *actors*, and all the members of the team of Cg.An work together to *conceptualise* the Cg.S. In addition, the Cognitive Analysis will help the Cg.An to identify the components of the Cg.Arch (Section 4.2 on page 53) that will support the *proposed solution*. This is very important because when the Cg.Arch is formed, it is possible to carry out the *prototyping* of the Cg.S. Experience has shown that a *prototype* keeps the empathy with the Beneficiary at a high level (or increases it if the empathy is low) and provides a preview that helps the recipient in his/her decision making (see the Appendix D.5 on page 205 for more information on prototyping). This type of Cognitive Analysis also elicits functional requirements, and it is important not to get carried away with functionalities that, although they may seem interesting, are not necessary for the current and future functioning of the company.

To summarise, defining **Cg.S** proposals needs to be supported by **Cognitive Analysis** with regard to:

- Definition of the desired cognitive and functional aspects of the **Cg.S**.
- Adequate and complete description of any **Cg.S**.
- Keeping all parts of the process and *possible-solution proposals* unambiguous.
- Accurate definition of every aspect of the behaviour of the **Cg.S**.
- Accurate communication of the desires, needs and problems of the **Beneficiary**.
- Identifying the components of the **Cg.Arch** and configuring it.

KMoS-RE process synthesis

When a **KM** process is to be carried out, the following considerations are taken into account:

- All *actors* are involved in the implementation of the **Cg.S**; this is mandatory for the **Beneficiary**, the **Cg.An** and the **DS**.
- The **Cg.An** also acts in the role of **Cg.S Architect**, and will orchestrate the whole process from the beginning to the release of the **Cg.S**.
- The **Cg.S Architect** will establish a strategic plan that will accomplish each phase necessary to implement and release the **Cg.S**.

Next, the **Cg.S Architect** guides the project by relying on the **KMoS-RE** process, indicating the particular actions to be carried out for each project according to its nature. But, in general, the actions achieve the following:

1. **Cognitive Analysis**. General modelling of the domain through a set of models—linguistic and graphical—that are particular, simple and represent each aspect of the **Beneficiary**'s needs. Any type of model can be used, but it must adequately represent the situation. All models should be communicated and validated with all of the *actors* involved in the development of the proposed **Cg.S**.
2. Strategic plan. The **Cg.S Architect** must clarify what is to be achieved and how to achieve it. This must be set out in a consensus document where the major decisions that will guide the progress of the project are specified. In other words, a map should be drawn up that outlines the actions to achieve the vision of what the **Cg.S** should be—trends, goals, objectives, rules, verification and results—always keeping in mind the strategic objectives and authority and power of the **Beneficiary**.
3. Establishing the knowledge essential for the implementation of the **Cg.S**. The **Cg.An** must elicit, discover, structure and enrich knowledge to facilitate the implementation of each approved **Cg.S** proposal.

Four activities are highlighted below, which are frequently carried out in addition to the above *actions*:

1. Identification of *pieces of knowledge* for elicitation. Based on an *analysis of the cognitive dialogue*, the aim is to identify *pieces of knowledge* that are hidden behind "linguistic traps", such as presuppositions.

2. Assessment of the *level of specialised knowledge and expertise*. The **Cg.An** must integrate into a *matrix* the level of familiarity, skill and experience of each *actor* who is a specialist (or who possesses the expertise) and who participates in the project. This level links each *piece of knowledge* identified with these *actors*. It thus provides certainty, trust and communicates—even if only partially—how much *collective knowledge* is possessed, and how it is distributed among these *actors*, to be taken as a basis for the implementation of the **Cg.S**.
3. *Belief Registry*. A record is kept of false assumptions or beliefs, that have been treated as knowledge or expertise. This record facilitates learning for the *actors* who are neophytes but must participate in the project. The **KMoS-RE** process (**Figure 4.5**), starts with an initial interview between the **Cg.S Architect** and *all knowledge holders*, meaning those who have the need or the problem and those who are obliged to participate in it. A **Cognitive Analysis** is then initiated, which continues to identify *pieces of* **TK**, and the *level of knowledge* of who they come from is assessed and beliefs are recorded. In the **Cognitive Analysis**, periodically, each activity carried out (e.g. an integrated model) is validated. Subsequently, the continuation of following activities is determined, or what has been obtained at the moment is perfected. Each *validation session* is a *learning experience* and, therefore, an *evolution of knowledge*. Here, everything that has been achieved in the stipulated timeframes is communicated, and the models are explained. After each communication, the already *validated pieces of knowledge* are assimilated and, as a consequence, *collective knowledge increases* and the cycle starts again.
4. *Validation of the solution proposal*. The proposed solution made during the **Cognitive Analysis** is communicated to the **Beneficiary** for the decision to accept it, send it for modification through another cycle of the **Cognitive Analysis** or reject it.

4.4 Cognitive Solution

What is a solution? In the **CMCg.I** context, a *solution* means solving the situation, problem or need of an individual or organisation, i.e. the **Beneficiary**. The solution is achieved by using the experience, expertise and talents of a highly specialised team of people (**Cg.S-P**). The **Cg.S** arises from the **CMCg.I** used by the **Cg.S-P**, which is supported by the **Cg.Arch** that works in a *systematic process* to provide the **Cg.S** to the problem or need. The **Cg.S** drives the current generation of intelligent machines that collaborate with humans to perform broader tasks in the service of humans; these are *solutions* that facilitate self-learning by leveraging learning models, business intelligence, **AI**, **IT**. . . Immersed in an **ISD** with information that grows exponentially, with technology that advances daily, companies are looking for help to take advantage of the information and make better decisions based on this information. Thus, a **Cg.S** is a set of products that can consist of software (or a lack thereof), services and processes. These products are *solutions* within a wide range of types, but all of them are designed to satisfy specific needs, and to help those who have a problem with the **CE** to solve it successfully or to face a complicated situation in the best possible way. **Figure 4.8** illustrates the Cg.S, and its definition is as follows:

Definition 4.4.1 *The* ***Cognitive Solution*** *(Cg.S) is the value-proposition already implemented as at least one solution from the possible outcomes of the Agile Innovation Process. Thus, let* ***possible outputs*** *be a finite set of three-tuple sets of entities* $\{G, F, M\}$ *corresponding to the sets of* $G = \{$***Goods or Products***$\}$, $F = \{$***Services***$\}$ *and* $M = \{$***Processes***$\}$. *There is an x which is an* ***Implemented Cognitive Solution***: $(\exists_x)(x \in (G \vee F \vee M))$.

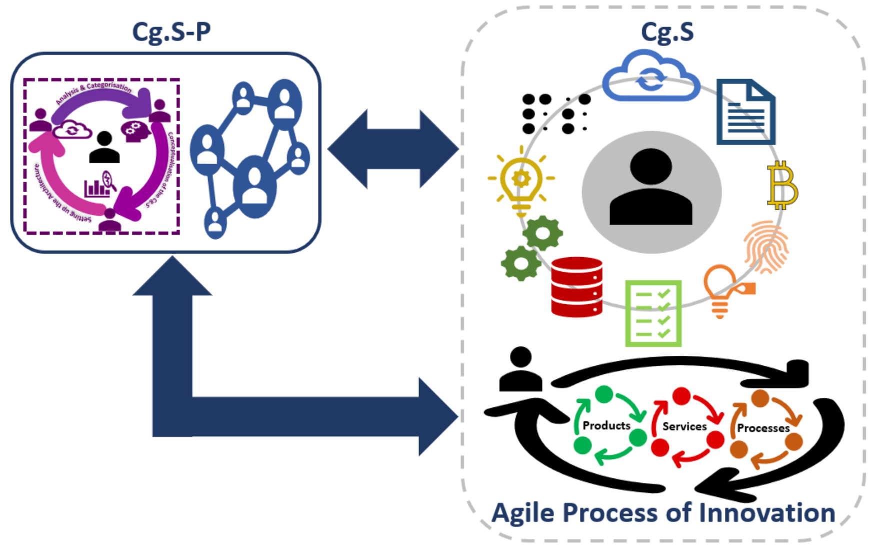


Figure 4.8: Figure of the CgS. In the lower right corner, an Agile Cognitive Innovation Process is distinguished. It generates three outcomes: products, services, and processes. The outcomes have fuzzy and decentralised boundaries. Therefore, the point of convergence is their dependence on organisational knowledge and cognitive processes, which are represented by circular cycles formed by arcs. The outer cycle around the results of innovation, which can be endless, are derived from the Cognitive Analysis, the Cg.Arch and the Cg.S implementation and evaluation. The upper right section exemplifies a variety of possible proposals for typical *solutions* in the CE. In particular, Cg.S implementation includes conceptualisation, Cognitive Analysis and implementation and validation of each Cg.S. Each Cg.S can feed back and generate changes in all processes or activities of the Cg.S-P.

Each Cg.S arises from the *conceptualisation* of a specific proposal for a particular domain, supported by a Cg.Arch that has a *Semantic Base* set containing the most significant formal representations—partial or complete—of the knowledge of those who have the need or problem (e.g. an organisation). The *Semantic Base* set must be a faithful reflection of the *elicited knowledge* of those who know all the processes, activities and tasks of the organisation, because, even if there are few misconceptions, these can be a major problem regarding the implementation of a Cg.S.

The process that the Cg.S proposal provides is initiated by the Cognitive Analysis. It can accelerate the *evolution of knowledge* in any organisation because of the ease of acquiring, analysing and interpreting information and transforming it into knowledge. Experience indicates that organisations that have implemented cognitive solutions under this scheme—consciously or unconsciously—enter a dynamic of constant transformation where knowledge evolves rapidly and surpasses the traditional ways of managing it. Today, the process of designing and implementing products and services requires specialised knowledge that is difficult for a single person to possess. Therefore, organisations need to obtain it, wherever it is located, for the achievement of the process, as KM and its proper use are a must to survive in the CE. It may sound simple but, in a Cg.Eco, there are obscure parts that generate uncertainty because the knowledge there is *tacit* and *non-homogeneous*. This knowledge is held by DS and, to a lesser extent, by *external actors*, such as customers and suppliers. In addition, organisations always have diverse sources of information that must be considered. Even the expertise and knowledge of the **Cg.S-P** must be included. As a result, all these sources of knowledge and information become an **ahCN**. Within the **Cognitive Analysis**, the **ahCN** participates by evaluating each singular need, each edge of a business, each product, each service and its market, and elicits *pieces of knowledge* necessary to establish the **Cg.Arch**, which is the support for each **Cg.S** that is to be built. Consequently, it is easy to perceive that the process to implement the **Cg.S** is extremely arduous, and must be orchestrated by one or several *actors* who assume the responsibility of coordinating the project. A leader with a broad vision of technology trends in the **CE**, with knowledge and skills in business management and the capability of orchestrating this innovation dynamic (i.e. a **Cg.S Architect**) is needed. Generally, a **Cg.An** plays the **role**[7] of **Cg.S Architect**, and is the one who obtains knowledge through a **Cognitive Analysis**. As a **Cg.S Architect**, he/she must drive the conceptualisation of a **Cg.S proposal**[8], which, in turn, accelerates the organisation's entry into the **CE** through the improvement or development of new products, services and processes. In short, a **Cg.S** is the result of the implementation of one of the proposed solutions. A *proposal* conceptualised from a **Cognitive Analysis**, supported by the **Cg.Arch** and as a result of an *Agile Innovation Process*.

7: **Figure 4.5** & **Figure 4.8** may give a slight idea of the dynamics of the **role** of the **Cg.S Architect** (human icon in black).

8: **Figure 4.8** gives an idea of what can be achieved with the implementation of a **Cg.S proposal**, and under which product category. . .

4.4.1 Agile innovation process

The highly dynamic and constantly changing world and its markets demand that innovation is present in products and services to differentiate them from the competition. Furthermore, these products and services must be designed and implemented through *agile processes*, and not be susceptible to continuous and constant changes and adjustments. This is in order to free up time for all of the *actors* in the process to focus on activities that allow them to "agile find" new products, services, internal processes or make adaptations or updates to existing ones. Think of a company that intends to venture into the **CE**. Such a company, in analogy to medical issues, would need a complete health check-up, which, among all the studies, should include a "full X-ray + Computed Tomography scan + Magnetic Resonance Imaging scan" of the customer's environment or its **ISD**. Why? Because it is necessary to identify areas of opportunity, as well as to know the products and services to be able to clarify and be assertive with regard to the client's vision and objectives. The **Cg.S Architect** would be in charge of this "complete check-up", and the company should be aware of the intangible good that it will result in. From the moment it is being configured, the **Cg.Arch** offers the company contents and tentative activities to be carried out. It should be noted that, at the beginning, it is impossible to detail all of the components of the **Cg.Arch** down to the minimum, since an **ISD** is largely unknown and, in the same way, the end of the process is relative since it would depend on the satisfaction of the company. As the environment of a company in the **CE** is very dynamic, the **Cg.Arch** and thus the **Cg.S** can/should change and adapt, i.e. innovate. The concept of *agile innovation* implies an organisational culture prepared with the necessary technological architecture to be at the cutting edge, but also with the right mindset to assimilate the exhausting challenge of permanent change. In other words, it is no use having an environment full of cutting-edge technology when the organisation's mentality is still anchored in past paradigms of working in silos, focused on particular objectives and leading profiles.

Finally, the expertise in the implementation of a **Cg.S** indicates that *innovation is implicit*—even if only marginally—and accelerates the *cyclical process of innovation*, whose impact can take the form of the improvement of products, services or processes or the generation of new ones.

4.5 Chapter summary and reminders

This chapter has revealed that the **CMCg.I** must always be analogous to the changes that are taking place. In this sense, the **CMCg.I** is similar to the reality of the **CE** (to a certain degree) but it allows the user of the **CMCg.I** to derive *solution proposals* that can be *prototyped* and *tested*. In this chapter, the main components, such as the **ahCN**, **Cg.S-P**, **Cg.Arch** and the **Cg.S**, were reviewed. Thus, it can be seen how the **CMCg.I** is *suitable* for the *essential representation* of those *components*, *entities*, *actors*, *processes* and *activities* involved in reaching a *proposed solution* for subsequent *implementation* in a **CE** where **ISD** exist everywhere. The use of the **CMCg.I**, through **case studies**[9], has allowed it to be enriched and fine-tuned, while always managing to successfully support the **Beneficiary**. That is why, in this book, whose main objective is the dissemination of knowledge, case studies have been selected to illustrate situations that have been addressed through the use of the **CMCg.I**.

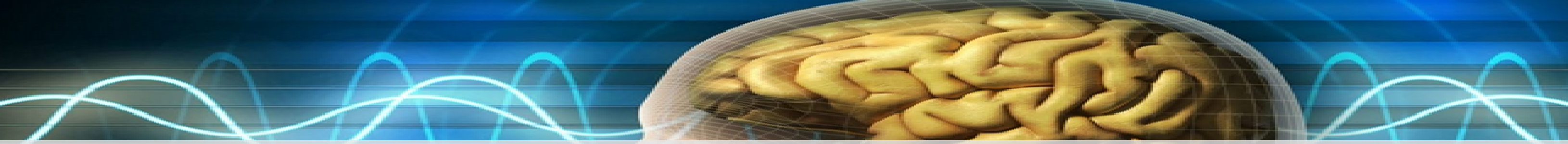
9: A **case study** is a research methodology used to investigate a complex phenomenon or detailed examination of a particular case—or cases—within a real-world context. It is used in a wide range of sciences and disciplines to describe and analyse the complexity of single or multiple cases in their specific circumstances.

Part II

Interesting cases and concluding remarks

List of Figures in Part II

List of Tables in Part II



5 Non-Technological Cognitive Solution in the Domain of Electroconvulsive Therapy

This chapter communicates, the use of the **Conceptual Model for Cognitive-Innovation** (**CMCg.I**) to formally develop a **Cognitive Solution** (**Cg.S**) that meets the needs of a **Beneficiary** in the domain of **Electroconvulsive therapy** (**ECT**). This case is particularly interesting because the **Beneficiary** was also the leader of the **Domain Specialists** (**DS**) team. The challenge was to find a way to support the **DS** in optimising the management of **ECT**, and make it more efficient to reduce the negative side effects of memory loss for patients receiving **ECT**. In addition, this chapter will highlight the actions, activities and process involved in achieving the **Cg.S** for this particular case.

5.1 Background on the ECT case

An interesting field of psychiatric study concerns therapies for various severe and treatment-resistant psychiatric disorders, such as major depression or schizophrenia. The ECT is used worldwide as a safe, effective, rapid, valuable and widely used treatment for patients with major depression, bipolar disorder and psychosis. ECT is a biological treatment procedure that involves the brief application of an electrical stimulus to produce a generalised seizure appropriate to the therapeutic response and improve the psychiatric condition, which, for example, in the case of intractable catatonia and neuroleptic malignant syndrome, could be life-saving. For patients who do not tolerate or respond poorly to medications and who are at high risk of drug-induced toxicity or toxic drug-drug interactions, ECT is the safest treatment option [21]. Even in certain conditions associated with neuropsychiatric disorders, such as parkinsonism, dementia and stroke, ECT is effective. Efforts are currently underway to optimise the use of ECT and, in synergy with other biological and psychological treatments, to reduce the intensity of side effects, and prevent relapses and recurrence of symptoms. However, several of the brain's biological events related to its efficacy are still unknown. The physiological response to ECT has been studied through heart rate, blood pressure, electrocardiogram effects, cardiac enzymes, electroencephalogram effects or hormonal response. However, for the time being, there is no formalised technique applied to this therapy, and one interesting avenue is the study of the neuropsychological effects of ECT on psychophysiological parameters such as reaction, decision or motor times. These effects are cognitive changes related to orientation, attention and calculation, memory loss and recall [21]. Therefore, the objective is to advance in the identification of the factors that provoke them, have a direct influence on the cognitive state of the patient, and analyse the effect on reaction times related to visual and audible stimuli after the application of an ECT.

[21]: Rodas-Osollo et al. (2022)

[21]: Rodas-Osollo et al. (2022)

Studies in similar situations in psychiatry, neurology or various areas of medicine have examined everything from simple comparisons of treatments to longer-term effects or pre-post responses to various treatments or medications. Increasingly, there is a need to detect more subtle or domain-specific effects that introduce additional complicating factors. In these situations, condensing the time series data into a summary statistic can simplify the analysis by eliminating the time element. This approach of using summary statistics does facilitate clear communication of the main findings both in simple terms to the public and with a full report of individual responses to the scientific community. But, the graphical presentation of time series data in a line graph does not allow for easy plotting of individual or paired responses. Measures of central tendency can illustrate group effects in graphs and figures. However, individual responses to each experimental condition are being presented, which remain "invisible", especially when sample sizes are small and do not facilitate the critical evaluation of the data [21].

[21]: Rodas-Osollo et al. (2022)

5.1.1 Data description

In this case study, 183 patients with major depressive disorder or schizophrenia were followed, according to the **ICD-10**[1] research criteria and the **DSM-5**[2] criteria for the ECT was indicated, and which gave their written informed consent for the study and to submit to the ECT. Information on the main characteristics of the patients is available, including conditions, somatic state, routine haematological and biochemical tests, chest X-ray, electrocardiograms, history of abuse or dependence on alcohol or other drugs, anaesthetic risk, comorbidities, age, weight, education. . .

1: The ICD-10 consists of a clear set of criteria and lexicons to provide definitions of terms of mental and behavioural disorders. In addition, assessment tools support the classification of disorders according to the criteria included in Chapter V (F) of the Tenth Revision of the International Classification of Diseases and Related Health Problems (ICD-10).

2: The DSM-5-TR is the Diagnostic and Statistical Manual for Mental Disorders, Fifth Edition, Text Revision. This version includes new diagnostic types, clarifying modifications to previous sets of criteria, the addition of the International Classification of Diseases (ICD-10) symptom codes for certain behaviours and descriptive updates for most disorders. This manual helps clinicians and researchers define and classify mental disorders, which can improve diagnosis, treatment and research.

The present standard practice optimises the therapeutic relationship in the selection of the parameters of the electrical stimulus such as the energy level, duration of the stimulus, pulse width and pulse frequency. Also, multiple patient responses are monitored by electroencephalogram, electrocardiogram and electromyogram, including a rigorous evaluation of the neuropsychological effects of the patient. For the measurement of psychophysiological parameters, the **Vienna Test System (VTS)**[3] was used at 2, 4, 6, 12 and 24 hours after each application of an **electroshock (ES)**[4]. The *VTS* assesses the ability to react to various stimuli by measuring *reaction time* (*RT*) for both single-choice and compound-choice reactions. Different modes of light and sound stimuli are available, with a choice of red, yellow or white, so that different combinations of stimuli can be created simultaneously or sequentially for reaction time measurement. The *VTS* provides eight test forms:

3: The Vienna Test System is a testing system for computerised psychological assessments. The *VTS* allows digital psychological tests to be administered and, at the same time, provides automatic and comprehensive scoring. It includes classic questionnaires and tests that can only be scored by a computer, such as time-dependent test presentation, multimedia presentation, adaptive testing, psychomotor skills, test combinations for specific purposes (test sets) and differentiated scoring of individual responses.

4: An electricshock, or electrocution, is when electricity runs through your body.

S1: Simple reaction, yellow – reaction to critical stimulus
S2: Simple reaction, tone – reaction to critical stimulus
S3: Choice reaction, yellow/tone – reaction to critical stimulus combination
S4: Choice reaction, yellow/red – reaction to critical stimulus combination
S5: Choice reaction, yellow/tone, yellow/red – reaction to critical stimulus combination
S6: Simple reaction, white under monotonous conditions
S7: Measurement of alertness – simple reaction, yellow (with acoustic cue)
S8: Measurement of alertness – simple reaction, tone (with optical cue)

The use of a rest key and a reaction key makes it possible to distinguish between reaction time and motor time. The main areas of use are those in which reaction times are measured, such as traffic psychology, personnel psychology (safety assessments), sports psychology and psychopharmacology. In recent years, the use of reaction time measurements has also increased in neurology, psychiatry, rehabilitation and occupational medicine. The way to interact with the *VTS* is that respondents react as quickly as they can to optical or acoustic signals. This involves pressing or releasing a button as quickly as possible when a simple light signal (yellow or red light), a tone or a combination of two stimuli (yellow and tone or yellow and red) is presented. The following measures were recorded for this particular study: erroneous decisions, erroneous reactions, absence of reactions, incorrect reactions, correct reactions, decision times, driving times and reaction times [21], and these measurements were made for four specific tests: simple visual (e5: S1), simple auditory (e6: S2), complex visual (e7: S4) and complex visual-auditory (e8: S5).

[21]: Rodas-Osollo et al. (2022)

5.2 Integrating the CMCg.I model into the ECT domain

Sometimes, the beginning of model integration is very diffuse and informal because it can start from the first time a person or organisation—an entity with a **Cognitive Era** (**CE**) problem—comes for help, so it is essential to be prepared to capture as much detail as possible. This may mean a meeting where several members of the **Cg.S Provider** (**Cg.S-P**) set are present to get different views and perspectives on the problem, recording the session for later analysis,. . . The number of sessions before the formal start of the work for the project will depend on the nature of the problem and the experience of the **Cg.S-P**.

What is it important to get out of the meeting(s)? It is important to gather sufficient information to understand the need that is to be met, and to determine whether the **Cg.S-P** team can, promptly, find a suitable solution. To carry out a **Cg.S** project means to always keep in mind that it is a big project; therefore, it is necessary to act with humility when the **Cg.S-P** does not have the knowledge, experience and technological infrastructure to offer the suitable satisfiers to the present need. Consequently, it is valid to say NO to the realisation of a **Cg.S** project. But, assuming that the experience and infrastructure are in place and if it is determined that the project will be formally initiated, it will not start from scratch. All previous sessions, at the time of the YES, are project progress, especially concerning the activity of gathering information and knowledge.

5.2.1 Pre-session before the start of the Cg.S project for the ECT domain

What is related to the pre-session, or pre-sessions, is communicated in this chapter, and is only based on some important facts and sayings provided by the *one who has the need*. Firstly, in the case of the **ECT**, *who has the need or problem* is a person from the medical profession. This doctor has a speciality and a doctorate in psychiatry, as well as another doctorate in **Artificial Intelligence**. This is important to bear in mind because he is the one who is profiled to be the leader of the **DS**.

After the "handshaking", the interview begins to define their motives, needs and "pains". The **format of the interview**[5] is free and depends very much on the experience of the **Cg.S-P**. At the end of this pre-session, the team of the **Cg.S-P** will take the **necessary time**[6] to determine the YES or NO, times, forms, budgets,. . . During this time, the **Cognitive Analysis** starts, working with the recording made in the session and the information captured by the equipment of the **Cg.S-P**. This particular **Cognitive Analysis** has been worked out by distinguishing verbs, actions, terms and phrases used by the person in need and considered as being important.

5: Nowadays, fortunately for those who start in this work, the internet already offers, even for free, many **format of interview** suggestions via the internet search engine of preference.

6: This **time** will vary depending on the nature of the problem and the experience of the team of the **Cg.S-P**.

How do you make the distinction? By listening to the recording several times and paying attention to the number of times some of these verbs, terms,. . . , are repeated, as well as the emphasis or intonation with which they are delivered. When these distinctions begin to emerge, a list is made and based, for example, on **Bloom's Taxonomy**[7], and a classification is made to rank the cognitive processes at different levels associated with the actions, present activities, possible future activities and even possible desires of the person with the problem. Each present level of the hierarchy can be used to realise the objectives of the **Cg.S**. It is necessary to remember that this kind of activity of gathering information or knowledge, analysing it and making decisions is a process involved in an *evolutionary cycle*. This cycle will be present for a good part of the time it takes to realise the project. Generally, based on experience, the preliminary part takes between one to two sessions of interview(s) and discussion(s) with whoever needs to gather the information necessary to make a decision; but, this is not a rule!

7: The Bloom's Taxonomy is a model that describes the cognitive processes of learning and developing mastery of subject.

After analysis of both the first recording and the hierarchy of terms in the constructed list, it was determined that the *person needed knowledge*. Logically, the frequency with which the phrase "need to know", "need to be informed" or "should know" came up in the interview was very high. Furthermore, it was determined that the person in need had sufficient external and internal information to characterise the explicit part of the problem but not enough to offer a solution. There was frustration on the part of the **DS** because they had too much data about the therapy, its application and the patients to make a good statistical analysis, but it did not yield results that the **DS** could use to satisfy they need. The **DS** had the "hunch" that by doing something different, something innovative, they could find the determining parameters for the desired optimisation of the therapy.

Why was they so interested in **ECT**? Contrary to popular belief, **ECT** is very safe, but it is a very expensive therapy and has the serious side effect of memory loss. It was therefore very desirable for the **DS** to find out how to optimise the therapy; the fewer but more effective applications of the therapy, the greater the cost savings and the lesser the side effects. It was clear that finding a way to optimise the therapy would require not only the *specialist's data* but also the *knowledge* of the **DS**.

In summary, it is clear that this problem is embedded in an **Informally Structured Domain** (**ISD**) and is directly related to the **DS** *experience and knowledge* of data derived from their research, and that it was going to be necessary to do something different to find the parameters that would allow them to optimise the **ECT**. Finally, it was concluded that it was possible to offer the necessary knowledge to the **DS** to identify the desired parameters as a solution. What is mentioned in this subsection is summarised, expressing only facts and decisions, but in the background there were a lot of working hours that went into getting the **Cg.S-P** team and the *person in need* to say YES to the adventure of this project. It is worth clarifying that from the moment of the YES, the integration of the model formally begins and the *person*, *organism* or *entity* that has the *need or problem* is treated as the **Beneficiary**.

The integration of the **CMCg.I** model is orchestrated by the **Cg.S Architect** who, together with the **Cognitive Analysts** (**Cg.An**) team, formalises the *components* of the **model**[8]:

- **ad hoc Collaborative Network** (**ahCN**)= {I, S, E, P}
- **Cognitive Architecture** (**Cg.Arch**)= {R, U}
- **Cg.S-P**: P= {Cognitive Solutions Provider}, T= {Cognitive Analyst team} and A= {Cognitive Architect}.
- **Cg.S**= {G,F,M}

8: The **model**, the model components and their formal definitions are described in detail in Chapter 4 on page 51.

The main task carried out by the **Cg.An** team, from the first formal work session with the person with whom the problematic situation occurs, is the identification of the necessary components to support the **Cg.S** (see **Figure 4.1**). It is necessary to remember that identification does not mean "to take a look", but to carry out activities or actions to examine *entities* or *actors* and to know their identity, nature, characteristics, potential, circumstances. . . , in order to provide adequate support to implement a solution promptly. Therefore, the components necessary for success can be modified as many times as necessary during the **Cognitive Analysis** and implementation time. Is the possibility of modifications a disadvantage? No. On the contrary, when working on a problem embedded in an **ISD**, as introduced in the previous section, the solution is particular and the aim is to work the activities, actions and process—that are part of the model—until the **Beneficiary** is satisfied.

5.2.2 Identification of all ad hoc Collaborative Network components

First, it is desirable to identify as much of the **ahCN** as possible. Projects of this type often require changes in all components over their lifetime. For the **ECT** domain situation, most of the *actors* or *entities* of the **ahCN** *component* were identified in fewer than ten working sessions. An extract of the **index matrices**[9] of the **CMCg.I** *model components* can be seen in the **Table 5.4** set.

9: The **Table 5.4** set shows an extract of the **index matrices** that have identifying information of the *entities* and *actors* corresponding to the **ahCN** component. As each **Cg.S** is particular, the matrices will have the necessary information to be functional, and this may vary from project to project. Matrix (I) has information of *pieces of internal knowledge*; i.e. their labels, their description, in which repository they are found, the source from which they were explicitly stated. Equivalently, matrix (S) communicates the *pieces of information*. Matrix (E) deals with *external knowledge pieces* and matrix (P) contains the identification of who the **Cg.S-P** is.

In this particular case, the **Beneficiary** was also the leader of the **DS** team. This situation allowed for faster decision-making and many components of the matrices to be identified quickly. The **Beneficiary**, in his/her dual role, was the one who signalled which other *specialists* he/she was going to work with. He also provided a good deal of additional information from his research and work with patients (see **Table 5.4** matrices I, S, E and P). It is necessary to emphasise that, although the information in the matrices is subject to change throughout the project, it is important to fill in as much as possible from the first formal working session as it gives certainty about the work to be done.

5.2.3 Building the Cg.Arch

For many projects, the **Cg.Arch** may be the most important part of the project as it is the one that provides the knowledge support for solutions that include technological development. For non-technological solutions, **Cg.Arch** is the one that motivates acquisition of the knowledge necessary to satisfy the need or solve the problem of the **Beneficiary**.

In the case of **ECT**, building the **Cg.Arch** implied carrying out the hard work of **Cognitive Analysis**, as well as the statistical analysis of the information provided by the **DS**, and the particular treatment of information through the *Knowledge Discovery in Serial Measures (KDSM) methodology* for the *discovery of knowledge where serial measures* are present. This is in addition to the representation of the *pieces of knowledge* for adequate communication with the **DS** set. Therefore, performing the activities and actions to build the **Cg.Arch** meant, in this case and for practical purposes, building the solution to the problem posed by the **Beneficiary**. The following sections communicate only the most relevant aspects of the **Cg.Arch** construction process.

Cognitive Analysis for the ECT case

The activities and actions of the **Cognitive Analysis**, such as series of interviews, working meetings, discussions, reviews and validations over the lifetime of the project, produce various knowledge representations (see a brief summary about it in Appendix C) and information such as glossaries, lexicons, conceptual models, ontologies, . . . It is worth mentioning that all activities of the **Cognitive Analysis** can be carried out in parallel with other activities corresponding to other components of the model. Each project determines which activities and actions are carried out, at what pace and at what moment; therefore, the model is open and non-sequential.

In order to develop the ontology of the **ECT** domain, the *specialist's knowledge* was elicited through multiple interviews. From these activities, 53 symbols belonging to the domain were identified and recorded in a Microsoft Excel document that served as the structure for the **Knowledge of Domain on an Extended Lexicon** (**KDEL**) information. In addition, acronyms, references and synonyms were recorded and classified into a definition, objects, subjects and verbs. The concepts were validated by the **DS** and the **Beneficiary** until the shared vocabulary was identified and the requested modifications were made so that the **KDEL** reflected the existing knowledge in the domain to the satisfaction of the **DS** and the **Beneficiary**. The **Table 5.1** presents an example of how the **ECT** concept is represented in **KDEL**, while the corresponding **conceptual model**[10] can be seen in **Figure C.3** which is an extract of it.

10: **Conceptual model** or domain model is a graphical representation of a problem, need or situation through, for example, entity-relationship diagrams, dictionaries, glossaries or class diagrams.

Once the first version of a model is obtained, it is essential to validate it with everyone involved in the process of implementing the solution, as the first validation always identifies areas of improvement necessary for the following

Table 5.1: The table shows an example of the representation of the ECT concept in the KDEL.

Type	Verb
Label	Electroconvulsive Therapy
Synonym	Electroshock therapy
Acronym	ECT
Description	ECT is a set of electrical current applications to trigger controlled seizure activity in the brain. This therapy causes neurophysiological changes that can reverse the symptoms of some mental illnesses. It is particularly useful in the treatment of schizophrenia or some severe depression, although it can be used in patients with delusions and other psychotic symptoms
Intention	Specialist, electroshock
Source	Mayo Clinic (https://www.mayoclinic.org/tests-procedures/electroconvulsive-therapy/about/pac-20393894)

iterations of the modelling process, until the results represent domain knowledge to everyone's satisfaction (**Figure C.3**). Once the concept model was validated, the development of the ECT ontology followed (**Figure C.4**).

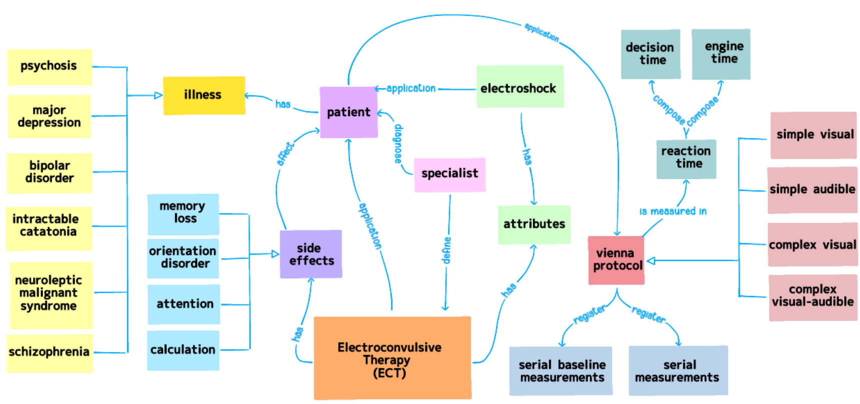


Figure 5.1: The figure shows an extract of the **conceptual model**. It graphically describes the need or problem of ECT and all related concepts.

Description of the situation presented by the data from the research of the specialists

The arduous statistical analysis of the information provided by the DS made it possible to distinguish an *implicit structure* in this information so that, for this case of the ECT domain, the representation of a set of patients corresponds to $(i_1 \ldots i_n)$ in which n_i occurrences of a given ES take place at different times $(E_1 \ldots E_n)$. There are psychophysiological parameters denoted by Y, which are connected to the occurrence of each ES (for this particular case the RT), that reflect the performance behaviour of the patient. Therefore, a few Y measurements are taken for each patient and each ES occurrence. In this particular case, this number (r) is too small and is fixed for all occurrences of an ES, and the time points at which Y will be measured are also fixed. This measurement is performed during the first 24 hours after the application of each ES, in particular after 2, 4, 6, 8, 12 and 24

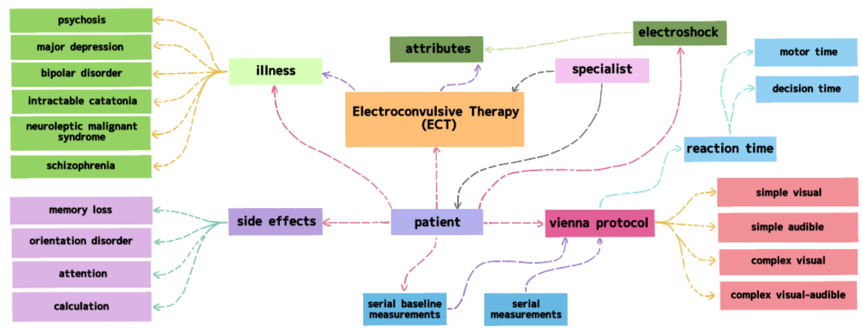


Figure 5.2: The figure shows a simplified ontology of the ECT. The figure shows a **simplified ontology** that defines types, properties and relationships between entities that exist in the ECT domain. This ontology catalogues ECT terms and establishes the relationships between them, limiting the complexity of the domain and organising the explicit information and knowledge.

hours. The measurement of this RT is of particular interest for the study of side effects resulting from ECT. This scenario generates three types of information that can be formalised by three matrices:

- Matrix X contains a set of quantitative or qualitative characteristics: $X_1 \ldots X_K$ of each patient.
- Matrix Y contains sets of very short serial measurements of a parameter of interest (in this case, RT) at all the fixed time points for each ES occurrence.
- Matrix Z contains a set of quantitative or qualitative characteristics: $Z_1 \ldots Z_L$ of each ES.

The number of ES and the time at which they occur may differ from patient to patient without any other underlying pattern. However, all ES applied to the same patient are influenced by their characteristics, which means that all RT measurements for the same patient are influenced by the same patient. Therefore, in the Y and Z matrices, each patient acts as a blocking factor, defining, in the Y matrix, bundles of curves that are not at all independent of each other. A block is constituted by all the measurements following the application of each ES on the same patient. Thus, the analysis deals with a set of very short and repeated serial groups of measurements of the parameter of interest with a blocking factor delimited by the patient. Consequently, the characteristics of the matrix structures X (patient characteristics $X_1 \ldots X_K$), Y (serial measurements of the parameter of interest RT) and Z (ECT characteristics $Z_1 \ldots Z_L$) differ; the knowledge that interrelates them is not trivial by complying with the ISD description in Subsection 2.2.1 on page 17.

The current method of simplifying RT measurements by averaging them and presenting them as a single serial measurement for each patient (black line in **Figure 5.3** and **Figure 5.4**) is inappropriate. This approach overlooks important information that may affect the optimisation of ECT and its efficacy. For example, if the mean RT is relatively high but there is a lot of variability in the data, this may indicate that ECT is not having a consistent effect in all patients or that certain patient characteristics are influencing the results. Although this presentation is not recommended, it is often used to facilitate classical analysis, although this does not reveal any significant findings. To better understand treatment and develop more effective interventions in the future, it is important to consider variability in the analysis of ECT data. By taking variability into account, DS can gain a more accurate understanding of the effects of ECT and develop better interventions to improve its effectiveness.

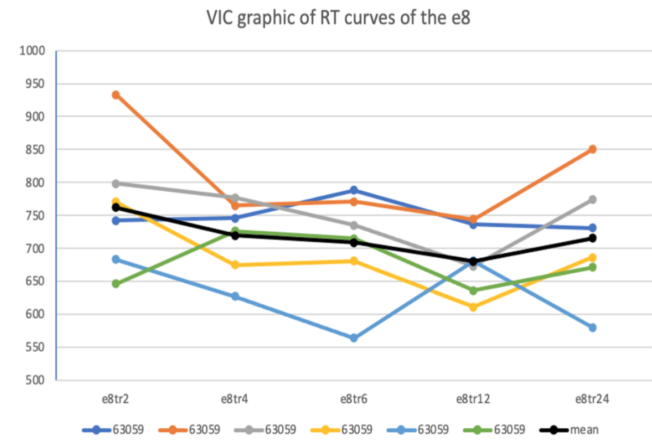


Figure 5.3: **Variability in class (VIC) graphic of RT curves of the e8 test of the 1st patient.** The *VIC graphic* shows the evolution of the *RT* through its curves for an *ECT* of 6*ES* applied to the 1st patient. The *RT* correspond to the complex visual-audible (e8) and were measured at 2, 4, 6, 12 and 24 hours after applying each *ES*.

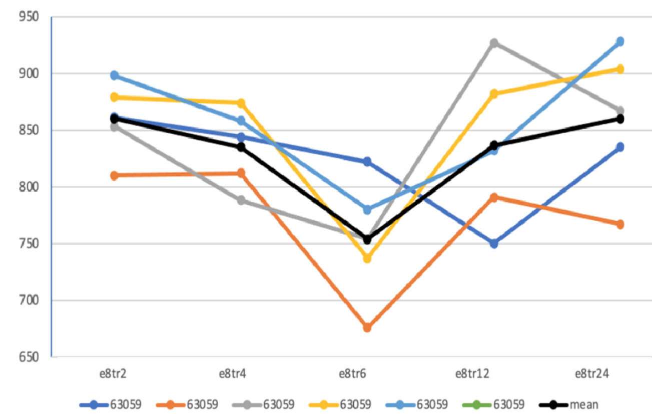


Figure 5.4: **VIC graphic of RT curves of the e8 test of the 4th patient.** It shows the evolution of the *RT* through its curves for an *ECT* of 5*ES* applied to the 4th patient. The *RT* correspond to the complex visual-audible (e8) and were measured at 2, 4, 6, 12 and 24 hours after applying each *ES*.

Even the curves representing each serial measure show considerable variability, making it difficult to identify a general pattern. Furthermore, the number of applications of an *ES* varies, requiring an assessment of the effect of each application. Given the lack of prior knowledge for training machine learning models, it is recommended to use the *KDSM* (all details in [21]) methodology to perform **Knowledge Management** (**KM**) analysis of serial measures. To represent and communicate the patient's response to **ECT**, it is possible to use the mean curve and the individual curves of each serialised measure. This approach provides an overview of the patient's overall trend.

[21]: Rodas-Osollo et al. (2022)

KM by KDSM

KDSM is a methodology for knowledge discovery in an **ISD** where very short and repeated serial measurements with a blocking factor are presented (see **Figure 5.5**). Good **KM** it is done in three phases:

1. Individuals baselines analysis: Initially, the baselines and their relationship with the matrix X are studied to identify different initial profiles of individuals to be used as *a priori knowledge*;
2. Event effects analysis: The knowledge induced from the previous phase is used as input to study the effect of a given event (E) on the attribute of interest (Y). Subsequently, different patterns on Y are identified relating to the individuals who are affected by E;

3. Knowledge production: Finally, the results obtained in the previous phase are crossed with matrices X and Z to find relationships between them, and to determine which relevant individual and event attributes constitute the found patterns.

In short, the methodology will carry out the next tasks:

BLA: Individuals baselines analysis

- Extraction of a baseline matrix from matrix serial measures.
- Hierarchical clustering of the patients using baseline matrix.
- Use of attributes of patient's features to interpret the classes obtained.
- Rules induction from comparison between classes and patient's features attributes. A knowledge base (KB) is formed by the rules obtained.

EEA: Event effects analysis

- Blocking factor managing on serial measures for distinguishing the effect of the ES application on RT parameter.
- Rule-based hierarchical clustering technique of modified serial measures with a KB obtained previously.

KP: Knowledge production

- Interpretation of resulting classes.

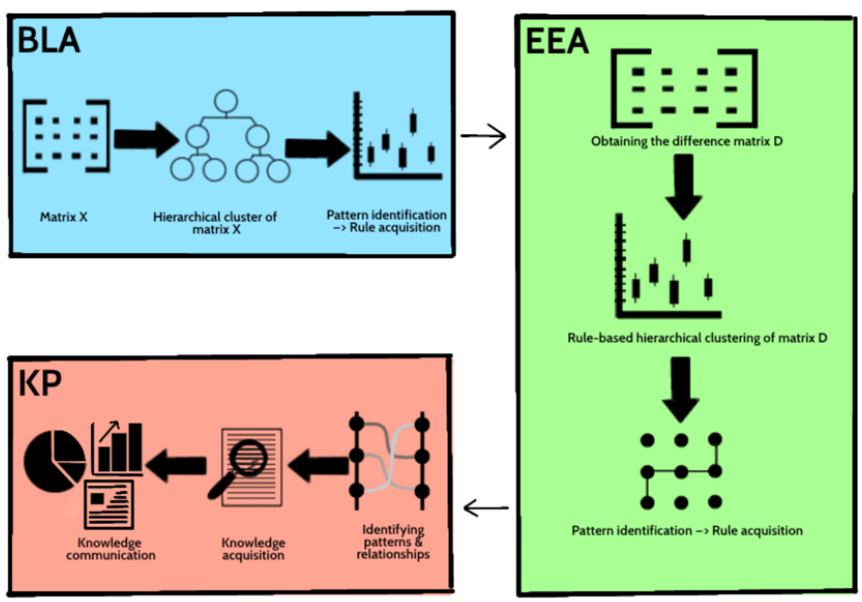


Figure 5.5: The KDSM Methodology Scheme. The scheme communicates the three phases of *KDSM methodology* for *knowledge discovery* in an ISD where very short and repeated serial measurements with a blocking factor are presented.

BLA phase

Initial reaction time measurements for the simple visual (e5) and auditory (e6), visual and categorisation (e7), visual and auditory and categorisation (e8) tests were analysed. A hierarchical clustering was used to classify the RT of patients, as these represent the initial condition of the patients (hierarchical reciprocal neighbours' method with Ward's aggregation criterion and Euclidean distance). Subsequently, patient characteristics that are relevant to the specialist's partitioning are distinguished to obtain rules. The classification technique suggested partitions into 2, 3, 4 and 5 classes that group different patients according to their baseline reaction times. In agreement with the DS a cut into three classes ($C1$, $C2$ and $C3$ see **Table 5.2**) was performed.

Table 5.2: The table shows a partial view of the arrangement of patient records in the three-cluster partition corresponding to the hierarchical cluster. The clustering technique indicates the varying baseline conditions of the patients.

Patient class label	Patient record number
Class 1	22 patients: 063059, 499969,. . . , 997938.
Class 2	68 patients: 437289, 522175,. . . , 997877.
Class 3	85 patients: 505652, 782035,. . . , 999464.

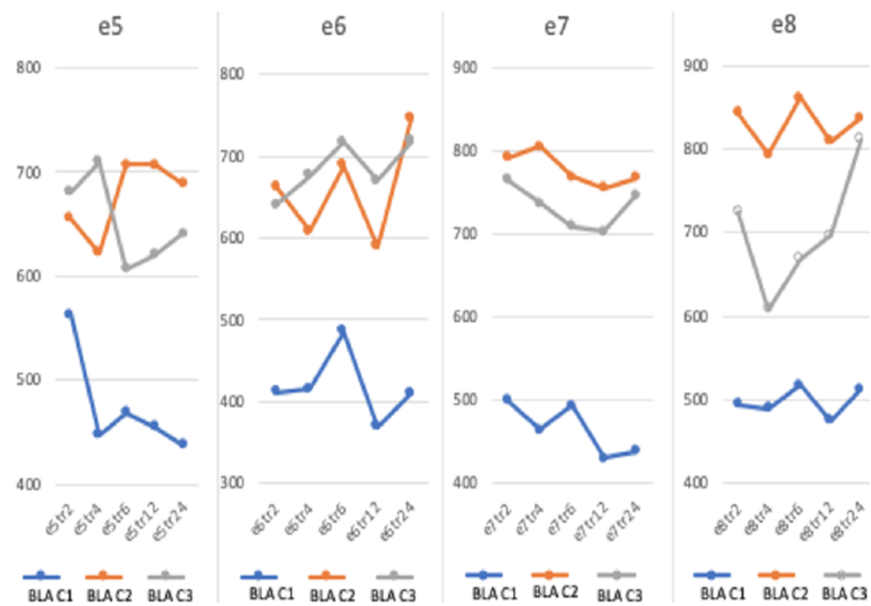


Figure 5.6: VAC plot of BLA phase. The variability among classes (*VAC*) plot illustrates the variation in basal RTs across different classes.

The characteristics of each group were then analysed with the information obtained from the classification structure. **Figure 5.6** shows the general trend of the baseline RT curves for each class, i.e. it shows the baseline conditions of the patients regarding RT. A consistent response can be observed in classes $C1$ (blue), $C2$ (orange) and $C3$ (grey) as a general trend, and the reaction times have largely the same level for all tests. The RT of classes $C2$ and $C3$ show a noticeable increase compared to class $C1$ for all tests (simple ones $e5$, $e6$, and complex $e7$, and $e8$) in RT.

As mentioned above, patient-specific information is available in matrix X (102 attributes), and this information is analysed to find attributes that identify patterns which characterise the selected partition. Quantitative and qualitative attributes that are significant for the partition are distinguished from the patient characteristics through the non-parametric H-test and the χ^2-test, both ($\rho <$ 0.05). In addition, multiple box plots and bar charts were used to visualise the distribution of the data and how these attributes of the X matrix interpret the chosen three-class partition.

The information derived from the tests and the graphs was reviewed by the DS to confirm which attributes he/she was interested in observing, including some that were not statistically significant. Subsequently, rules were obtained after the specialist's selection and interpretation (**DS** knowledge) of the graphs. These rules are of "crisp-type", and represent all the attributes selected by the **DS**, e.g. height, weight, number of cigarettes per day... Moreover, they constitute the initial and partial KB of this domain.

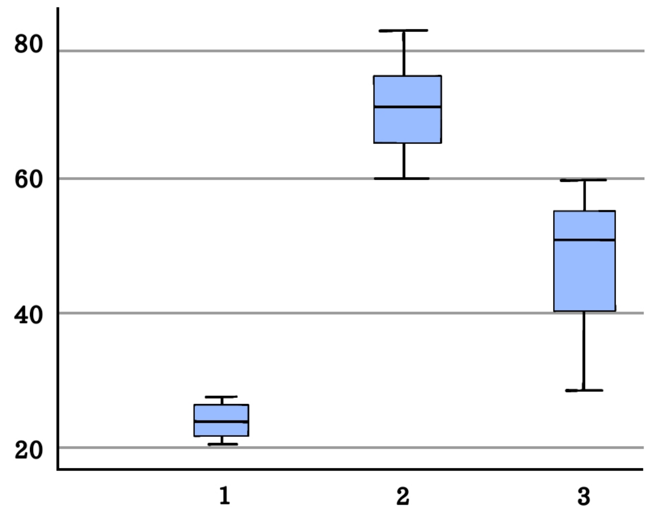


Figure 5.7: Boxplot of BLA phase. The boxplot shows that the distribution of the age attribute in each partition is remarkable for its symmetry and clear delimitation in each partition class. This attribute is extremely relevant because it shows a clear difference in RT between younger and older patients. Here, it can be seen that the youngest patients are found in *BLA C1*, with lower baseline RT than those in *BLA C2*, up to the mature patients in *BLA C3*.

Figure 5.7 shows the distribution of age attribute in the three-class partition. As can be seen, class *BLA C1* includes all baseline curves of the youngest patients (up to 29 years), and classes *BLA C2* and *BLA C3* include baseline curves of patients older than 29 years. The attribute of *age* was the first of the 40 statistically significant attributes selected, according to the extensive experience of the **DS**, and the fact that this attribute is one that exerts a strong influence on psychophysiological tests [21] consistent with clinical evidence. Therefore, the three classes of patients are described by: youngest patients—*BLA C1*—with shorter and more regular baselines RT for all the tests ($e5 - e8$) and young—*BLA C2*—and mature—*BLA C3*—patients with longer baselines RT, in particular, with much longer times in complex tests ($e7$ and $e8$) than in single ones ($e5$ and $e6$).

[21]: Rodas-Osollo et al. (2022)

From this class description, the next step is to integrate the 103 rules obtained from the selected significant attributes into the KB (**Table 5.5**). It was decided to include this knowledge for the EEA phase, with separate processes for *younger*, *young* and *mature patients*.

<u>*EEA phase*</u>

To study the effect of each ES on RT, and due to the existing blocking factor in this matrix, and the fact that the data in matrix Y are ill-conditioned for classical statistical hypothesis testing, this factor was treated. The treatment to remove the blocking factor consisted of transforming the Y matrix into a new matrix, but without the blocking factor. The transformation was carried out by performing the differences between *post-ES* and *pre-ES*. Then, on the transformed matrix, the rule-based hierarchical clustering technique (RBHC) [22] is applied. Thus, the RBHC based on the rules contained in the KB suggests six classes of effect curves for each ES applied to the RT. In three of these classes, the differences between *pre-ES* and *post-ES* are noticeable and slightly positive, as well as presenting a slightly more uniform pattern, where one class corresponds to younger patients,

[22]: Rodas-Osollo et al. (2005)

Table 5.3: This table shows an abstract of "crisp-rules" contained in the KB.

Patient-specific attributes	Extracted rules relating to the attribute
Age	If age >= 21 and < 30, then belongs to C1 If age >= 60 and < 83, then belongs to C2 If age >= 30 and < 60, then belongs to C3
Penthmed	If penthmed >= 200 and < 245, then belongs to C1 If penthmed >= 118 and < 130, then belongs to C2 If penthmed >= 130 and < 200, then belongs to C3
Sucme	If sucme >= 50 and < 67.7, then belongs to C1
⋮	⋮
Hamtre17	If hamtre17 = 6 or > 10 and < 17 or > 17, then belongs to C3

another to mature patients and the last to older patients. This means that RT are slower after ES application and would therefore be considered as poor reactions. The remaining three classes present a more variable pattern corresponding to patients with faster RT after the ES application. The differences between before and after an ES are negative, i.e. they are good reactions, and a uniform trend in the EEA classes $C1$, $C3$ and $C5$ for an increase in RTs (see **Figure 5.8**, **Figure 5.9** and **Figure 5.10**). Therefore, there is a tendency for patients in these classes to deteriorate. In contrast, in EEA classes $C2$, $C4$ and $C6$, a variable pattern is visualised, in which the effect tends to decrease the RT, i.e. a tendency towards the improvement of patients in these classes.

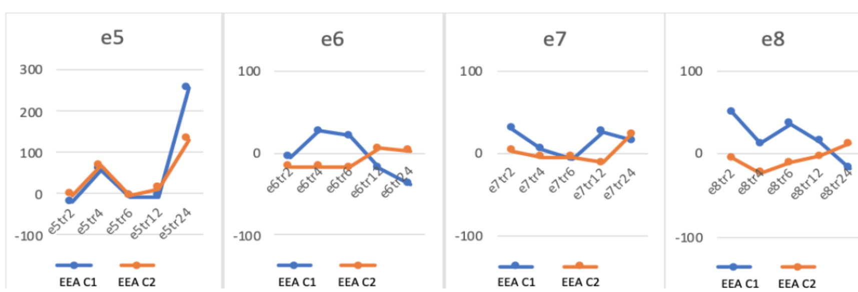


Figure 5.8: VAC plot of the age-rule1 of EEA phase. The *VAC plot* shows the variability between classes, regarding the effects of each ES, employing two class curves for tests e5 to e8 related to age rule 1.

KP phase

The KP phase produced interesting and target-relevant information for the receiver. The non-parametric H-test and the χ^2-test, both ($\rho < 0.05$) were used, and box and bar charts were made to visualise the distribution of the data. **Figure 5.11** communicates only a small part of the series of box plots for illustration purposes. The box plots correspond to the statistically significant attributes that were of interest to the specialist, which communicate the distribution of those attributes about the partition. Eight attributes were identified that, under certain combinations of their levels, can optimise therapy. All information about this specific work is in [21].

[21]: Rodas-Osollo et al. (2022)

Formal defining of the Cg.Arch

Finally, the construction of the Cg.Arch ends with its formal definition, which involves correctly identifying the members of the set of semantic elements (R)—

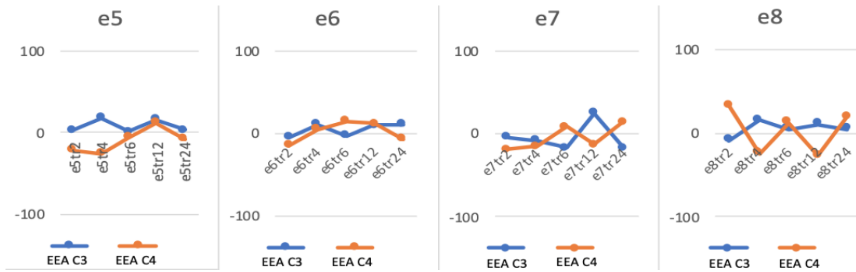


Figure 5.9: VAC plot of the age-rule2 of EEA phase. The *VAC plot* shows the variability between classes, regarding the effects of each ES, employing two class curves for tests e5 to e8 related to age rule 2.

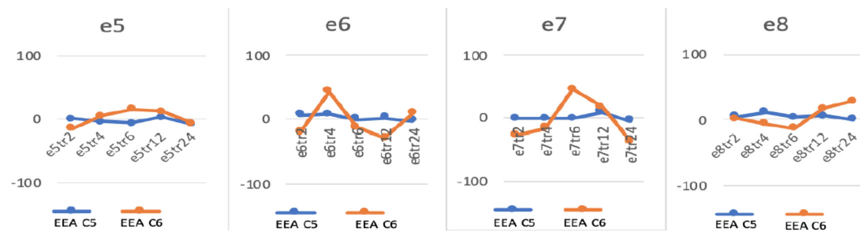


Figure 5.10: VAC plot of the age-rule3 of EEA phase. The *VAC plot* shows the variability between classes, regarding the effects of each ES, employing two class curves for tests e5 to e8 related to age rule 3.

partial or complete, but clear and meaningful representations of knowledge relations—and the set of cognitive elements (U)—set of entities, definitions, rules and all kinds of knowledge with possible linkage to the solution. In this case, R is the set of all knowledge representations arising through the *activities and actions performed*. For example, from the analysis of interviews emerged conceptual models (**Figure C.3**), and from the use of *KDSM* emerged important graphical representations (**Figure 5.11**), which were meaningful for the set of DS and the Beneficiary. Correspondingly, set U, contains all the rules that were obtained by the *specialists' reasoning* about the meaningful attributes (see **Table 5.5** with matrices exemplifying some members of R and U sets).

5.2.4 Identification of Cg.S-P

As previously mentioned, the advent of the CE has caused a constant state of transformation in the world of organisations, requiring the implementation of technology that allows for adaptation, if not for survival. The challenge for these organisations is to successfully navigate this transformation, and to do so, they must work with a Cg.S-P who can facilitate the process. But what about individuals who need a Cg.S? While organisations may be the most pressing to transform, they are not the only ones that need to adapt to the CE. Ultimately, everyone who is a part of this CE will eventually encounter situations that require resolution, as was the case for the *specialist* in this *ECT domain* who needed to seek the assistance of the Cg.S-P team. Personal circumstances may differ, but the longer an individual or organisation delays their transformation, the more their well-being or business is at risk.

As a Cg.S-P, it is essential to be able to offer effective KM services to help individuals locate and acquire the necessary *pieces of knowledge*. This may involve using technology such as online resources or databases, as well as providing personalised cognitive support methods and guidance. The Cg.S-P should work closely with the person under a problematic situation to understand their needs and tailor their approach accordingly, using various methods to ensure that the pieces of knowledge can be effectively used. By facilitating the acquisition of

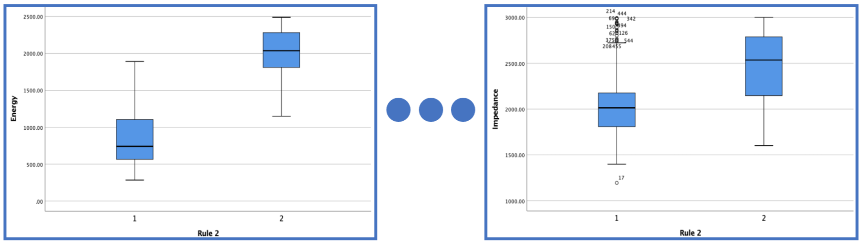


Figure 5.11: Series of boxploots from the KP phase. The image shows that boxplots, among others, were used to communicate the behaviour of attributes of interest in the study. The attributes identified are all statistically significant, as well as relevant in the experience of the **Domain Specialists**.

knowledge pieces in a supportive and accessible manner, the **Cg.S-P** and the *specialist* can, together, acquire the understanding needed to provide a high-quality **Cg.S**, even if this solution is not a technological one.

The identification and selection of team members is the responsibility of the team leader, the **Cg.S Architect**. The team should have the necessary skills and expertise to propose, design, develop and implement the project. These skills and expertise may come from *techno-scientific actors*. The main task of the **Cg.S-P** will be to conduct a **Cognitive Analysis** to determine which *actors* should be involved in the implementation and development of the **Cg.Arch**. At the beginning of the project, it is not necessary to have a formally defined **Cg.S-P** team, as this component of the model is also flexible and depends on the nature of the project.

For this particular case, the identification of the **Cg.S-P** was carried out early on by the project **Cg.S Architect**, with the approval of the **Beneficiary**. The **Cg.S-P** team was formally integrated as follows:

P = {**Karina Gibert, Jordi Rodes, Jordi Bergos**}, such that T = {**Karina Gibert, Jordi Rodes**} and A = {**Karina Gibert**}.

Thus, the project **Cg.S Architect** and first **Cg.An** was Karina Gibert PhD, the second **Cg.An** and primary **Information Technology** (**IT**) *specialist* was Jordi Rodes and the secondary **IT** *specialist* was Jordi Bergos. Although the **Cg.S-P** team was not large, this does not mean that the project is of little value. It simply means that the need for a technological solution was not necessary, and the excellent profile of the recipient and *specialist*, along with their willingness to assist, greatly facilitated the implementation of the **Cg.S**.

Compendium of essential activities carried out by the provider team for the case of the ECT domain

The provider team carries out several activities and actions to deliver a **Cg.S**. These may vary in type and quantity depending on the characteristics of the problem domain. However, it is always possible to highlight the most important activities carried out by the **Cg.S-P** and which are certainly present in most, if not all, projects.

The **Cg.S-P** team carried out the **KM** of the *ECT domain* through the systematic **Knowledge Management on a Systematic process for Requirements Engineering** (**KMoS-RE**) process. This process was active as long as the project was not released because, throughout the project period, the *knowledge evolves in cycles* as all the *actors* involved take ownership of the domain. Most of the working sessions are part of the hard work of **Cognitive Analysis** that generates products for domain analysis, understanding and validation, such as conceptual models (**Figure C.3**).

As the models are validated, it is possible to build the ontology (**Figure C.4**) to be able to define the desired cognitive and functional aspects of the **Cg.S**. Through precise definitions of the desired behaviours, as well as adequate and complete descriptions, it is possible to keep all parts of the process and the *proposed solutions unambiguous*. Through **Cognitive Analysis**, it became possible to accurately communicate the **Beneficiary**'s wishes, requirements and challenges in each work cycle. As a result, all *actors* were able to recognise and shape the elements of **Cg.Arch**.

Through the **KMoS-RE** process, the **Cg.S-P** team identified *pieces of knowledge* for elicitation. Based on *cognitive dialogue analysis*, the aim was to identify *hidden knowledge* behind *linguistic traps*, such as beliefs about terminology and the process of certain medical therapies.

When working with multiple **DS**, it is necessary to assess their *level of expertise* and *specialised knowledge*. However, in this particular case, no time was spent on this as the **Beneficiary** determined which *specialists* they were going to work with, and it was not necessary to adjust this because the team of specialists had a high degree of expertise. So the **Cg.An** integrated the matrix where he/she recorded the level of familiarity, skill and experience of each *actor* who was a specialist, or who possessed the specialist knowledge, and who participated in the project (see **Table 5.4**). This level linked each identified *piece of knowledge* to these *actors*. In this way, it provides certainty, confidence and communicates—even if only partially—how much *collective knowledge* is possessed and how it is distributed among these *actors*, to be taken as a basis for the implementation of the **Cg.S**.

In addition, the **Cg.An** should make a *record of beliefs*, including any false assumptions or beliefs that were previously believed to be knowledge or experience. At the same time, **Cognitive Analysis** should be carried out on an ongoing basis, periodically and after each **CMCg.I** activity, to identify *pieces of knowledge*, and assess its authenticity and relevance to the project together with the **Beneficiary**. As a result, it will help to determine the subsequent actions to be taken and to improve what has been achieved so far. In truth, each *validation session* serves as a *learning experience* and thus advances the knowledge of the domain. This was the most complicated part of the **Cognitive Analysis**, as it was necessary to design new ways of *representing knowledge* in order to be able to communicate it to the **DS** and thus be able to discuss it and make decisions based on what had been analysed. After each communication, the *validated knowledge* was assimilated and, as a consequence, the *collective knowledge increased* and, as long as necessary, the cycle started again. Fortunately, for this particular case, not many cycles of **Cognitive Analysis** were necessary due, primarily, to the willingness and commitment of the **Beneficiary** and, to a lesser extent, due to the particular *knowledge representations* that were implemented in this case.

After the evolutionary cycle of knowledge towards the end of the analysis, what was achieved?

Venturing into the domain of **ECT** meant that meticulous **KM** was required, and it was necessary to design *knowledge representations* particular to this problem in order to communicate it unambiguously. Doing the work according to the **CMCg.I** provided a better base structure for addressing the problem embedded in the **ISD**, maintaining order and clarity and providing certainty that a **Cg.S** would be reached. Before performing the **CMCg.I**, the available data was organised into a formal structure of three matrices: one matrix containing patient data, another matrix containing initial and post-shock *RT* measurements and a third matrix containing shock characteristics data. This, consequently, facilitated the management of this knowledge and its communication. The *pieces of knowledge* identified and validated with the **DS** revealed what the patient profiles were like before **ECT** treatment, and a *KB* (from *BLA phase*) was formed regarding the initial conditions of each patient. This is very important because it is possible to predict, in advance, whether a patient is suitable for the therapy or not, how many applications,. . . Using this *KB* meant that the effect of *ES* was studied in isolation. The relevant characteristics of *ES*, and how certain attributes directly affect them, were identified. These relationships were represented by rules that formed another *KB* (from *KP phase*) about the patients and their condition at the end of the treatment. Finally, with the knowledge gained and validated, an **ECT** optimisation **guideline**[11] could be developed to support the psychiatrist in determining which patient is suitable for therapy and, if so, to determine how many applications are most suitable.

11: The purpose of this **guideline** is to help general psychiatrists and other mental health professionals to determine the best therapy for major depression, psychosis and bipolar disorder. The guidelines also point out that ECT can be a useful first-line treatment for these mental disorders. They stress the importance of getting a second opinion and consulting with a doctor.

5.2.5 The proposed non-technological Cg.S in the domain of ECT

The results that the **Cognitive Analysis** provided to the **Beneficiary** was knowledge to profile patients and configure attributes that allow for the optimisation of **ECT**. It also allowed him/her to confirm that a problem related to serial measurements and embedded in an **ISD**, needs specific **KM**, otherwise, too much information is lost and a patient's development is affected.

Happily, the knowledge gained from this **Cognitive Analysis** was added to that of the **DS** and immediately changed the way they conducted their analysis and praxis to address the diseases that warrant the use of **ECT**, and to reconsider how to manage the effects of each *ES* applied throughout **ECT**.

The management of the problem linked to **ECT** that is embedded in an **ISD** through the **CMCg.I** provided knowledge to satisfy a need through tactics that included machine learning and statistics, knowledge representation, rule induction, *KB* management. . . In addition, it considered a special type of data management to emphasise how certain characteristic attributes of the therapy and the patient exert an influence on patient evolution, and demonstrated that the model has been used with much success in this domain of **ECT**.

What was the Cg.S?

The **CMCg.I** model has simplified the process of defining a solution that meets the needs of medical professionals or the **Beneficiary** in the context of ECT. As a result, a non-technological **Cg.S** has been developed using the **CMCg.I** model. This solution consists of a set of products tailored to specific knowledge requirements. The **Cg.S** is formally classified as a proposed value solution, which is part of the set of goods or products (set G) referred to in Definition 4.4.1. It includes a *guide* to optimising the ECT, knowledge bases and ontologies that may be useful in the future to feed some cognitive tools.

Endnote to the guide for the optimisation of ECT

This guide addresses ways to improve the outcomes of ECT and minimise adverse effects. It contains guidelines on ECT, based on specific literature reviews and expert opinion. It is intended to improve the treatment of patients with this therapy.

Although ECT is recommended for several mood disorders and may also be a first-line treatment for catatonia or delusional mania, treating psychiatrists should always obtain second opinions from experienced ECT psychiatrists and other appropriate specialists before administering ECT, especially to a child or adolescent patients, pregnant patients and patients with high medical risks.

Despite its poor reputation, ECT is safe and well tolerated, with a response in older patients superior to that of medication alone. Pre-ECT evaluation should include psychiatric and physical examinations, cognitive screening, medication review, complete blood work, electrocardiogram and chest X-ray. Dosage (stimulation dose relative to seizure threshold), electrode placement (right unilateral, bitemporal, bifrontal, left anterior temporal), pulse width, frequency of sessions, concomitant medication and anaesthesia should balance efficacy, speed of recovery and adverse cognitive effects.

The guideline also provides recommendations for pulse width and threshold parameters for three electrode placements.

For responding patients, continued ECT for 6 months (once every 1–4 weeks) usually prevents relapse (> 50% of responding patients relapse within 12 months, typically within 6 months). Beyond that, maintenance ECT may be useful for patients who experience frequent relapses.

Finally, these guidelines remind general psychiatrists and other mental health clinicians that ECT may be a useful first-line treatment for depression and psychosis, but not for other conditions. The guidelines underline the importance of obtaining second opinions and consultations in complex circumstances.

5.3 Chapter summary and reminders

This chapter communicates the usefulness of following a working model, such as the **CMCg.I** model, to formalise the process of providing a **Cg.S** that satisfies the need(s) of the **Beneficiary** belonging to the domain of the **Electroconvulsive therapy** (**ECT**). This case was very interesting, not only because of the domain but also because the **Beneficiary** was also the leader of the **DS** team. The challenge to be solved consisted of providing the necessary knowledge so that the **DS** could optimise the management of the **ECT** and, in doing so, be more efficient concerning the side effect of memory loss in patients receiving **ECT**. In addition, it was shared how special knowledge management situations were handled and solved by using the *KDSM* methodology. Methodology to analyse very short and repeated serial measurements, at specific points in time, of an attribute of interest present in the **ECT** domain. Finally, it can be said that there is satisfaction in having worked on this project which has contributed to the medical practice in psychiatry, reconsidering how to study the effects of each *electroshock* of **ECT**.

Table 5.4: Fragment of the set of index matrices corresponding to the *ahCN component* of the *ECT-CMCg.I model*.

Actors and entities of the internal knowledge index matrix (I)

Label	Piece of knowledge	Description	Location	Specialist	Contact
i_1	RecordX	Information from ER about X	IKIM-ER-Rec-Repository	Emili R	er@hcb.cat.es
i_2	RecordY	Information from ER about Y	IKIM-ER-Rec-Repository	Emili R	er@hcb.cat.es
i_3	RecordZ	Information from ER about Z	IKIM-ER-Rec-Repository	Emili R	er@hcb.cat.es
⋮	⋮	⋮	⋮	⋮	⋮
i_{40}	OWL-ECT	Ontology file of ECT domain	IKIM-ER-Doc-Repository	Emili R	er@hcb.cat.es

Actors and entities from sources of information index matrix (S)

Label	Piece of information	Description	Location	Source
s_1	Paper01	Electroconvulsive Therapy S...	SIIM-Doc-Repository	https://www.ncbi.nlm....
s_2	Paper02	Electroconvulsive Therapy S...	SIIM-Doc-Repository	https://www.ncbi.nlm....
s_3	Paper03	Electroconvulsive Therapy S...	SIIM-Doc-Repository	https://www.ncbi.nlm....
⋮	⋮	⋮	⋮	⋮
s_{35}	Paper35	Electroconvulsive Therapy R...	SIIM-Doc-Repository	https://www.nejm.org/doi...

Actors and entities of the external knowledge index matrix (E)

Label	Piece of knowledge	Description	Location	Specialist	Contact
e_1	RecordABT1	ABT InfoP1 from MQ	EKIM-MQ-Rec-Repository	Maria Q	mq@uab.edu.es
e_2	RecordABT2	ABT InfoP2 from MQ	EKIM-MQ-Rec-Repository	Maria Q	mq@uab.edu.es
e_3	RecordABT3	ABT InfoP3 from MQ	EKIM-MQ-Rec-Repository	Maria Q	mq@uab.edu.es
⋮	⋮	⋮	⋮	⋮	⋮
e_{23}	SurveyNA	Neuropsychological assessment	EKIM-LS-Doc-Repository	Lynn S	lschaefer@numc.edu

Actors and entities of the Cg.S Provider index matrix (P)

Solution provider	Name	Role	Contact
p_1	Karina Gibert	Architect/Analyst	kg@mls.edu
p_2	Jordi Rodes	Analyst	jr@mls.edu
p_3	Jordi Bergos	Data Engineer	jb@mls.edu

Table 5.5: Fragment of the set of index matrices corresponding to the *Cg.Arch component* of the *CMCg.I model*.

All knowledge representations index matrix (R)

Label	Semantic elements: representation	Description	Location	Source
r_1	Conceptual model v1	Conceptual model emerging from validation s...	ARCH-R-Doc-Repository	Validation session 10 May
r_2	Record VSMay10	Record of validation section	ARCH-R-Rec-Repository	Validation session 10 May
r_3	FileSPOMay10	Boxplots, VAC & VIC graphics, and bar charts	ARCH-R-Doc-Repository	Validation session 10 May
$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$
r_{20}	OWL-ECT	Ontology file of ECT domain	ARCH-R-Doc-Repository	Validation session 10 May

Documents of rules index matrix (U)

Label	Cognitive elements: rules	Description	Location	Source
u_1	KB-BLA	Rules from BLA phase document	ARCH-U-Doc-Repository	Validation session 23 Apr
u_2	KB-KP	Rules from KP phase document	ARCH-U-Doc-Repository	Validation session 30 Apr
u_3	DKB-BLA	Rules from BLA phase description document	ARCH-U-Doc-Repository	Validation session 23 Apr
$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$
u_{15}	RSKB-KP	Rules from BLA phase record session	ARCH-U-Rec-Repository	Validation session 30 Apr

6 Cognitive Technology Solution in the GCC Domain

The **Cognitive Era** (**CE**) is offering interesting challenges to all types of organisations and in different fields, such as embedded education in a context where *innovation* is necessary to make a difference, especially in the so-called smart cities. For a cement company that operates globally, the issue of **Cognitive Transformation** is addressed and worked on every day in its different areas. One of them, the educational area, oversees training operators who prepare cement mixes for construction and this chapter deals with this interesting success story. The need for efficient operator training is not trivial, as there is no established process to prepare it and guarantee the desired quality for the customer. To address this, the company decided to implement a **Cognitive Solution** (**Cg.S**) project. The challenge was to find a technology that could leverage the knowledge of specialised operators to reduce the time and cost of training, which relies heavily on human senses. The **Conceptual Model for Cognitive-Innovation** (**CMCg.I**) addresses this challenge by implementing a process that generates the necessary *cognitive flexibility* for a **Cg.S** that guarantees customer satisfaction. This **CMCg.I** *model* focuses on the selection and analysis of cases to reduce the time and number of examples needed for knowledge transfer from digital documents or virtual reality situations. Although the solution may seem straightforward, this chapter focuses on the *model* that orchestrates actions and activities to generate the **Cg.S** for a specific training need and ensures quality and customer satisfaction, rather than the virtual reality solution itself.

> Before reading on, consider the following reflection. . .
>
> The company behind the project places great emphasis on the quality of both its work, its products and its services. With this in mind, in a morning reflection, a dialogue took place:
>
> —*Quality can mean different things depending on the context in which it is used. In general, quality refers to the degree of excellence of something. It can refer to the inherent characteristics of an object, service or process that make it valuable or desirable. For example, a product can be of high quality if it is durable, reliable and performs well. A service can be of high quality if it is efficient, effective and customer friendly. A process can be of high quality if it is efficient, well-organised and produces consistent results. In all these cases, quality is a measure of how well something meets the standards or expectations that have been set for it.*
>
> —*Wow! So I'm working in a very swampy area. . . trying to live up to another human's expectations. . . is there something wrong with my head?*
>
> —*Definitely! I mean, it is a challenging task to try to meet the expectations of human beings, as everyone has their own unique needs, desires and expectations. However, it is important to try to do our best to understand and meet the needs of*

others to the best of our ability. This can help to build strong relationships and create a sense of fulfilment and satisfaction in our work and personal lives.

—Who said that? Oh, I think it was me earlier.

(From a dialogue with the mirror, Jorge Rodas-Osollo. Croatia 2023.)

6.1 Background on the Grupo Cementos de Chihuahua case

Grupo Cementos de Chihuahua (GCC) is a renowned company that produces innovative products and solutions for the construction industry using cutting-edge technology. With a presence in North America, including northern Mexico, the United States and Canada, GCC has a wide distribution network throughout the Americas. In order to meet its high demand and deliver excellence, GCC fosters a culture of innovation. Thus, to succeed in the **cognitive transformation**[1], it is crucial to focus on technology. GCC understands this and, as a result, has a robust innovation management division that covers various areas such as Research and Development, Specialty Products, Composite Cements and **Digital Transformation**. The company team consists of multidisciplinary specialists who work closely with research centres to utilise environmentally friendly, intelligent technologies and data analysis to create innovative solutions. Specifically, digital transformation of GCC efforts are focused on using technology to enhance the quality of service provided to customers. One area that the company identified as needing transformation was its training programme for preparing concrete mixes. By leveraging the tools and platforms of the **CE**, GCC aims to improve this aspect of its operations. The development of a *Virtual Reality On-the-job Training Simulator* (*VR-OTS*) [23] solution to address this training need is notable not just because of the product itself, but because it exemplifies how the **CMCg.I** [24] can be applied to address issues related to quality, digital transformation and training, all at once. By using this *model*, GCC was able to successfully develop a *solution* that satisfied their needs.

1: The cognitive transformation, also referred to as the CE, represents the next phase of technological advancement. We are currently in the midst of this transition and significant changes are already occurring in the corporate world. Those companies that do not adapt to these shifts will fall behind. It is essential that we proactively prepare for this significant shift in the technology and business landscape.

[23]: Gerlach et al. (2015)

[24]: Rodas-Osollo et al. (2021)

What was the training situation in the mixing process?

The mixing process in the plant is carried out using modern, automatically controlled machinery. However, due to the various factors that can affect the quality of the mix, such as weather conditions, it is not currently cost-effective to fully automate the process and use machine learning and evolutionary computation tools to optimise the mix. Instead, the process is semi-automated and supervised by experienced operators who have been trained through daily work and trial and error. These operators use their senses (hearing, sight and touch) to ensure the mix is optimal. In order to maintain a consistent supply of high-quality mixes, especially in the absence of the operators, the plant has implemented a training programme to better utilise, communicate and teach the expertise and dexterity of these specialised operators; but how? In the business environment of today, it is common for companies to encounter the need for employee training and education to improve their work processes. While there have been many studies and solutions developed to address this issue [25], it is important to recognise that each situation is unique and may require a tailored approach. The **CMCg.I** *model* has been successfully used as a working modus operandi for similar situations in the past and can be a useful approach to consider in these situations. This chapter shares the experience of using the **CMCg.I** *model* as a tool to assist organisations and individuals in effectively utilising their knowledge and experience to address various problems and challenges. This is particularly relevant in the current **CE**, where organisations and individuals must adapt and innovate to remain competitive. By working with a model such as **CMCg.I**, organisations and individuals can benefit from structured support and guidance in their *transformation* and *innovation* efforts. The characteristics of the **Informally Structured Domain** (**ISD**) [26] match the need for GCC, which was discussed earlier. Therefore, in order to use the experience of the specialists in the cement mixing process in a *VR-OTS*, the **CMCg.I** *model* was followed, which made it possible to address the situation conveniently.

[25]: Garcia-Fracaro et al. (2021)

[26]: Rodas-Osollo et al. (2017)

6.1.1 Regarding ISD

For decades, the dream of the **Artificial Intelligence** (**AI**) community has been to use computers to harness human knowledge, experience and common sense to solve problems and meet the needs of the people. While there have been impressive advances in **AI**, the application of these capabilities has been limited. Computers still fall short of human intelligence and reasoning. Intelligent tools can be powerful, but they are only as effective as their programming. A deep understanding of a domain and the ability to capture all of its knowledge is the key to developing **AI** that can truly replace human intelligence. This understanding, known as an **ISD**, is essential for determining the knowledge and functional requirements for building intelligent solutions. It also involves converting *tacit a priori knowledge* into an *explicit*, representable form that can be used to train intelligent tools.

As a consequence, it is important to be aware of the characteristics of an **ISD**:

- The *knowledge* in them is mostly *tacit* and *informal*, and even some formal knowledge. It belongs to one or more specialists in that particular field. This *knowledge is shaped by their particular background*, interests and expectations. It is not possible to have complete knowledge of the whole domain, this *knowledge is partial*. Moreover, this *knowledge is often inhomogeneous*, of *varying specificity* and *incomplete*. In essence, it is knowledge that is both *tacit* and *explicit*, *informal* or *formal* and depends on the expertise and characteristics of the specialist;
- Working with these domains requires the presence of one **Cognitive Analysts** (**Cg.An**) or more, who are generally not involved in the domain and who are responsible for knowledge elicitation tasks or the elicitation of knowledge requirements;
- The needs or problems embedded in them require tangible or intangible cognitive products or solutions, which may be technological solutions or a set of knowledge or even knowledge requirements that can explain behaviour or solve or address a particular and unrepeatable situation.

The above description shows that it is a complex and challenging task to extract truly useful information or knowledge from an **ISD** and, coincidentally, the characteristics of the domain to which the GCC problem belongs. It requires **Explicit Knowledge** to implement an appropriate *VR-OTS* as its solution. In addition, not having enough *a priori knowledge* to train machine learning tools can make the **Cognitive Analysis** of this problem more difficult. It would be worth assessing whether any *knowledge discovery process* is necessary to gather knowledge. Regardless of the assessment, all of the above characteristics make the **CMCg.I** *model* and facilitate the work on an **ISD**.

6.1.2 Regarding CMCg.I model

The **CMCg.I** is a simplified representation of the GCC situation. It is used to understand, explain or predict its behaviour. It can be a set of concepts or ideas described by documents, mathematical formulation or computer simulation. The purpose of a model may vary depending on the domain in which it is used. In some cases, a model may be used to represent a real-world system as accurately as possible for the purpose of prediction or decision support. In other cases, a *model* may be used more abstractly to explore or understand complex **Tacit Knowledge** (**TK**). In both cases, the goal of the *model* is to provide a useful and informative way of thinking about a problem and its area in order to find the best way of tackling the problem. Thus, while simplifying or abstracting away other aspects that are not relevant or well understood, the purpose of the *model* in this case is to capture the essential characteristics and behaviours of the GCC situation and its domain. The *model* is therefore useful because it *helps in the organisation and understanding of complex pieces of knowledge* or components by breaking them down into smaller, more manageable pieces. It can be used to *identify the key variables and relationships within the* **Cognitive Architecture** (**Cg.Arch**). This can help to *understand how the entities and actors in the domain work*, and how they might behave under different conditions. This model can also be used to communicate the situation to others, *providing an environment for cognitive dialogue and discussion*. Therefore, the **CMCg.I** is an *open and flexible model* designed to help individuals and organisations to address problems and needs in the **CE**. As mentioned in Chapter 4, the *model* is made up of four main components: the **ad hoc Collaborative Network** (**ahCN**), the **Cg.Arch**, the **Cg.S Provider** (**Cg.S-P**), and the **Cg.S**. The *model* aims to accurately reflect the reality of the **CE** and is able to support users in a variety of domains and situations. It has been refined and improved through use, providing consistent support for those facing cognitive problems or needs.

6.1.3 VR-OTS

[27]: Patle et al. (2014)

[28]: Brambilla et al. (2011)

[29]: Reinig et al. (1999)

VR-OTS are computer-based tools used for operator training in process industries or other human activities [27–29]. These simulators typically have one or more graphical user interfaces that allow trainees to interact with them by using emulated tools or dashboards. A *VR-OTS* offers visualisations to train operators in various virtual scenarios of a process, testing alternative operator actions, solving technical problems, changing controller settings and following standard procedures. Through the use of a *VR-OTS*, trainees can practise and improve their skills in a safe, controlled environment before applying them in the real world.

Specifically, a VR-OTS offers the following benefits:

- Significantly improves operator understanding and skills of a process or complex activity;
- Training time for new operators can be reduced and good operator performance achieved more quickly; this has a positive impact on training costs;
- Accessing *VR-OTS* in the plant environment allows for repeated and accelerated training, leading to improved operator skills;
- Incorporating *VR-OTS training* into a quality system of the plant is crucial for compliance with regulatory standards, such as Subpart B of the **Code of Federal Regulations**.[2]

2: The Code of Federal Regulations (Title 21, Volume 8, Part 820—Quality System Regulation) is a set of regulations, issued by the U.S. Food and Drug Administration (FDA), that pertains to food and drugs. These regulations cover everything from the manufacture, packaging, labelling and distribution of food and drugs, to the safety and efficacy of these products. They also include guidelines for the testing and approval of new drugs, as well as the recall of unsafe products. Title 21 is updated regularly to reflect new scientific and technological advancements, as well as changes in federal laws and policies.

Identifying the actual training needs, from the perspective of the operator, is a crucial aspect of the design and implementation of a *VR-OTS*. This helps to ensure that the *VR-OTS* selected is the best fit for the intended training purposes. Once the training needs have been identified, the *VR-OTS* can be configured and prototyped accordingly. It is important to regularly assess and evaluate the effectiveness of the *VR-OTS* in meeting the identified training needs and make any necessary adjustments to the configuration as needed.

6.1.4 GCC training programme

Through training, development and ongoing coaching, GCC is committed to enhancing the skills and capabilities of its employees. To support these efforts, the company uses IHunch as an internal platform to identify opportunities for improvement, to generate impactful ideas and **foster innovation**[3]. IHunch assists in the ranking and scoring of these ideas so that GCC can determine which ideas can be effectively implemented. For example, as part of its *digital transformation*, GCC identified several specific needs related to operator training at its plant in Ciudad Juárez, Chihuahua, Mexico. These needs included improving the skills and abilities of the concrete operators, addressing errors made by both new and experienced operators, documenting operator training, reducing errors in the concrete mix due to poor consideration of slump and updating the operator operating manual. In response to these needs, GCC is determined to innovate its operator training programme on the basis of the **CMCg.I** *model*. This is particularly challenging as Ciudad Juárez is GCC's largest plant bordering the USA and has the highest demand for concrete production. Systematic conceptualisation and evaluation of the identified training needs to ensure a high level of accuracy in the execution of the model's activities and tasks is required for the successful implementation of a *VR-OTS*.

3: GCC uses a high impact framework for foster innovation and a range of tools. These include agile philosophy, lateral thinking, design thinking, user experience and journey mapping. An internal platform for fostering a culture of innovation, IHunch, is also used. This platform identifies opportunities through the integration of continuous improvement, high impact ideas and innovation. It is a useful tool for the ranking of ideas and the assessment of what can be implemented or scaled across the company.

When the project started, the specific solution needed to implement a *VR-OTS* was unknown. In order to identify the best solution, it was first necessary to thoroughly study and characterise the domain and perform a **Cognitive Analysis**. It was through this process that GCC decided to focus the project on training the mixing operators at the Juárez plant. A team of between two and ten operators is responsible for preparing concrete mixes at this plant. These operators are responsible for both field operations, such as performing tasks directly on the machine, and control panel operations, such as valve adjustment and sampling. The integration of the model began at this point.

6.2 Integrating the CMCg.I model into the GCC training case

The beginning of a model integration may be informal and involve several meetings to gather information and understand the problem that needs to be addressed. The purpose of these meetings is to determine whether the **Cg.S-P** team has the knowledge, experience and technological infrastructure to find a *suitable solution* for the problem. If the team does not have the necessary resources, it may be necessary to decline the project. However, if the team has the necessary experience and infrastructure, and it is decided that the project should be formally launched, the previous meetings will be considered as progress in the project, particularly in terms of gathering information and knowledge.

6.2.1 Pre-session before the start of the Cg.S project for the GCC training domain

During the pre-session or pre-sessions, the organisation with the need or problem, typically a team of specialists in the GCC training domain, discuss their motivations, needs and pain points with the **Cg.S-P**. The format of the interview is flexible and depends on the experience of the **Cg.S-P**. After the pre-session, the **Cg.S-P** will take time to determine whether to proceed with the project, the timeline, the budget and other details. During this time, the **Cognitive Analysis** *team* will review the recordings and information gathered during the pre-session and identify key verbs, actions, terms and phrases that are important to the organisation's needs. To identify these key "tokens", the *team* listens to the recording of the pre-session multiple times and pays attention to the number of times certain words are repeated, as well as the emphasis or intonation with which they are spoken. This information is used to create a list of keywords and to classify them using a hierarchy, such as **Bloom's or Marzano's**[4] taxonomies to understand the cognitive processes involved in the organisation's current and desired actions. This process of gathering and analysing information is an ongoing cycle that takes place throughout the project. Based on the analysis of the first recording and the hierarchy of terms in the constructed list, it was determined that the organisation in need had a knowledge gap and needed to find an *innovative solution to improve its training*.

4: Bloom's and Marzano's taxonomies are designed to classify different levels of thinking. By using these taxonomies to classify the words and phrases in an interview, the level of importance and complexity of the interviewee's thoughts can be identified. This can help an outside observer to understand and empathise with the interviewee. Marzano's taxonomy was developed after Bloom's and was created to address the shortcomings of the widely used Bloom's taxonomy. However, both taxonomies remain valid. In some cases, they can be used in conjunction to provide a more comprehensive understanding.

In summary, the problem is related to the expertise of master operators in an **ISD**, and it was determined that the optimal solution for the training programme was a *VR-OTS*. Once this decision was made, the integration of the model formally began, with the GCC company, which had the problem, being treated as the **Beneficiary**. The process involved significant effort and hard work to arrive at this conclusion.

Therefore, the integration of the **CMCg.I** *model* was organised specifically for the situation in GCC, and its components were formalised as follows:

- **ahCN**: Internal and External Knowledge, Information Sources and the **Cg.S-P** *team*;
- **Cg.Arch**: Semantic Base and Cognitive Element sets;
- **Cg.S-P**: **Cognitive Analysis** *team*, **Cg.S Architect** and *different types of providers*; and
- **Cg.S**: Products, Services and Processes.

The **Cognitive Analysis** *team's* main task is to identify the components necessary to support the *VR-OTS* to implement a solution promptly. This identification process involves examining the *entities or actors* involved in the problematic situation and understanding their identity, nature, characteristics, potential and circumstances. It is important to note that identification does not simply mean taking a quick look, but actively working to gather information. The necessary components for success may be modified during the **Cognitive Analysis** and implementation process, as the aim is to find a solution that satisfies the **Beneficiary**. This flexibility is not a disadvantage, but rather an important aspect of working on a problem within an **ISD**, where the solution is often unique and requires adjustments to the activities, actions and process being used.

6.2.2 Identification of all ahCN components

First, it is desirable to identify as much of the **ahCN** as possible. Projects of this type often require changes in all components over their lifetime. For the GCC training domain situation, most of the *actors or entities* of the **ahCN** component were identified in fewer than five working sessions. An extract of the index matrices of the **ahCN** component of the **CMCg.I** *model* can be seen in the set of matrices in **Table 6.1** (matrices I, S, E and P). It is necessary to emphasise that, although the information in the matrices is subject to change throughout the project, it is important to fill in as much as possible from the first formal working session as it gives certainty about the work to be done.

6.2.3 Building the Cg.Arch

Cg.Arch is the foundation of a **CE** project and plays a crucial role in the implementation of the *VR-OTS*. In the following subsections, key aspects of this **Cg.Arch** will be highlighted.

Cognitive Analysis for the GCC training case

The **Cognitive Analysis** carried out a variety of activities, such as interviews, meetings, discussions and reviews to gather and represent various types of knowledge and information, including glossaries, lexicons, conceptual models and ontologies. To create an ontology for the *GCC training* domain, the knowledge of domain specialists was gathered through seven interviews, and 98 symbols related to the domain were recorded in a Microsoft Excel document, which served as the basis for the **Knowledge of Domain on an Extended Lexicon** (**KDEL**). This document also included acronyms, references and synonyms, which were classified into definitions, objects, subjects and verbs. The concepts were then *validated* by **Domain Specialists** (**DS**) and the **Beneficiary** until a shared vocabulary was established and any requested modifications were made to ensure that the **KDEL** accurately reflected the existing knowledge in the domain. Based on the **KDEL**, a *conceptual model* depicted in **Figure 6.1** was developed. It was important to validate this model with all parties involved in implementing the solution, as the first validation identified any necessary improvements for subsequent iterations of the modelling process. Once the *conceptual model* was validated, the development of the *GCC training ontology* could begin (see **Figure 6.2**).

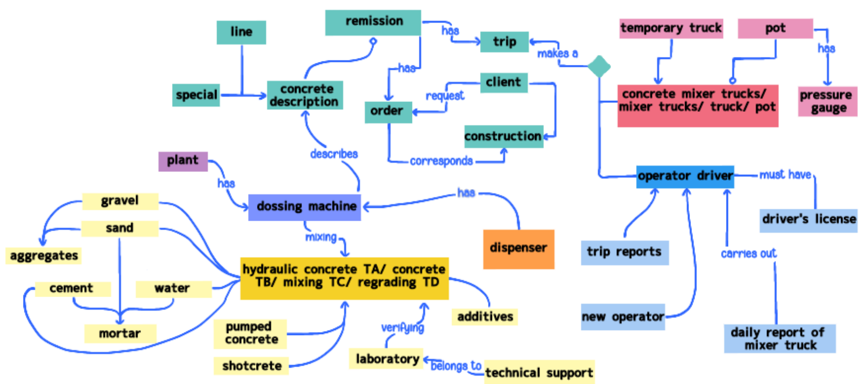


Figure 6.1: The figure shows an extract of the **conceptual model**. It graphically describes the need or problem of *GCC training* and all related concepts.

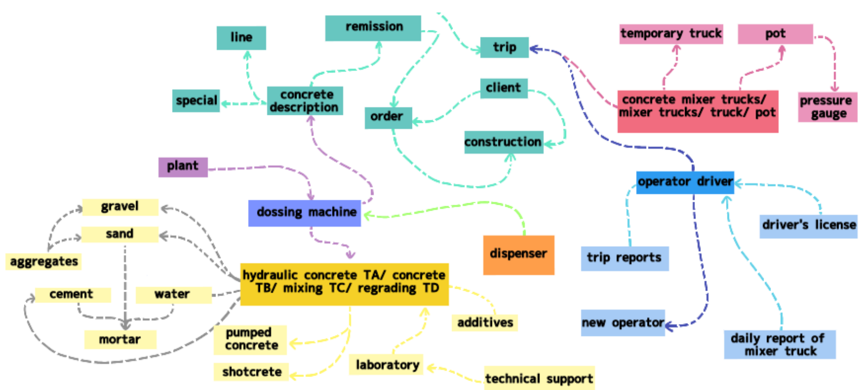


Figure 6.2: The figure shows a **simplified ontology** of *GCC*. The illustration shows how entities are categorised, their attributes and the links between them in the *GCC training programme domain*. This ontology serves as a catalogue of relevant terms related to training, enabling a streamlined understanding of the domain and an explicit organisation of information and knowledge.

From needs to requirements

In ensuring customer satisfaction, requirements or stated needs and expectations play a crucial role. It is important to identify and understand these expectations. They go beyond the satisfaction of a need and include the overall experience that the customer wants. This can be seen in everyday scenarios, such as a meal in a restaurant. Initially, the customer's need may only be to satisfy their hunger. However, if the restaurant provides additional experiences, such as live music and personal attention, the customer's expectations change. The customer's satisfaction may then decrease, even though the food is just as good, if these experiences are removed. In initiating the project with GCC, the collective consciousness has always contained the huge significance of the above, and a lot of time and experience was invested in establishing the requirements with GCC. This was to ensure that the **Cg.S-P**, the **Cognitive Analysis** and *GCC teams* would see, understand and act as one. Some of the aspects of these needs, directly linked to the *VR-OTS*, that were turned into requirements are as follows:

- ▶ The solution is to modernise the training programme for cement mixer operators. A *VR-OTS* will streamline the training process. It will be less time-consuming and less expensive. It will provide a virtual simulation of the mixing process. This will accurately reflect the realistic conditions identified by the **Cognitive Analysis**.
- ▶ The solution will be designed and implemented using an agile approach, and will be an adaptable solution that can accommodate future plant changes and allow for easy adjustment of mixing process parameters. In addition, the *VR-OTS* design will serve as a framework for the rest of the Cementos de Chihuahua group's plants.
- ▶ For tasks such as mixing types A, B and C, setting conditions and performing various secondary actions, the *VR-OTS* contains specific training scenarios. The training process is divided into three parts: Preparation, Procedural Actions and Completion, which includes the submission of a report for evaluation by an instructor or tutor. A critical parameter in assessing the success of the process is the transfer of training—the skills acquired by the operator through the *VR-OTS*.
- ▶ The *VR-OTS* will provide functions for mixing raw materials under pre-defined environmental conditions and must record and report all data it processes for further interpretation and process control. It will also provide moulding process instructions, such as standard and exception operating procedures, control setpoints and other mixing process objectives. It should also have the ability to handle new metrics or adapt existing metrics to assess additional training performance, such as reduction in training time for newly hired operators, reduction in errors after training and reduction in the need for operator pairing.
- ▶ The *VR-OTS* will have interfaces similar to real control systems, will contain 80% of the flow diagrams of the plant control process and will send messages to the trainee operator. There would be more details to share, but these paragraphs are only intended to provide an overview of the types of requirements that are generated in a cognitive project, with a focus on the **non-functional and technical requirements**[5] that often require a high level of knowledge.
- ▶ And, naturally, much more. . .

5: The full set of **non-functional and technical requirements** for the VR-OTS is available online: Y:\GCC Project\IK-Doc-Repository (accessed on 6 January 2023).

Formal defining of the architecture

The **Cognitive Analysis** is completed with the verification and validation of all "artefacts" generated in the different activities by the **DS** and the **Beneficiary**. The **Cg.Arch** is completed with the formal definition of **Table 6.2**. The formal definition involves the correct identification of the members of the *semantic base*—partial or complete, but clear and meaningful representations of the knowledge relationships—and of the *set of cognitive elements*—the set of entities, definitions, rules and all types of knowledge that may be relevant to the solution. In this case, the *semantic base* is the *set of all knowledge representations* generated by the activities and actions performed. For example, the *analysis of the interviews* may have produced *conceptual models* (**Figure 6.1**), *ontologies* (**Figure 6.2**), a compendium of functional and non-functional requirements, and other "artefacts" that are meaningful to the **DS** and the **Beneficiary**. The set of cognitive elements includes *all the rules* obtained through the reasoning of the **DS** about meaningful concepts and requirements.

6.2.4 Identification of Cg.S-P

The advent of the **CE** has created a constant state of change for organisations, requiring them to adopt technologies that enable them to adapt or risk survival. To successfully navigate this transformation, organisations need to work with a **Cg.S-P** who can facilitate the process. Various factors can delay transformation of an organisation, and the more their well-being or business is at stake, the greater the risk. As a **Cg.S-P**, it is vital to offer effective **Knowledge Management** services to help organisations to find and capture the knowledge they need. This may involve the use of technology such as online resources or databases, as well as the provision of specialist cognitive support methods and guidance. The **Cg.S-P** should work closely with the organisation in a problem situation to understand its needs and *tailor* its high-quality **Cg.S** accordingly. The identification and selection of team members is the responsibility of the **Cg.S Architect**, who is the Team Leader and a member of the **Cg.S-P** *set*. The team should have the necessary skills and expertise to propose, design, develop and implement the project. These skills and expertise may come from *technical and scientific actors*. The main task of the **Cg.S-P** is to perform a **Cognitive Analysis** to determine which *actors* should be involved in the implementation and development of the **Cg.Arch**. It is not necessary to have a formally defined **Cg.S-P** *team* at the start of the project, as this component of the model is also flexible and depends on the nature of the project. Conveniently, the **Cg.S-P** *team* is assigned early on in the project by the **Cg.S Architect**, with the approval of the **Beneficiary**. It is important to have a clear understanding of who will be involved in the project from the outset to ensure that the necessary skills and experience are available in order to ensure successful completion of the project. For the GCC project, the *team* consisted of 10 people and included a **Cg.S Architect**, three **Cg.An**, two *Business Analysts* and four **IT** *Engineers*.

6.2.5 The proposed Cg.S in the GCC training domain

Upon completion of the **Cognitive Analysis**, GCC and the **Cg.S-P** determined that the best solution for their needs was to develop a *VR-OTS*. Prototyping was identified as a valuable tool in the process of implementing a *technology* **Cg.S**, as it allows a nearly complete solution to be tested and analysed before it is finalised. *Agile prototyping* was used to quickly develop a high-quality prototype. **Unity Pro**[6] software was used to design the *VR-OTS*, including its graphical user interfaces, control schemes and functions. The *VR-OTS* was able to simulate the

6: Unity Pro is a paid version of the Unity game engine, which is used to develop video games and other interactive 3D content. It includes additional features and capabilities not found in the free version of Unity, such as advanced rendering and physics options, support for a wider range of platforms and access to source code. It is typically used by professional game developers and studios.

actual concrete mixing process, allowing trainee operators to practise in a virtual environment that closely resembled real conditions.

Prototyping is particularly useful in virtual reality as it allows for experimentation and helps to make abstract concepts more concrete. **Figure 6.3** illustrates the value of prototyping in virtual reality. It can be difficult to effectively communicate and understand complex virtual reality experiences through verbal or visual explanations alone. As a result, prototyping can help to clarify the overall project and make it more understandable (see the Appendix D.5 on page 205 for more information on prototyping).

Figure 6.3: Prototype of a GCC-VR project. The figure shows images related to the testing phase of the prototype of the GCC virtual reality project.

The prototype was completed within eight weeks and tested with experienced plant operators who provided feedback and suggested improvements. These changes were implemented and the *VR-OTS* was deemed ready for adoption as the new training programme. However, GCC requested that the *VR-OTS* be evaluated on a long-term basis with new trainees to fully understand its benefits. The *VR-OTS* has proven to be very flexible, allowing experienced operators to easily adapt the training process with minimal adjustments.

6.3 Endnotes for the GCC training domain solution

This chapter communicates how the **CMCg.I** *model* can be used to support the design of a *VR-OTS* as a **Cg.S**. The design process began by gathering and analysing the needs of the *VR-OTS system* and identifying the functional elements required to meet those needs. An assessment was also made of the expertise required for the training, presentation and integration of the solution. The use of the **CMCg.I** *model* for the construction of the *VR-OTS* will ensure that all previously identified requirements are met. However, depending on the preferences of those involved in the implementation of the **Cg.S**, the results may vary. It is therefore important to have reliable access to accurate and relevant information about the domain, such as the plant and mixing process conditions. This *can affect the quality and usefulness of the solution*. The *VR-OTS prototype* should be tested and evaluated at each stage of development using the *agile approach*. It should ultimately be validated through long-term testing with different operators. Initial results show that both experienced and novice operators can easily understand and effectively use the *VR-OTS* according to the instructions provided in the manual. The *VR-OTS* is also adaptable to operational changes, such as changes in equipment or raw materials, making it more widely applicable. However, adjustments to the user interface design, and possible reconfiguration of connections or re-parameterisation of the *VR-OTS*, may be required in the event of significant changes to the plant structure.

There is an ongoing debate about what a *smart city* will look like and which country will be home to the first one in the current **CE**. What is clear, however, is that the *transition to a cognitive society* will require *overcoming various technological challenges* and *expertise*, as well as *economic considerations*. This transition will not be easy and will involve significant changes at various levels. It is therefore important to work with cognitive specialists, also known as **Cg.S-P**. These *providers* can use models and tools, such as the **CMCg.I**, to help achieve successful cognitive transformations. The implementation of the *VR-OTS training programme* for cement mixer operators at GCC is an example of such a transformation. This required time and economic effort, but with the help of the **Cg.S-P** using the **CMCg.I** *model*, the *VR-OTS prototype* was successfully implemented within the estimated timeframe, and it met all the requirements of GCC. The company is pleased with the solution, which not only guarantees the desired quality for its customers, but also makes the teaching and learning process more efficient for its operators. The use of *virtual reality allows for cognitive flexibility* and a more efficient transfer of knowledge from digital documents and virtual situations, reducing the time and number of examples required. In the end, the solution, while seemingly simple, was an important and satisfying activity for GCC, providing a **Cg.S** that met their specific training needs and ensured customer satisfaction.

6.4 Chapter summary and reminders

This chapter has shown that the transition to a *cognitive society* requires overcoming several technological and economic challenges. Partnering with experts in the field, known as **Cg.S Provider**s, who can use models and tools to support successful cognitive transformations, is crucial. An example of this transformation effort is the prototype for *Virtual Reality On-the-job Training Simulator (VR-OTS)* training of cement mixer operators at Grupo Cementos de Chihuahua (GCC). The **Conceptual Model for Cognitive-Innovation** *model* was used to gather and analyse requirements, determine the necessary functional elements and guide the training. The resulting prototype is effective and can be easily used by both experienced and novice operators. The *VR-OTS* implementation met the requirements of GCC and achieved cognitive flexibility and efficient knowledge transfer, providing a solution that met specific training needs and ensured the satisfaction of GCC.

Table 6.1: A fragment of the set of index matrices I, S, E and P corresponding to the *ahCN component* of the *GCC-CMCg.I model*.

Actors and entities of the internal knowledge index matrix (I)

Label	Piece of knowledge	Description	Location	Source	Contact
i_1	RecordX	CIO interview	GCC-IK-Audios-Rep	CIO BF	bf@gcc.mx
⋮	⋮	⋮	⋮	⋮	⋮
i_{32}	OWL-GCC	Ontology file of GCC domain	GCC-SI-Doc-Repository	CIO BF	bf@gcc.mx

Actors and entities from sources of information index matrix (S)

Label	Piece of information	Description	Location	Source
s_1	NMX-C-155-ONNCCE-2014	The concrete normative for...	GCC-SI-Doc-Repository	https://www.onncce.org.mx...
⋮	⋮	⋮	⋮	⋮
s_{27}	Paper12	Towards design guidelines for...	GCC-SI-Doc-Repository	https://www.sciencedirect.com/science/...

Actors and entities of the external knowledge index matrix (E)

Label	Piece of knowledge	Description	Location	Specialist	Contact
e_1	RecordRV1	Record interview with RV...	GCC-EKIM-Rec-Repository	Angel S	angel@stragile.com
⋮	⋮	⋮	⋮	⋮	⋮
e_{23}	SurveyRV	Use of RV for training	GCC-EKIM-Doc-Repository	Leny S	lsawyer@numc.edu

Actors and entities of the Cg.S-P index matrix (P)

Solution provider	Name	Role	Contact
p_1	Jorge Rodas-Osollo	Architect/Analyst	jr@mls.edu
⋮	⋮	⋮	⋮
p_9	Andrea Martinez-Perez	Business Analyst	am@stragile.com

Table 6.2: A fragment of the set of index matrices corresponding to the *Cg.Arch component* of the *CMCg.I model*.

All knowledge representations index matrix (R)

Label	Semantic elements: representation	Description	Location	Source
r_1	Conceptual model v1	Conceptual model emerging from validation s. . .	IK-Conceptual Model-Repo. . .	Validation session 4 Oct
r_2	Record VSOct 04	Record of validation section	IK-Rec-Repository	Validation session 4 Oct
r_3	FileSPOOct 04	Boxplots, and bar charts	IK-Doc-Repository	Validation session 4 Oct
⋮	⋮	⋮	⋮	⋮
r_{32}	OWL-GCC5v	Ontology file of GCC domain 5th version	IK-Doc-Repository	Validation session 10 Oct

Documents of rules index matrix (U)

Label	Cognitive elements: rules	Description	Location	Source
u_1	RulDctov1	Rules document 1st version	IK-Doc-Repository	Validation session 25 Oct
⋮	⋮	⋮	⋮	⋮
u_{13}	ReqDctov1	131 requirements: 79 functional and. . .	IK-Doc-Repository	Validation session 30 Oct

7 Interesting CMCg.I Support in Other Domains

This book could offer many more chapters to share a wide range of experiences through case studies of applying the **Conceptual Model for Cognitive-Innovation** (**CMCg.I**) to support the transition to the **Cognitive Era** (**CE**). However, as this chapter comes before the book's conclusions, two highly acclaimed successful experiences of using the model have been carefully selected and succinctly summarised. These experiences come from the different fields of industry and social & health care. These summaries aim to emphasise that, although the **CE** has only just begun and cognitive technology is developing at an accelerated pace, there will undoubtedly be countless success stories to tell throughout this exciting adventure.

7.1 Industry experience

FLUTEC is an innovative international company specialising in the manufacture of custom-designed refrigeration, ventilation, air conditioning and other modules for commercial customers. FLUTEC has been committed to providing personalised **HVAC**[1] solutions that meet the specific needs of their customers. Although these modules have similarities, each project is unique, which can result in higher costs.

To ensure that the proposals met the customer's expectations, a requirements document called the **DNA**[2] was used. However, completing the DNA was a complex process involving several people, resulting in delays and errors in the proposal, which put FLUTEC at a disadvantage.

To maximise the benefits of a project, it is essential to improve the project process. The HVAC project process encompasses many aspects, from initial design specifications to final delivery. Just one wrong decision can affect the overall project time and profitability. FLUTEC is committed to maintaining a competitive edge in the dynamic HVAC market by improving proposal turnaround times and project budgets. These factors have a significant impact on the quality of the design process and other critical aspects that contribute to the success of projects. The commitment to improving these aspects reflects an understanding of the importance of delivering high quality products and services that meet the specific needs of its customers.

Is the implementation of the CMCg.I model convenient?

Continuous innovation is essential for the survival of a company in a dynamic market such as air conditioning. To this end, FLUTEC has decided to embrace the **CE** and pursue a **Cognitive Solution** (**Cg.S**). In order to start the process and work on the **CMCg.I** model (for more information on **CMCg.I** activities, please

1: **HVAC** (Heating, Ventilation and Air Conditioning) systems use technology to regulate the indoor environment in order to provide a comfortable and healthy place to live or work. They are widely used in residential, commercial and industrial buildings, as well as in vehicles such as cars, buses and aeroplanes.

2: **DNA** is an acronym used by FLUTEC as a guide for designing HVAC systems to meet specific customer needs. The acronym "DNA" draws an analogy to deoxyribonucleic acid, the genetic material that carries the blueprint for the development and functioning of living organisms. At FLUTEC, the DNA document contains the comprehensive information and knowledge required to design and implement an HVAC system that meets the customer's specific needs.

see Chapter 4 on page 51), the **Cg.S Architect** initiated a series of interviews to gain familiarity with the domain. During these interviews, it became clear that there were different opinions about DNA management and its importance, which boiled down to two approaches: DNA is important or DNA can be ignored. As a result, it was pointed out that a DNA document is informal and that many DNA documents from older projects have left out too much important information.

The process of specifying the HVAC domain started with the analysis, understanding and conceptual modelling of seven main processes: heating, cooling, humidification, dehumidification, cleaning, ventilation and air movement. These processes are accompanied by five complex tasks that require knowledge, including establishing basic specifications, analysing building characteristics and airflow patterns, selecting appropriate components, and analysing control systems.

A **Cognitive Analysis** of the **CMCg.I** model was conducted, which included recording, transcription, interview analysis, construction of the **Knowledge of Domain on an Extended Lexicon** (**KDEL**) to gain further domain knowledge, and conceptual modelling. In addition to information on prior processes and tasks, additional information was collected on FLUTEC's business activities, basic information about the importance of DNA in the design of refrigeration modules and the use of DNA to generate new proposals for potential customers.

The **Cognitive Analysis** revealed disorganised and incomplete data and information, as well as **Distributed Tacit Knowledge** (**DTK**) within an **ad hoc Collaborative Network** (**ahCN**), which is a significant challenge. This indicates that the empirical guidance, referred to as DNA, does not provide the necessary knowledge requirements to design HVAC modules that meet specific customer needs. Due to its empirical and informal nature, there was often a weak communication bridge between all *actors* in the **ahCN**, leading to delays, iterations, changes, adjustments and costly problems.

In summary, the analysed results showed that the HVAC design process domain had the characteristics of an **Informally Structured Domain** (**ISD**). The **Cg.S Architect** continued the process to establish the **Cognitive Architecture** (**Cg.Arch**) indicated by the **CMCg.I** model to find **Cg.S** alternatives. After analysing the information obtained from the process, it was confirmed that the **CMCg.I** was a convenient model, and thanks to this model, it was possible to create a prototype of **Case-Based Reasoning (CBR)**[3] to meet the company's needs (mainly the reduction of the time needed to create proposals).

3: Case-Based Reasoning (CBR) is a problem-solving approach that involves solving new problems by finding similar past cases and adapting their solutions to fit the new situation. In other words, CBR is a process of problem-solving that relies on retrieving and adapting solutions from a set of previously solved cases. CBR involves four main steps. The first step is to retrieve similar past cases from the case base. The second step is to reuse the solutions from those similar cases to solve the current problem. In the third step, the solution(s) are evaluated and refined as needed. Finally, in the fourth step, the new solution(s) and the solved problem are added to the case base for future use. By using CBR, problem-solving can become more efficient and effective, as the solutions are based on successful past cases. CBR is used in many fields such as expert systems, intelligent agents, decision support systems and machine learning.

7.2 Working the CMCg.I model to obtain a prototype for FLUTEC

In light of the above information, and with the aim of providing FLUTEC with an efficient **Cg.S**, the **CMCg.I**'s suitability to guide the activities that formalise knowledge assets, the transfer of **Tacit Knowledge** (**TK**) to **Explicit Knowledge** (**EK**), the identification of areas for improvement and the enablement of the **Cg.Arch** for the development of the CBR prototype was confirmed. Accordingly, the **Cg.S Provider** (**Cg.S-P**) indicated that the model activities for integrating the

Cg.Arch that would underpin any Cg.S proposal would focus on the following items:

Analysis of the DNA guidance document. This Cognitive Analysis highlighted the shortcomings that hinder the proper development of HVAC. This document is improvised, informal and lacks a global vision of the project, so it is necessary to describe the significant assumptions and conceptual relationships of all FLUTEC knowledge. Deficiencies identified in the DNA included disorganisation, incorrect, irrelevant, ambiguous, missing or poorly recorded information (incorrect attributes, informal descriptions and unclear knowledge requirements).

To overcome these shortcomings, the Cognitive Analysis aimed to formalise the *empirical DNA domain* and transform it into a *new and formal solution*. This involved eliciting knowledge, refining the conceptual relationships and assumptions and organising the information in a clear and concise manner. In doing so, the Cognitive Analysis will improve the usability of the DNA guidance document and provide a solid foundation for the successful development of the HVAC project.

Specialised explicit training. Before performing the Knowledge Management on a Systematic process for Requirements Engineering (KMoS-RE) indicated in the CMCg.I model, FLUTEC engineers struggled to recognise the significance of a Cognitive Analysis for identifying knowledge requirements. This led to a lack of understanding of certain elements or concepts in the HVAC domain. However, after adopting the new way of working, the Domain Specialists (DS) (from FLUTEC) underwent training during the Cognitive Analysis, allowing them to internalise new EK, reduce ambiguity and improve their quality of work. This experience taught them that:

- Knowledge requirements elicitation is best approached in a systematic manner;
- the CMCg.I model is an effective tool for transferring knowledge; and
- FLUTEC's preconceived and tacit ideas or expectations of a project can lead to redesigns after delivery, which can be avoided if made explicit during the project's development.

Reducing the learning curve for the HVAC domain. The activities and process indicated by the CMCg.I model involved the formalisation of HVAC domain concepts such as attributes, concepts, relationships between concepts and basic constraints (such as HVAC design and budget project characteristics). This formalisation, and tasks such as externalisation, transfer and consensus building, were carried out within the ahCN to integrate a Pieces of Knowledge Matrix (PoK-M) that minimised the symmetry of ignorance. As a result, the HVAC learning curve was significantly reduced from several months to a few weeks. It should be noted that the Cg.S-P confirmed that the DNA document was not useful and that, taking into account the activities and processes indicated by the model, the Cg.S-P was able to obtain a Cg.Arch.

A CBR to support fast delivery of proposals. The establishment of an appropriate Cg.Arch allowed the knowledge and experience of the ahCN to be used. This knowledge was managed explicitly and formally, allowing for a clear understanding of the project's ISD, and its assimilation by the Cg.S-P enabled the

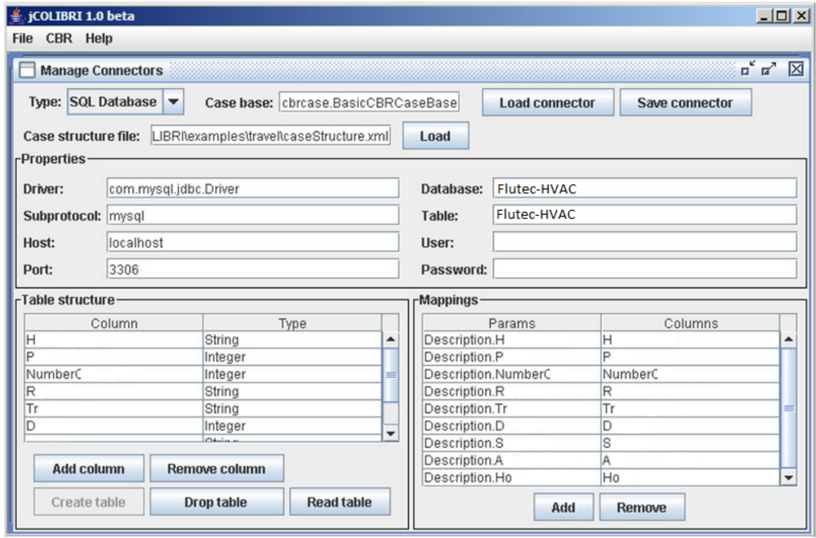


Figure 7.1: **jCOLIBRI CBR-FLUTEC connector configuration.** The jCOLIBRI framework provides a user-friendly graphical tool for configuring connectors that can load case bases from various formats. This figure demonstrates how the tool can be used to assign attributes of a case structure to specific columns within a designated table for database configuration.

development of the Cg.S (the case-based reasoning) prototype. The prototyping process for the Cg.S, which employs case-based reasoning, was developed using the three-stages: pre-model, pre-design and prototype. For more details about the prototyping process, please refer to Appendix D.5 on page 205.

The development involved identifying the most important attributes according to the HVAC design DS. These attributes were weighted according to their importance to integrate them into vectors that combine attribute-weights and define the set of vectors that form a robust case-base. The case-base, documents, specifications and all the essential components necessary to develop a CBR prototype (using jCOLIBRI[4], see Figure 7.1) were validated by FLUTEC DS and, finally, the CBR prototype was completed. It is worth noting that the presentation and testing of the prototype exceeded the company's expectations, as it was already evident how quickly it was possible to identify the existence of a previous project similar to the requirements of the potential new customer. This streamlines the design of blueprints and the determination of specifications, thus reducing the time required to develop a new proposal.

4: **jCOLIBRI** is a framework in Java that helps developers to create CBR applications through specialised methods using several information retrieval or information extraction libraries such as Apache Lucene, GATE... It simplifies development by allowing the reuse of previously designed systems. It uses a CBR ontology and problem-solving methods that can be customised. It focuses on reusability, flexibility, extensibility and ease of use, separating problem-solving methods from the domain model for more efficient reasoning and accurate knowledge representation. This framework has been developed to facilitate academic research in the field of CBR. It is important to note that it has only been used for prototyping purposes and is not intended for commercial use. Although the framework is versatile and easy to use, it is desirable and encouraged to develop a new tool, with a modern user interface, to provide an optimal CBR experience for end users and one that can be used on all the different operating systems used today.

7.2.1 Reflection on the industry experience

The main objective of the prototype was to improve FLUTEC's ability to reduce the time needed to identify a correlation between a potential customer's expectations and the blueprints and other specifications of a previously implemented HVAC design. After testing, the CBR prototype proved to be effective in reducing the time needed to find correlations, resulting in faster delivery of budget proposals for new HVAC designs to potential customers. Customer satisfaction feedback and the usability of the proposed Cg.S were analysed, concluding that the CBR prototype met 97.65% of customer expectations. In other words, the success of the project ultimately translated into satisfaction for FLUTEC.

In summary, the activity guidance provided by the CMCg.I model, combined with the systematic KMoS-RE process, supported the implementation of a robust Cg.Arch that captured and effectively utilised FLUTEC's expertise. This ensured a clear understanding of the project **ISD**, resulting in the CBR prototype and a new and improved DNA document.

Experience has shown how important it is for the **Beneficiary** of a **Cg.S** to be aware that the more the focus is on the tangibles of a solution, the more important the requirements become. This is because there are many assumptions that the **Beneficiary** has that can cause the **Cognitive Analysts** (**Cg.An**) to spend more time defining and negotiating requirements. If the requirements elicitation is not done well, likely, the customer will not be satisfied with the implemented **Cg.S**.

On the other hand, it is a disadvantage for FLUTEC to be dependent on the knowledge of its **DS** and not to know when this **TK** will no longer be available. Therefore, a **Cg.S** containing the **TK** elicited by case-based reasoning helps to reduce this disadvantage considerably. Finally, the in situ tests confirmed that the empirical process previously carried out by FLUTEC is essentially the same as CBR, but efficient (memory, knowledge and experience of its HVAC **DS**). The realisation of the prototype and the new and improved DNA document demonstrate FLUTEC's commitment and dedication to innovation in order to continuously improve the service it offers to its customers.

7.3 Social & health care experience

Access to quality health services is critical to improving the well-being and life expectancy of a nation's population. In Mexico, the Ministry of Health is responsible for designing, implementing and coordinating public policies related to health services through the National Health System, which includes three levels of care. The first level serves as the primary setting for preventive care, where common diseases are detected and public health measures are implemented. Patients requiring more specialised care are referred to the second level, while those with complex illnesses are referred to the third level.

To reduce the number of patients admitted to higher levels of care, the Ministry of Health in Mexico aims to prioritise preventive medicine. This means focusing on hygiene, nutrition, vaccination and the prevention of disease and addiction. In the State of Chihuahua, diseases such as diabetes, obesity and hypertension are leading causes of death and morbidity. The Ministry of Health has therefore implemented the Family Health Leaders (FHL) strategy, which aims to prevent these diseases through preventive medicine programmes.

The FHL strategy involves appointing a leader in each family and training them to develop a personalised health plan for each family member, including vaccinations, diagnostic tests and care for the sick and elderly. In this way, the FHL strategy aims to improve the well-being of families and reduce the number of visits to second and third-level care.

However, to achieve the goals of the FHL strategy, it is necessary to harness the technology of the **CE**. This includes building a **Cg.Arch** to serve as the basis for developing a cognitive preventive medicine assistant. Such a tool would enable FHL leaders to intelligently manage their family's health plan and avoid an increase in the demand for second—and third—level medical care.

Overall, the FHL strategy represents a promising approach to preventive medicine in Mexico that could help improve health outcomes for families, reduce the burden on the healthcare system, and ultimately lead to better health for the nation as a whole.

Is the implementation of the CMCg.I model convenient?

Cognitive assistants are collaborative cognitive applications designed to enhance human capabilities, augment human intelligence and support decision-making. To support the FHL strategy, the Ministry of Health has decided to develop a cognitive assistant. This requires taking into account both **EK**, and **TK** from **DS** in various fields associated with the project, as well as **DTK** from an **ahCN**. However, the amount of **TK** was much greater than the amount of **EK**, and the latter was incomplete. Therefore, it was crucial to build a **Cg.Arch** that implements an **ontology**[5] to manage the specific knowledge of the first cognitive assistant prototype. Developing a **Cg.Arch** for a cognitive assistant requires conceptualisation, design and implementation based on **Cognitive Analysis**. It must be able to adequately reflect the **Cognitive Ecosystem** (**Cg.Eco**) of the **ISD**. It is important to note that the domain of the **ISD** is full of uncertainty and requires specialised, non-homogeneous knowledge. In everyday life, decision-making processes require extensive knowledge and optimal cognitive processes. Cognitive Assistants can help humans to make decisions and take actions by harnessing their capabilities and adapting to the dynamics of the real world, which requires the consideration of multiple perspectives. To achieve this, cognitive assistants typically perform natural language processing, machine learning and case-based reasoning induction, among other techniques. The use of cognitive assistants in social healthcare can revolutionise preventive medicine on a large scale. In Mexico, social health information is unstructured and only digitally stored in a few agencies, making it difficult for patients to access their data and leaving its management entirely in the hands of the government. Cognitive assistants that support the FHL strategy provide personalised healthcare plans and allow patients to access their data, giving them an overview of their health. This benefits both healthcare organisations and patients, enabling them to make informed decisions and take greater control of their health. In addition, cognitive assistants enrich diagnoses and social healthcare plans by allowing them to be better designed and adapted to the specific needs of each family. The information gathered by the cognitive assistants will enable the Minister of Health to make faster and more efficient cost-benefit decisions. Specifically, the primary objective is to build a semantic model that integrates **EK** and **TK** of preventive medicine to address the specific problem presented in the State of Chihuahua. This will be achieved by building a **Cg.Arch** that supports the development of a cognitive assistant capable of performing intelligent data analysis and assisting the family health manager in decision-making. Therfore, the proposed **CMCg.I** is well suited to provide the Health Secretariat with a **Cg.S** and support its FHL strategy with cognitive technology. By using a cognitive assistant, the FHL strategy can harness the collective intelligence of **DS** in different fields, optimise decision-making and improve the overall effectiveness of the strategy.

5: **Ontology** is a knowledge representation that uses a controlled vocabulary and is designed to facilitate knowledge sharing and computational reasoning.

7.4 Working the CMCg.I model to obtain a prototype for FHL

CMCg.I was used as a working strategy to develop conceptual models for each preventive action of the different programmes of the Ministry of Health. In addition, an ontology was built to accurately represent the knowledge of these actions and an inference model was developed to allow analysis. The Cg.S Architect is responsible for coordinating all the activities of the CMCg.I model by linking all the *actors* involved in obtaining the Cg.S, in particular the DS and the Cg.S-P. The first step involves a series of interviews between the Cg.S Architect, in his/her *analyst role*, and the *decision makers*. Knowledge models are then generated, verified and validated by all the *actors*. The process is repeated until the models are deemed sufficient to obtain the Cg.S. For more information on CMCg.I activities, please see Chapter 4 on page 51.

Results from working the CMCg.I model

Conceptual models were developed to guide preventive interventions, which were then used to generate the KDEL. The KDEL was used to develop the conceptual model of the prototype, and a standard model was also created for any Ministry of Health programme. The Agile methodology (see Appendix D for more information) was used to implement the prototype, see Figure 7.2. Firstly, epics and user stories were developed to establish the functional requirements of the Cg.S, and the three stages were carried out: pre-model, pre-design and prototype (see Appendix D.5 on page 205 for more information). Once the prototype was validated, the Cg.S Requirements Specification was incorporated. The inference model for the hypertension prevention programme was the first focus of development. The ontology was implemented and verified by DS in the field.

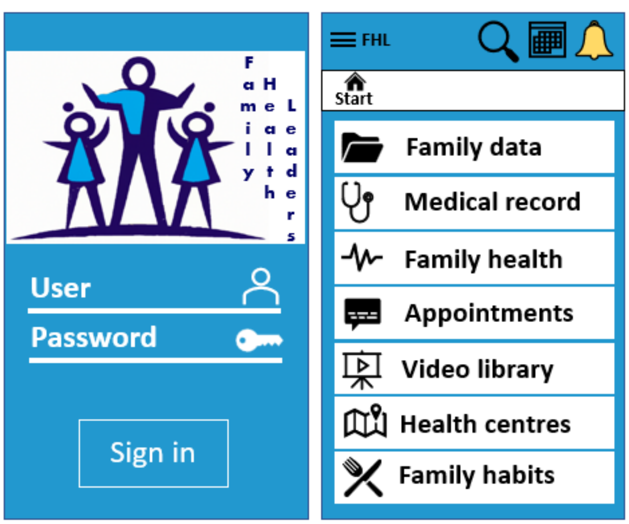


Figure 7.2: FHL cognitive assistant mobile application. This figure shows the introductory screen of the FHL cognitive assistant mobile application, which aims to provide cognitive health support.

7.4.1 Reflection on the health care experience

There is no doubt that cognitive assistants will become ubiquitous in all aspects of society. For organisations to stay ahead of the curve, they need to adopt innovative **Cg.S** practices to solve problems. However, decision-makers need to approach their specific situations systematically and formally in order to implement effective change and avoid providing ineffective solutions.

In the context of using the **CMCg.I** model, various artefacts were generated to create a **Cg.Arch** and solidify the FHL cognitive assistant prototypes. In addition, working with the FHL strategy helped to address other critical issues, such as formalising and securing information, as the Department of Health needs to manage all knowledge and information with the utmost care.

The FHL strategy, which aims to promote preventive medicine and improve the health of the population, was conceived by Arturo Jose Valenzuela Zorrilla, a physician and director of the Northern Zone of the Chihuahua State Ministry of Health for the 2016–2021 government period. The **Cg.S** (FHL Cognitive Assistant) is a strong supporter of achieving the objectives of this noble strategy. In addition, the activities (outlined in the **CMCg.I** model) to obtain this **Cg.S** have contributed to the structuring and formalisation of the FHL strategy. These activities have not only improved the FHL strategy, but they have also provided a solid foundation for future improvements and expansions of the Ministry of Health's preventive health services. The impact of the work done by all *actors* involved in achieving the **Cg.S** has been largely positive, leading to an improvement in the health of the population and the approach to preventive healthcare. The FHL strategy has a significant social impact, improving the quality of life in society by raising awareness of the importance of preventive health measures and supporting the health management of individual families. It is expected to reduce the number of people requiring hospital care and to promote a healthier lifestyle in the region. The FHL strategy also has a positive economic impact by reducing the costs associated with medical care and improving the productivity of the general population. Finally, it should be noted that the environmental impact of this project is also significant, given the reduction in the amount of medical waste generated by the healthcare sector, and given the promotion of healthy lifestyles that contribute to a more sustainable environment.

Great appreciation

It is only fitting to conclude this subsection with a heartfelt thank you.

Dr Arturo Valenzuela and Dr Karla Chacón, the team of doctors and administrative staff of the Northern Zone Directorate of the Ministry of Health. I would like to express my sincere gratitude and deep appreciation for your invaluable guidance and contribution to the FHL strategy. Your exceptional leadership and coordination skills have facilitated an excellent working dynamic. As a participant in the design and implementation of the FHL strategy, I am particularly grateful for the opportunity you have given us and the trust you have placed in us. Thanks to your unwavering support and guidance, we have been able to achieve seemingly impossible goals and overcome the challenges posed by bureaucracy and the lack of support for socially beneficial projects.

Once again, I would like to express my sincere thanks to you and your entire team for your dedication, passion and leadership, which are fundamental to FHL's success. I look forward to our continued collaboration and progress in the future.

7.5 Chapter summary and reminders

The chapter highlights two successful experiences of implementing the **CMCg.I** working model in the industrial and health and social care sectors. In the industrial sector, a CBR prototype was used to identify the correlation between customer expectations and HVAC design specifications. In the health and social care sectors, a mobile cognitive application was used to provide families with basic medical knowledge to help them recognise when a non-serious health problem requires hospital treatment. The **CMCg.I** model-driven activities, together with its systematic process **KMoS-RE**, contributed to the implementation of a robust **Cg.Arch** for each experience, in which knowledge from both industry and medicine was effectively harnessed, enabling the successful development of both prototypes. The aim of sharing these experiences is to encourage those who may be reluctant to embark on a transformation project to join the **CE**.

8 Afterword

A summary of the interesting topics of the **Cognitive Transformation** (**CT**) adventure in the **Cognitive Era** (**CE**) accompanied by the **Conceptual Model for Cognitive-Innovation** (**CMCg.I**) is communicated in this last chapter. It is therefore important to remind the reader of the value of knowledge and its application in the **CE**. This era requires a process of **CT** in which **Knowledge Management** (**KM**) is of great importance and is necessary to provide successful solutions. Some of the concepts addressed in this chapter are those most closely related to **CT**, such as the **Cognitive Ecosystem** (**Cg.Eco**) and **Cognitive Architecture** (**Cg.Arch**), and the relationships between the *actors* that interact within them. This close relationship between concepts also highlights the importance of the **Requirements Analysis Process** (**RAP**) and the need for a working model that can communicate knowledge and represent the entities, processes and activities involved in the development of a **Cognitive Solution** (**Cg.S**). The chapter recalls the experience of success stories gained over more than 10 years of accompanying **CT**. It can therefore be concluded that this book conveys that **CT** is easier when a working model such as the one used here is available as a means of support.

8.1 Interesting aspects in CT

The section on **CT** recalls convenient aspects of this concept, which were discussed in this book, that support individuals or organisations to address their problems and knowledge needs through a working model that includes a systematic process of transformation. This involves leveraging *cognitive technology*, as well as **Artificial Intelligence** (**AI**) technology, to drive change. The section is divided into several subsections, each of which focuses on topics closely related to **CT**, such as the **Informally Structured Domain** (**ISD**) (for details, see Subsection 2.2.1 on page 17), **Digital Transformation** (**DT**) (for details, see Section 1.1 on page 3) and from **DT** to **CT**. Through these subsections, readers can better link the underlying concepts and processes involved in **CT**. With the world evolving rapidly, it is clear that **CT** is becoming increasingly important. This section provides an overview of its importance, inviting readers to pay attention and be prepared for the future that began yesterday.

8.1.1 Ill-structured domains

These domains refer to complex problem-solving situations that lack clear definitions, standard procedures or known solutions. These domains are characterised by high levels of uncertainty, ambiguity and conflicting information, and often involve multiple *actors* with different perspectives, values and interests. Examples of these "poorly" structured domains include environmental policy making, urban planning, health care management and strategic decision making in business.

In contrast to well-structured domains, which are characterised by well-defined problems, well-established procedures and known solutions, *ill-structured domains* require flexible and adaptive problem-solving approaches that can accommodate diverse and changing contexts. Researchers and practitioners have developed various methods and tools to support problem solving in *ill-structured domains*, such as systems thinking, scenario planning, stakeholder analysis and participatory decision making.

One of the key challenges in working with *ill-structured domains* is the need to balance analytical rigour with creative and collaborative approaches in a way that can generate new insights and solutions. Effective problem solving in *ill-structured domains* often requires interdisciplinary collaboration, effective communication and a willingness to experiment and learn from failure.

8.1.2 How are ill-structured domains related to the CE?

The concept of *ill-structured domains*, in a particular sense, has been referred to in this book as the **ISD** and is closely related to the **CE** (for details, see Section 1.1 on page 3), which refers to the current period of technological development characterised by the emergence of *cognitive technologies* that can augment or replace human cognition in various domains. For example, processing large amounts of data, identifying patterns in it and generating insights can be extremely difficult or impossible tasks for humans. Therefore, *cognitive technologies*, such as **AI**, *machine learning* and *natural language processing*, provide humans with such capabilities.

In the context of the **ISD**, *cognitive technologies* can play an important role in supporting problem solving and decision making by providing advanced analytical capabilities and real-time feedback. For example, *machine learning* algorithms can be used to identify patterns and trends in complex data sets, while *natural language processing* can be used to analyse and interpret unstructured text data from multiple sources.

However, the use of *cognitive technologies* in the **ISD** also raises ethical and social concerns, such as the potential for bias, the impact on human employment and the responsibility for decisions made by autonomous systems. Therefore, effective problem solving and decision making in an **ISD** requires a thoughtful and holistic approach that considers the ethical, social and cultural implications of using *cognitive technologies* in complex problem-solving situations.

8.1.3 How does the ISD relate to DT?

DT refers to the process of using *digital technologies* to fundamentally change the way organisations operate and deliver value to customers. In the context of an **ISD**, **DT** can play a key role in supporting problem solving and decision making by providing new tools and capabilities for processing and analysing complex data sets.

For example, **DT** can enable organisations to collect and analyse data from multiple sources, including social media, Internet of Things (*IoT*) sensors and other digital platforms, to gain a better understanding of complex problems and identify potential solutions. Furthermore, when **AI**, *machine learning* and *natural language processing* are added to **DT**, they can be used to support decision making by providing real-time information and recommendations based on complex data sets.

However, **DT** in an **ISD** also presents challenges, such as the need to manage and secure large volumes of data, the risk of bias and error in automated decision-making systems and the potential impact on human employment and decision-making processes. Effective **DT** in an **ISD** requires careful consideration of these challenges, as well as the development of new skills, processes and governance models that can support the use of *digital technologies* in complex problem-solving situations.

8.1.4 How can the ISD be linked to CT?

The concept of the **ISD** is closely related to **CT** (for details, see Section 1.2 on page 4), which refers to the transformational changes that occur in organisations when cognitive technologies, such as **AI** and *machine learning*, are introduced and integrated into their operations. **CT** enables organisations to improve their problem-solving and decision-making capabilities by augmenting or replacing human cognition in various domains.

In the context of the **ISD**, **CT** can play a significant role in improving problem-solving and decision-making capabilities by providing advanced analytical and computational capabilities. For example, **AI** algorithms can be used to identify patterns and trends in complex data sets, while *machine learning* can be used to generate insights and predictions based on large volumes of data.

However, the introduction of *cognitive technologies* into the **ISD** also raises challenges and ethical concerns, such as the potential for bias and error in automated decision-making systems, the impact on human employment and the need to develop new governance models to ensure accountability and transparency in decision making.

Effective **CT** in an **ISD** requires a thoughtful and holistic approach that considers the social, ethical and cultural implications of using cognitive technologies in complex problem-solving situations. This approach should involve interdisciplinary collaboration, effective communication and a willingness to experiment and learn from failure.

8.1.5 What are the differences and how are the terms DT and CT related, given that the former precedes the latter?

DT and **CT** are two related but distinct concepts that address different types of problems or needs. **DT** addresses the need to process analogue data digitally or to improve digital processing capabilities, while **CT** focuses on solving complex problems using knowledge and digital tools. These concepts apply to individuals, organisations and businesses. For example, in the case of the organisations and businesses, DT uses digital technologies to revolutionise operations and deliver value to customers. This includes the adoption of technologies such as *cloud computing*, *big data analytics*, AI and the *internet of things* to improve business processes, create new revenue streams and enhance customer experiences.

CT, on the other hand, refers to the use of advanced *cognitive technologies* to transform business operations and decision making. This includes the use of AI, *machine learning*, *natural language processing* and *robotics* to automate tasks, optimise processes and gain insights from data.

While DT generally focuses on using *digital technologies* to improve business operations, CT takes this a step further by using advanced *cognitive technologies* to automate tasks and improve decision making.

It is worth noting that DT often precedes CT, as organisations (or businesses) must first adopt digital technologies before they can use advanced cognitive technologies. In addition, DT is a necessary foundation for CT, as the data and processes required for CT are often digital in nature.

In summary, DT and CT are related concepts, but DT typically precedes CT because organisations must first adopt *digital technologies* before they can leverage advanced *cognitive technologies* to transform their operations and decision-making processes.

8.2 The dark light of AI

The hope and belief of this author is that AI will not surpass human intelligence, creativity and common sense in this CE, or ever.

This author is not in a position to predict the future with any certainty. However, it is important to note that AI and human intelligence are fundamentally different in nature. While AI can process and analyse vast amounts of data and perform complex calculations quickly and accurately, human intelligence encompasses a wide range of cognitive abilities, including creativity, intuition, empathy and common sense, which cannot be easily replicated (emulated or even simulated) by AI entities. There are ongoing debates and discussions about the future of AI and its potential to surpass human intelligence, also known as the "singularity". Some experts believe that we will eventually reach a point where AI surpasses human intelligence in certain areas, while others argue that human intelligence will always have a unique advantage over machines. Whatever the outcome, it is important to approach the development and implementation of AI responsibly and ethically, considering the potential risks and benefits to society as a whole.

Will AI soon surpass humans?

Many experts in the field of AI do not believe that machines will surpass human intelligence any time soon, and some argue that it may not even be possible. While AI has made significant progress in recent years, there are still many challenges to overcome before AI entities can replicate the full range of human cognitive abilities and intuition. Additionally, even if AI entities do surpass human intelligence in some areas, it is mandatory to consider the ethical and societal implications of such advances. As **AI** continues to advance, a crucial question arises: do human beings really want a powerful **AI**? But the bigger question is: who will be the main beneficiaries of this technology? Will it be you and me, or someone else?

What are the ethical and societal implications?

The development and use of advanced **AI** technologies may have a number of ethical and societal implications that need to be carefully considered. Here are some potential issues to review:

1. *Job displacement*. As **AI** systems become more sophisticated, they may replace human workers in certain jobs, leading to widespread unemployment and economic inequality.
2. *Bias and discrimination*. **AI** entities are only as unbiased as the data on which they are trained. If the data is biased, **AI** can perpetuate and amplify that bias, leading to discrimination and inequality.
3. *Privacy and surveillance*. **AI** entities can collect, analyse and use vast amounts of personal data, raising concerns about privacy and surveillance.
4. *Autonomy and control*. As **AI** entities become more intelligent, they can make decisions and take actions without human oversight, raising questions about who is ultimately responsible for the outcomes.
5. *Safety and security*. **AI** entities can pose risks to safety and security if they malfunction, are hacked or used maliciously.
6. *Transparency and accountability*. The complexity of **AI** entities can make it difficult to understand how they work and to hold developers and users accountable for their actions.

It is important to address these ethical and societal implications of **AI** through regulation, policy and public engagement to ensure that **AI** is developed and used responsibly and beneficially.

In what areas will AI entities surpass human intelligence in the near future?

It is difficult to predict with certainty in which areas **AI** entities will soon surpass human intelligence. However, there are some areas where **AI** entities are already showing promise and may continue to make significant progress:

1. *Data processing and analysis*. **AI** entities are already very good at processing and analysing large amounts of data quickly and accurately, and this ability is likely to improve with advances in *machine learning* and *natural language processing*.
2. *Pattern recognition*. **AI** entities can identify patterns in data and images that humans may miss, making them useful in areas such as medical diagnosis, fraud detection and security surveillance.
3. *Repetitive tasks*. **AI** entities are highly efficient at performing repetitive tasks, such as manufacturing and assembly-line work, with a high degree of accuracy and consistency.
4. *Gaming and strategic decision making*. **AI** entities have already surpassed human intelligence in certain games, such as chess and Go, and are likely to make further progress in strategic decision making.
5. *Natural language processing*. **AI** entities are already able to understand and generate human language to some extent, and this ability is likely to

> improve with advances in *AI technologies* such as *natural language processing* and *machine translation*.

It is important to note that even in these areas, **AI** entities may not completely surpass human intelligence, but rather augment and enhance human capabilities.

Given these previous opinions, will AI be used, by other humans or by itself, to control humans like slaves?

This author is not an oracle, nor does he have the ability to predict or speculate on the future actions of humans or **AI** entities. However, the use of **AI** to control or oppress humans would be a highly unethical and worrying development. The development and use of **AI** should be guided by ethical considerations and a commitment to promoting the well-being of all individuals and society as a whole. It is important to recognise that **AI** is a tool that can be used for both positive and negative purposes, and to take steps to ensure that it is developed and used responsibly and beneficially.

In opinion of the author. . .

Unfortunately, our world is still divided by borders, religions, gender, wealth, desires and preferences. Those in power often seek absolute control over those who do not, making it seem as if a happy, peaceful world without greed or materialism is just a dream, perhaps even an utopia.

However, for those of us who are not caught up in this power struggle, it is important to focus on the present moment and encourage others to let go of their past and future fears and conflicts. By striving for harmony and unity, we can work towards creating a better, more peaceful world.

While our world may be plagued by division and inequality, it is up to each of us to work towards positive change. By prioritising the present and fostering a sense of community, we can begin to break down the barriers that keep us apart and create a more peaceful world for all.

Otherwise, what do we want the *technology* for? Or how and what will we use **AI** for?

While *technology* and **AI** can be powerful tools, they do not hold the keys to *the way*, and *the truth* and *the life*. Rather, they are simply tools that we can use to achieve our goals and improve our lives.

It is worth noting that *the way* existed long before any technology, past, present or future. Ultimately, if we seek an abundant life, we must look beyond the tools we develop and focus on the principles that underlie our existence. These principles include love, compassion and a commitment to serve others.

So, while we could embrace *technology* and **AI** as valuable resources, we must also recognise that they are no substitute for *the truth* that gives meaning and purpose to our lives. By keeping this perspective in mind, we can use *technology* to enhance our lives without losing sight of what really matters.

8.3 The Cg.Eco scenario

The **Cg.Eco** scenario (for details, see Section 2.2 on page 17) refers to a complex and interconnected system of cognitive processes, technologies and *actors* that interact to develop products and services that meet the needs of the **CE**. The scenario recognises the importance of cognition in acquiring knowledge, solving problems and making decisions, and categorises cognition into hot and cold processes depending on the role of emotions.

The **Cg.Eco** emphasises the importance of human cognition as the basis of intelligence and high-level mental functioning. Human cognition is influenced by many types of repositories, cultural practices and technologies that increase its scope and creativity. The scenario also recognises the role of **AI** entities in decision making, but notes that human cognition will continue to play a significant role in the **Cg.Eco**, taking on different roles in the future.

The scenario also recognises the importance of the **ISD** in the **Cg.Eco**, which requires deep cognitive processes to acquire and process information. The scenario identifies three spheres of *actors* or entities in the **Cg.Eco**: static knowledge, which contains explicit information found in various sources such as data repositories; cognitive functions, which perform cognitive tasks such as perception, learning, differentiation, reasoning, calculation, problem solving, decision making, memory and information processing; and dynamic cognition, which analyses and interprets market behaviour to make informed decisions based on constantly changing market conditions.

Overall, the **Cg.Eco** scenario provides a comprehensive perspective on the complex and interconnected system of cognitive processes, technologies and *actors* that are shaping the **CE**.

Essences in the Cg.Eco

In the context of the **Cg.Eco**, there are several key concepts that stand out and play an important role in creating a systemic, dynamic and flexible model for improving knowledge transfer and transformation. These concepts include the **ISD**, **Cg.Arch**, **KM**, **Tacit Knowledge** (**TK**) and **Explicit Knowledge** (**EK**), and **Cognitive Analysis** (for more detailed information, see Subsection 2.2.2 on page 19, Subsection 2.2.3 on page 20 and Subsection 2.2.4 on page 24).

The **ISD** refers to the complex and dynamic domains where information is difficult to find or where it is unclear how to approach a problem. This type of domain often requires complex cognitive processing to acquire and process information, which is a great challenge for humans and their computer tools.

Cg.Arch refers to the organisation of the cognitive processes that will support the construction of the **Cg.S**. A well-organised **Cg.Arch** can improve cognitive performance and enable effective information processing and decision making.

KM is the systematic process of bringing, sharing, using and managing knowledge and information either within an organisation or among *actors* or entities of an **ad hoc Collaborative Network**. This process can involve both **TK** and **EK**, where **TK** refers to knowledge that is difficult to articulate or transfer, and **EK** refers to knowledge that can be easily shared or documented.

Cognitive Analysis involves the systematic study of cognitive processes and their outcomes. It can help to identify cognitive strengths and weaknesses, inform decision-making processes and guide the design of a more effective **Cg.S** (for more information, see Section 2.2 on page 17).

Taken together, these concepts can be used to create a systemic, dynamic, repeatable and flexible **CMCg.I** model (for detailed information about this working model, see Chapter 4 on page 51) for delivering a **Cg.S** and improving knowledge transfer and transformation. By understanding and harnessing the essence of the **Cg.Eco**, organisations and individuals can develop effective strategies to address complex and challenging problems across a wide range of domains.

Given the above information, why is a working model necessary to obtain a Cg.S?

A working model is necessary to achieve a **Cg.S** because the **Cg.Eco** is complex and dynamic, and requires a systematic and flexible approach to effectively address the challenges posed by the **ISD**. The **CMCg.I** working model provides a framework for organising and integrating the key concepts and essences of the **Cg.Eco**, and enables the creation of repeatable and flexible processes for addressing cognitive challenges.

In addition, a working model provides a way to test and refine a **Cg.S** over time, based on feedback and data. By continuously iterating and improving the working model, it becomes possible to develop a more effective and efficient **Cg.S** that can adapt to changing circumstances and evolving cognitive needs.

Overall, the **CMCg.I** working model provides a structured and strategic approach to sourcing a **Cg.S**, enabling organisations and individuals to harness the power of the **Cg.Eco** in a systematic and effective way.

8.4 Interconnecting ideas through the CMCg.I working model to guide the CT and problem solving embedded in an ISD

The book discusses the ideas and issues associated with the **CT**, a significant change in problem solving and decision making in today's world. To address this transformation, cognitive technology and **AI** are being used to address knowledge needs and problems in an **ISD** that require adaptive and interdisciplinary approaches.

To provide guidance for individuals and organisations to navigate **CT** and problem solving in an **ISD**, the book presents the **CMCg.I** working model as a framework. Such a working model is crucial as it provides a structured and systematic approach to solving complex problems and taking advantage of digital and cognitive technologies.

The book also mentions the relationship between the **ISD**s, digital technologies and **CT**, highlighting the ethical considerations and challenges associated with the use of cognitive technologies and digital tools in decision-making and problem-solving processes. Understanding these issues is crucial for individuals and organisations to develop effective strategies for using these tools.

While this book does not provide a comprehensive discussion of the current state of affairs in this era, the author is concerned about the inappropriate use of cognitive technology as a weapon to establish a totalitarian world order. The book aims to promote a **CT** that prioritises social welfare and the truth as the foundation of human freedom, and the **CMCg.I** working model is only intended to provide a framework for addressing the challenges associated with this transformation. The book also addresses relevant issues for individuals and organisations to consider when developing effective strategies for using digital and cognitive technologies. Using the **CMCg.I** working model, individuals and organisations can identify relevant information, assess the problem or situation and develop effective strategies for designing **Cg.S**s in **ISD**s.

In today's **CE** context, economic and global crises have exposed the vulnerability of economic, social, health and political systems, regardless of the form of government. Behind these situations is a plutocracy that exercises its dominance over all aspects of life, masquerading as benefactors and philanthropists. This plutocracy is made up of the owners of giant technology companies and major financial conglomerates, the wealthiest class on the planet. Behind their self-congratulatory façades, they pursue power without regard for the impact of their actions on society. The crises, conflicts and repercussions arising from the struggles of this plutocracy go beyond military confrontations; they revolve around the elite's struggle for control and power over the populace, using fear, manipulation, censorship and, sadly, the erosion of society in all its dimensions. Unfortunately, **AI** plays a central role in this context, but it only serves the interests of this privileged class. Finally, in light of the above description, the author emphasises in this book the benefits and merits of using technology to solve problems and meet needs in a way that promotes the common good and avoids malevolent outcomes.

8.5 What issues can be derived from the ideas discussed in this book?

The cases selected in the book encompass interesting observations in the process of making the transformation or finding a **Cg.S**. However, the book also mentions issues, derived from the ideas and anecdotes presented, that should be addressed in the immediate future. Some of these topics include:

1. Exploring the use of cognitive technologies to solve problems in an **ISD**, conducting further studies on their effectiveness in supporting decision making and generating new knowledge in complex situations in the **CE**. It is mandatory to consider the ethical and social implications of using these technologies in such contexts.
2. Develop new tools and methods for problem solving in an **ISD** that are adaptable to diverse and changing contexts. Approaches include the devel-

opment of tools and methods that support interdisciplinary collaboration and effective communication for problem solving.

3. Investigate the impact of digital technologies, such as *IoT* sensors and other digital platforms, on the **ISD** and how these can enable organisations to collect and analyse data from multiple sources, providing new tools and capabilities to process and analyse complex data sets. Examine the potential of **CT** in different sectors, such as healthcare, education and business, to drive change. Researchers could explore how **CT** can be applied in these sectors and identify the challenges and opportunities it presents.
4. Identify the challenges for governance in the **CE**, as there is a need to ensure transparency, accountability and fairness in decision-making processes. It would be desirable to develop innovative governance models that support the effective use of cognitive technologies in complex problem-solving situations while addressing the ethical and social implications of their use.
5. It is mandatory to explore how **CT** can be applied to address global challenges such as climate change, poverty and healthcare. The challenges and opportunities they present must be identified, as well as how they will be addressed.

In parallel, and taking into account the current state of **AI** and current ethics and regulation, all studies, research, advances and transformation efforts need to focus on forcing responsible use for the benefit of all humanity, especially those who do not represent the plutocracy. An **AI** that is not used to control humans, either by other humans or by itself. The development and use of **AI** must be highly regulated, thoroughly vetted and take into account many ethical considerations. It must be ensured that **AI**, in the **CE**, is not used to perpetuate prejudice or discrimination; that is, an **AI** must be unbiased. Furthermore, **AI** must continue to be developed for use by humans and, as such, be subject to human oversight and control. While **AI** can make decisions and take actions autonomously, there must continue to be human actors responsible for its development and deployment. The ethical and social implications of **AI** should be kept under continuous discussion and debated widely, and efforts should be made to ensure that **AI** is used responsibly and for the benefit of society as a whole.

In terms of how to work on **CT**, there is an insistence on working under a model such as the **CMCg.I** to support problem-solving and decision-making processes. Thus, a working model provides a structured and systematic approach to problem solving and decision making, enabling individuals and organisations to tackle complex problems in a more organised and effective way. Moreover, working models, especially the **CMCg.I**, are flexible, allowing for adaptation and iteration over time, which is crucial in dynamic and constantly changing environments. Furthermore, they integrate key concepts and essences, providing an integrated and holistic approach to problem-solving and decision-making processes. A model allows for working in an organised way to improve the cognitive performance of the **Cg.S** and performs effective information processing for decision making. Continuous improvement is present in the **CMCg.I** work model so that the **Cg.S** is continually reviewed and updated over time based on feedback and data, leading to continuous improvement in problem-solving and decision-making processes. The model highlights the ethical considerations and challenges associated with the use of cognitive technologies and digital tools in decision-making and problem-solving processes, ensuring that individuals and organisations take these issues into account when using such tools.

Overall, the **CMCg.I** working model, to date, has provided a comprehensive framework for problem-solving and decision-making processes, improving cognitive performance, enabling flexibility and continuous improvement, and ensuring that ethical considerations are taken into account. But, in the face of a **CE** that is changing by the second, the model must continue to be refined. For example, the **Knowledge Management on a Systematic process for Requirements Engineering** (**KMoS-RE**) process has proven its effectiveness in identifying knowledge needs, but there is room for further development and refinement. Possible future work could focus on improving the efficiency of the process, increasing the coverage of **TK** and adapting the process to specific domains. A possibly good idea would be to incorporate **AI** and *machine learning techniques* into the process to improve its effectiveness and efficiency. For example, *natural language processing* could be used to identify and classify **TK**, and *machine learning algorithms* could be used to automate some of the knowledge elicitations and structuring tasks. Moreover, although the **CMCg.I** and its **KMoS-RE** process have been successfully applied to healthcare, logistics, education and manufacturing, many other areas could benefit from its use. Future work could focus on applying the **CMCg.I** model to new areas, such as finance, law and marketing, and make the necessary adaptations to the process. Even the **KMoS-RE** process could serve as a basis for developing new tools and systems that incorporate the principles of **KM**. For example, a **KM** system could be developed for a specific domain and the **CMCg.I** model could be used to obtain and structure the relevant knowledge. Other **KM** frameworks could be incorporated into the **CMCg.I** model to improve its effectiveness. Finally, it is desirable to evaluate the impact of the **CMCg.I** model based on project outcomes, such as project success, customer satisfaction and user acceptance. This could involve case studies and surveys to assess the effectiveness of the model in different contexts.

8.6 A brief chronology of CT projects: a call for deeper engagement and research

The following chronology provides a brief description of a series of projects developed by a team of specialists in **Cg.Arch**, **KM** and **Information Technology** (**IT**), led by **Cg.S Architect** PhD Jorge Rodas-Osollo. Their work spans a wide range of domains, from healthcare and education to logistics and manufacturing. These projects involve the development of tools, systems and models designed to enhance human cognition, promote healthy behaviours and improve the efficiency of complex processes. The team's focus on knowledge requirements, **Cg.Arch** and knowledge representation has enabled them to develop innovative solutions to real-world problems, such as preventing chronic diseases, optimising logistics operations and developing educational games for children. This timeline provides an overview of cognitive transformation projects over the last 10 years (see **Chronology** 8.1).

2014 ► *FLUTEC CBR*. Developed a case-based reasoning tool for the design of HVAC modules for the company FLUTEC.

- *UACJ OWL*. Developed a semi-automatic OWL ontology generation tool for KDEL to support the **CMCg.I** working model.

2015
- *COLECH VL*. Designed a **Cognitive Architecture** of a virtual library for El Colegio de Chihuahua, a public research and postgraduate institution, on behalf of the Government of Chihuahua.

2016
- *HRU MS*. Conducted research and developed a cognitive assessment tool for patients with multiple sclerosis for the Health Research Unit.

2017
- *MHGCH ODM*. Developed an ontology for diabetes mellitus on behalf of the Ministry of Health, Government of Chihuahua.

2018
- *GCC Cg.Arch*. Designed a **Cognitive Architecture** for Grupo Cementos de Chihuahua.
- *GCC VR-OTS*. Developed a prototype VR-OTS for Grupo Cementos de Chihuahua.
- *BFCo Cg.T*. Accompanied the **Cognitive Transformation** of a binational freight company.
- *UACJ PoK*. Developed a method for representing, evaluating and interpreting pieces of knowledge for UACJ.

2019
- *MHGCH ECR*. Designed a knowledge model to facilitate interoperability in electronic clinical records for the Ministry of Health, Government of Chihuahua.

2020
- *MHGCH FHL1*. Development of a cognitive assistant-a for family health leaders for the Ministry of Health, Government of Chihuahua.

2021
- *MHGCH FHL2*. Development of a cognitive assistant-b for family health leaders for the Ministry of Health, Government of Chihuahua.
- *MHGCH Cg.Arch-PH*. Developed a **Cognitive Architecture** for the prevention of hypertension for the Ministry of Health, Government of Chihuahua.
- *MHGCH BMDM*. Development of a prototype for a recommender system based on a Bayesian model for diabetes mellitus cases for the Ministry of Health, Government of Chihuahua.
- *UACJ ECT*. Optimisation of ECT (new data) for UACJ.

2022
- *UACJ SG1*. Developed a gamified application to promote physical activation in high school students for UACJ.
- *UACJ SG2*. Developed a serious game to prevent burnout syndrome for UACJ.
- *UACJ SG3*. Developed a serious game to raise awareness of healthy eating among primary school children for UACJ.

2023
- *UACJ Karasek*. Developed a knowledge model for the prevention of work stress based on Karasek's theory for UACJ.

In mentioning some of the flagship projects over the years in the above list, it is worth remembering that this book has focused on the use of *requirements analysis techniques*, enriched with techniques from psychology and communication, for the design of a **Cg.S**, especially in an **ISD**. In this sense, it is essential to have a working model, such as the **CMCg.I**, that guides a systematic process for defining *knowledge requirements* and obtaining the necessary *pieces of knowledge* for the development of a **Cg.S**. This working model has been used successfully in several projects, such as those listed above. It has proven to be particularly useful in the **ISD**, where the definition of their concepts and the determination of *pieces of knowledge* is approached collaboratively among all domain *actors*, and where there are no formal recipes for solving problems or addressing needs embedded in them. Furthermore, this model minimises the risk of failure in obtaining the **Cg.S**.

8.6.1 An open invitation to get involved in these issues

An invitation is extended to delve into the captivating world of **CT** and the **CE**, and to explore innovative projects such as those outlined in this communication. Those interested in creating tools, systems and models that augment human cognition, promote healthy behaviours and streamline intricate processes in **ISD**s, such as healthcare, education, logistics and industrial manufacturing, for the betterment of society are welcome.

The pressing need for **CT** requires the development of groundbreaking solutions to real-world problems in this **CE**. Examples include the prevention of chronic illnesses, the optimisation of logistics operations and the creation of educational games for children. However, these solutions must have a positive and significant impact on society. The design of projects that demonstrate a steadfast commitment to innovation and an unwavering dedication to enhancing the world around us is crucial.

Participation in the discussion and potential research on the topics addressed herein are now a necessity. In conclusion, this communication is intended to inspire the exploration of responsible **CT** and ongoing dialogue regarding how to continue leveraging *cognitive technologies*, **KM**, **AI** and **IT** to have a positive impact on our world.

8.7 Original contributions from the CT experience

The main contributions are presented at the intersection of **Knowledge Engineering**, **Requirements Engineering** and the **RAP**. The book focuses on the formalisation of actions, tasks and processes in order to deal with problems or needs embedded in an **ISD** and to provide a **KM** perspective.

Scientific contributions

Scientific contributions over more than 10 years of performing digital and cognitive transformations include the development of strategies, methods, procedures and models such as the **Knowledge Evolution Cycles**, the use of the *Nonaka's SECI model* for **KM** or the **Pieces of Knowledge Matrix** to store the relationships between **Domain Specialists**, *pieces of knowledge* and reliability levels. These contributions improved knowledge transfer, the process of achieving a successful **Cg.S** and the determination of the **CMCg.I** working model.

Methodological contributions

The methodological contribution involves innovative approaches, tied to digital or **CT** experience. They offer a systematic framework or set of procedures that guide the transformation and lead to more precise solutions. A significant **KM**-focused contribution is the **CMCg.I** working model, which guides the **KMoS-RE**, providing structure to the incorporation and **KM** within a **Cg.S**. The book also suggests techniques like ontologies for managing **TK** and representing knowledge.

What does the immediate future hold?

The aforementioned contributions emphasize the need for continual improvement in working models, systemic processes, ontologies, and conceptual models. This paves the way for tool development, including automatic identification of presuppositions and self-classification of discourse. It also highlights the significance of developing new techniques, strategies, methods and processes to address the **ISD**.

8.8 And to end the last chapter of this book

As the book draws to a close, it becomes clear that the **Cognitive Era** (**CE**) and **Cognitive Transformation** are of great significance in today's society. The world's complexity demands a thorough understanding of the challenges and the capacity to create solutions that reflect the vast knowledge at our disposal. The **Conceptual Model for Cognitive-Innovation** (**CMCg.I**) offered in this book provides a structured approach to the development of a **Cognitive Solution** (**Cg.S**) that can address problems or needs of various kinds, but is embedded in **Informally Structured Domain** (**ISD**)s.

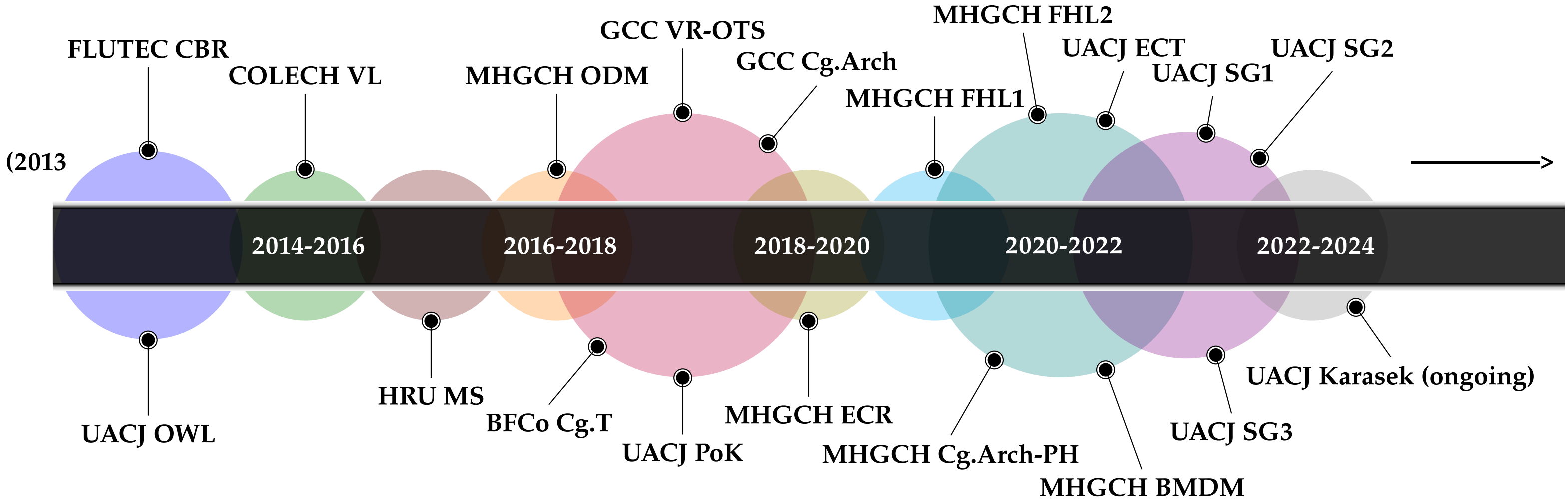
The **CMCg.I** model is unique in that it guides a *systematic process* for **Knowledge Management** with the ability to represent complex **ISD**s and their associated knowledge. This way of working ultimately becomes a powerful problem-solving tool, as it can be adapted to meet different *knowledge requirements* and **ISD**-specific situations. Under the guidance of the **CMCg.I** model, it is possible to obtain a more effective, efficient and applicable **Cg.S** for the real problems of the **CE**.

Throughout the book, the significance of the **Cognitive Analysis** stage in **Cg.S** development was stressed. It is vital to comprehend **ISD**-specific knowledge to design a solution that meets the **Beneficiary**'s needs. The **CMCg.I** model provides a helpful framework for conducting this **Cognitive Analysis**, and the case studies outlined in the book demonstrate how this approach can result in positive outcomes.

The application of the **CMCg.I** model is not confined to the industrial, business or organisational sector, as evidenced by the case studies in the health and social care sectors. This illustrates the model's versatility and its ability to be used in **ISD**s of various areas.

In summary, the book presents the **CMCg.I** working model as a set of good practices and approaches to cultivate a **Cg.S** that is efficient, effective and capable of tackling real-world issues in a way that meets the requirements of the **Beneficiary**. Furthermore, this book emphasises the importance of the **Cognitive Analysis** and the consideration of specific knowledge from an **ISD** while obtaining a **Cg.S**. By adhering to the guidance provided in this book, will make it easier to obtain a **Cg.S** and may even be of influence in making positive considerations for the surrounding world.

Chronology 8.1: The timeline shows the projects developed over the last 10 years by specialists (**Cg.Arch**, **KM** and **IT**), led by **Cg.S Architect** Jorge Rodas-Osollo. The labels linked to each circle correspond to the identifier of each project carried out, which appears in more detail in the description Section 8.6 on page 127.



Part III

Appendix

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A

Linking KM and RAP

This appendix contains supporting information on a range of topics related to either **Knowledge Management** (**KM**), **Requirements Analysis Process** (**RAP**) or both.

A.1 Knowledge representation

On one hand, knowledge representation allows humans to process knowledge—coming from another human being, **Tacit Knowledge** (**TK**)—in a simplified and unambiguous way; on the other hand, it provides machines with the knowledge that humans possess so that they can perform tasks more similar to human reasoning. It is a fact of life that the more a person knows about a subject, the more likely he/she is to perform a correct action or make a correct decision. Therefore, **Cognitive Analysts** (**Cg.An**) working on the **Cognitive Solution** (**Cg.S**) have to represent the knowledge of the human world in such a way that the **Cg.S** addresses the complex problems of the **Cognitive Era** (**CE**). Unfortunately, human information processing and knowledge formation are very complex. This processing involves intuition, intentions, prejudices, beliefs, judgements, common sense. . . However, some human knowledge is simple, such as knowing certain facts, general knowledge about objects, events, people, academic disciplines and language, among other simple things that today's technology can exploit. Knowledge representation and reasoning aims to depict the complex part of human processing in formats that allow those who need it to take advantage of that knowledge (or part of it). In this case, knowledge means useful information related to the environment, reasoning means deducing that information and intelligence means making decisions and taking actions based on knowledge and reasoning.

The first thing to identify is what is to be presented in the first place. This can be as follows:

- *Entities*: There are numerous entities all over the place and the information related to these objects is something that can be considered as a type of knowledge. For example, cars have wheels, the piano has keys, the table has legs. . .
- *Events*: The perception of the world is based on what is known about the various events that have taken place in it. This knowledge refers to all these events. Wars, famines, achievements, the advancement of societies. . .
- *Performance*: Actions and reactions to different situations faced by human beings. It, therefore, helps to understand the behavioural side of knowledge.

- *Meta-knowledge*: In a simplified way, if all existing knowledge is added up and categorised, it can be divided into three classes: what we know, what we know that we do not know, and what we do not know that we do not know. Meta-knowledge deals with the first class. Thus, meta-knowledge is the knowledge of what is known.
- *Facts*: Knowledge of the factual description of the world.
- *Knowledge base*: A set of information relating to any discipline, field. . . For example, a knowledge base on the installation of a power plant.

A.1.1 Types of knowledge representation

Knowledge representation is a complex subject that must be treated with great attention and patience. First, the different types of knowledge must be identified and classified. The following are the formal terms by which knowledge can be described:

- *Declarative knowledge*: Represents facts, objects and concepts that help to describe the real world. That is, it is concerned with representing through descriptions.
- *Procedural knowledge*: This refers to how things behave and work. It is used to represent any task employing certain procedures, rules and strategies. This type of knowledge is highly dependent on the task to be performed.
- *Meta-knowledge*: This is the body of knowledge that, when combined, constitutes a type of knowledge in itself. Therefore, it is knowledge relative to other types of knowledge.
- *Heuristic knowledge*: It is provided by specialists in certain domains, subjects, disciplines and fields, and has been obtained after years of experience. It helps to adopt the best approach to certain problems and to make decisions.
- *Structural knowledge*: Helps to establish relationships between concepts or entities and their descriptions, acting as the basic form of knowledge for solving a real-world problem

A.1.2 Properties of knowledge representation

When working on knowledge representation, certain properties must be evident that support the evaluation of knowledge representation. These properties are the following:

- *Adequacy of the representation*: The representation must be adequate and useful, i.e. it must represent all the knowledge that a **Cg.S** needs in order to deal with a particular domain.
- *Inferential adequacy*: The knowledge is flexible enough to deal with current knowledge and to make way for new knowledge.
- *Inferential effectiveness*: New knowledge should not be accommodated in the presence of old knowledge, but if the new does not contradict the old then effective updating is possible.
- *Acquisitive efficacy*: The last property is mandatory in a technology-type **Cg.S** and refers to the ability to acquire new knowledge automatically and, consequently, to be an adaptive **Cg.S**.

A.1.3 Knowledge representation techniques

The aforementioned communicates how the knowledge possessed by humans can be described and classified, including what properties an adequate representation of knowledge will have. But how can this knowledge be represented so that it is useful both for another human being and especially for a technological Cg.S? There are several different techniques or methods of knowledge representation. It must be taken into account that it is an open subject, in a state of constant change, that there are already numerous ways of doing it, that many more will surely emerge, that none of them are perfect and all of them have their pros and cons.

In general, there are four kinds of knowledge representation: logic, semantic network, production rules and framework.

Logical representation This is the most basic form of knowledge representation, where a well-defined syntax with appropriate rules is used. This syntax must be unambiguous in its meaning and it must deal with prepositions. Therefore, this logical form of presentation acts as communication rules and is the reason why it can best be used when representing facts to be exploited by a technological Cg.S. There are two types of logical representation: *propositional* or *first order*. The former is also known as propositional calculus; it works using classical logic, i.e. true or false. The second is also known as first-order predicate calculus logic. This logical representation employs quantifiers and predicates, and is a version that includes more information than the previous one. This representation is still the basis of most of the "intelligence" in today's machines. It is highly versatile. However, its strict nature makes it difficult to work with, as the representations achieved are often not very "human" and sometimes negatively impact the intended use of it.

Semantic networks A graphical representation of knowledge that links concepts together and illustrates how the relationships that interconnect them. The relationships found in **semantic networks**[1] can be of two types: *IS-A* and *instance* (*KIND-OF*). The *IS-A* relationships represent a hierarchical classification of objects, while *instance* relationships represent the relationship of a specific object to a general class of objects. These forms of representation are more natural than logical. It is easy to understand, but it is computationally expensive and does not have the equivalent of the quantifiers of the logical representation. A special case of the semantic network is when it is set up as an ontology. An ontology is nothing more than a generalised way of representing knowledge in a particular domain, and there are multiple ways of doing this. An ontology is formally defined so that the knowledge represented in it can be used in programmes in order to reason with it. It should be noted that there are many more types of semantic networks, so they can be used to represent a wide range of relevant information. Since the purpose of an ontology is to show the relationships between entities relevant to a domain, they are usually represented as networks. Ontology is therefore the broadest and most general term for the semantic network.

Production rules One of the most common ways of representing knowledge is that it can be understood as a simple if-else rule-based system and, in a sense, is the combination of propositional logic and first-order predicate logic. So, it is a set of production rules, a rule applicator, a working memory

1: **Semantic networks** are a type of knowledge representation used in **Artificial Intelligence** and *Cognitive Science*. They are made up of nodes/blocks, which represent entities, concepts or objects, and arcs/edges (the connections), that show how relationships are established between them. Two types of relationships found in semantic networks are *IS-A* and *instance* (*KIND-OF*). *IS-A* relationships represent a hierarchical classification of objects or concepts. For example, a dog is *IS-A* mammal, which is *IS-A* vertebrate, which is *IS-A* animal. This relationship implies that any attribute or property that is true for a higher-level concept in the hierarchy is also true for any lower-level concept that is a subtype of it. *Instance* relationships, on the other hand, represent a relationship between a specific object and a general class of objects. For example, Fido is a *KIND-OF* dog, which is a *KIND-OF* mammal, which is a *KIND-OF* animal. This relationship implies that any attribute or property that is true for the general class of objects is also true for the specific object.

and an act recognition cycle. For each input, conditions are checked against the set of production rules and, upon finding a suitable rule, an action is performed. This cycle of rule selection based on conditions and subsequent action to solve the problem is known as the recognition and action cycle, which takes place for each input.

Frame representation It is an array with a collection of attributes and values bound in it. This matrix is known as a frame and uses a series of slots and fillers; that is, slot values, which can be any type and form of data. Here, the slots are attributes, and the knowledge related to them is stored in the fillers. The frame representation can be very versatile as it can divide knowledge into structures and then into substructures. Moreover, being like any typical data structure, it can be easily understood, visualised and manipulated, and typical concepts such as adding or deleting slots can be carried out without much effort. A special case of the evolved case of frameworks is the scripts.

A.1.4 Approaches to knowledge representation

Knowledge representation, for use by a technological **Cg.S**, is linked to how knowledge is stored. There are four main approaches: simple relational, inheritable, inferential and procedural, each of which corresponds to a knowledge representation technique mentioned above.

Simple relational knowledge A relational method of storing facts, where each fact relating to an object is provided in columns. This method is prevalent in database management systems.

Inheritable knowledge Hierarchical method of classes where data is stored, which provides the opportunity to make inferences. Inheritance property can be applied, which allows for inheritable knowledge. In this way, relationships between instance and class can be identified.

Inferential knowledge Method using logic. Being a very formal approach, facts can be retrieved with a high level of precision.

Procedural knowledge Method using programmes and codes that use simple if-then rules. Not a desirable method for representing all forms of knowledge, but domain-specific knowledge can be stored very efficiently in this way.

A.1.5 Ontologies in RAP

An ontology is a formal definition of types, properties and relationships between entities that actually or fundamentally exist for a particular domain. Ontologies can be used for different purposes in the **RAP**. One of its most widespread applications is to represent knowledge of the domain. Through an ontology, key concepts, their properties and the relationships they have among them [30] can be represented. Potential uses of ontologies in **RAP** include:

[30]: Castaneda et al. (2010)

- *Description of requirements*. Describe the model of requirements, imposing and allowing an entire paradigm of giving structure to the requirements.
- *Specification documents for requirements*. To model the knowledge acquisition structures of the domain. This type of ontology could reduce insufficient information on the requirements specification document.

- *Application domain ontology*. They represent knowledge of the application domain and the commercial information necessary to develop a solution in a specific domain.

Table A.1 communicates a small sample of the use of ontologies that is focused on managing the expertise of *actors* implementing Cg.S and eliciting better functional requirements.

Table A.1: Some interesting ontologies focused on functional requirements.

Authors	Objectives	Proposals
Breitman et al. **[breitman2003]**	Recognise that a domain ontology must be a sub-product of the RAP.	The process of constructing the ontology is centred around the concept of application language. The concept is rooted in a representation scheme called the Lexicon Extended Language Lexicon (LEL).
Lee et al. **[lee2005]**	Address the complexity of a knowledge-intensive project.	A framework that uses a mixed-initiative approach to capture, represent and analyse the diversity of factors associated with the intensive process of generating a solution.
Omoronyia et al. **[omoronyia2010]**	Improve the quality of the requirements obtained.	A rule-based approach to construct ontology from natural language technical documents.
Farfeleder et al. **[farfeleder2011]**	Generate high-quality requirements to prevent design errors and facilitate verification and validation.	Transformation of natural language requirements into a formal template. A textual requirement template based on a domain ontology.
Siegemund et al. **[siegemund2011]**	Detect and correct inconsistent and incomplete requirements by modifying the approach used to obtain them.	It proposes an approach for the capture and validation of the project requirement using ontologies (represented in a web ontology language) and automated reasoning technologies.

A.2 What does applying KM to RAP imply?

KM is a discipline that aims to magnify the results of an organisation by capturing knowledge through its transformation, conversion and adequate representation and distribution, as well as the management of its flow. KM has a broader scope than the popularly understood view of using Information Technology (IT) to manage knowledge; this discipline has evolved theoretical concepts and methods that explain and address the inherent problems of knowledge exchange and that can be successfully applied in the RAP area. A KM perspective on RAP involves the inclusion of three topics. The first is to visualise the RAP as a KM *process* where knowledge is transferred and transformed into a knowledge evolution spiral. The second is to distinguish between Explicit Knowledge (EK) and TK. Finally, consider the mechanisms to facilitate the distribution and exchange of knowledge between the ad hoc Collaborative Network (ahCN). The topic of TK is extensively explained in Subsection 2.2.3 on page 20, and a brief description of the rest of the topic is provided below [31].

[31]: Giraldo et al. (2019)

A.2.1 Process of knowledge transfer and transformation

This process takes place when a person transforms their knowledge into natural language, or any other form of human communication, to transmit it to another person who then decodes it. Decoding is intrinsically linked to the mental models of the person, so any transfer of knowledge is inherently limited to the recognition of information and therefore will always involve a degree of ambiguity. This ambiguity can cause the conceptualisation of the solution to be incomplete since those involved in the project can construct different, and even incompatible, interpretations. A knowledge conversion model, based on Polanyi's theory, was established in [**nonaka2009**], where the creation of knowledge in an organisation is the result of the social interaction of TK and EK. This model postulates four iterative conversion modes, known as the *SECI*: *Socialisation*, *Externalisation*, *Combination* and *Internalisation*. In fact, if the *SECI model* is carried out consistently and in cycles, the loop through this knowledge spiral can improve the overall collective knowledge [**nonaka1995**]. Therefore, a RAP should adopt this model as it guarantees a good job. This adaptation as well as some techniques that can be used in each mode of knowledge conversion are explained below and presented in **Figure A.1**.

nonaka2009

nonaka1995

Socialisation It is the process of transferring TK between individuals who share mental models and technical competencies. Thus, it occurs in any communication activity between *actors* in an ahCN. Knowledge flows in both directions: when the Cg.An elicit the knowledge of the Domain Specialists (DS) and when he/she explains his/her models that are to be validated by them. Thus, as the project progresses, an Cg.An will learn about the domain, and DS will increase their understanding of the implementation of the Cg.S. Techniques that can be used in this conversion mode include interviews, **JAD/RAD sessions**[2] and even digital communication. Despite their complexity, ethnographic techniques [32] are the best way to share TK. However, socialisation is a limited form of knowledge transfer because it must be explicit, through models and artefacts, so that it can be shared by the individuals involved in the project.

Externalisation It is the process of turning TK into EK through the development of models, protocols and guidelines. Model development involves an externalisation process that includes the use of *knowledge representation languages* such as **Lexicon Extended Language**[3] [33] and ontologies [34] to model the application domain. Scenario-based techniques can also be used to force the conversion of TK coming from DS into EK. Due to the nature of TK, these techniques could be complemented with *discourse analysis techniques*, as in [35], to identify the linguistic triggers that can hide TK.

Combination It is the process of recombining or reconfiguring existing bodies of EK to create new EK. This mode occurs when the Cg.An combine different documents to create new models. Indeed, the techniques of *Intelligent Data Analysis or Machine Learning* could be used to support the extraction of patterns and regularities from various sources such as interviews, user manuals and policies of the organisation [36].

Internalisation It is the process of learning by repetition of tasks. Some of these tasks could have been defined by EK. Individuals will absorb knowledge as TK again. This modality is related to the ability to recognise *pieces of*

2: JAD/RAD sessions. JAD is a design workshop that brings together user representatives, sponsors, analysts, designers and developers in one physical location. The purpose is to gather all key knowledge holders together in one place, answer all the questions about the requirements, and come up with a design. RAD is a rapid iterative development process in which a prototype is built to answer a given design question. The purpose is to gather all key knowledge holders together in one place, answer all the questions about the requirements and come up with a design. The idea is to expose part of the solution to the end user as early as possible in the development cycle so that he/she can receive critical feedback and react to it.

[32]: Lopes da Costa et al. (2019)

3: **LEL**: It is a semi-formal model holding the most relevant words or phrases of the language of the application domain carrying a special meaning.

[33]: Ridao et al. (2021)

[34]: Alrumaih et al. (2020)

[35]: Dalpiaz et al. (2020)

[36]: Deng et al. (2020)

knowledge that are indispensable for dealing with a real situation. Its essence is assimilation, knowing that which should increase knowledge. Thus, the **Cg.An** must assimilate domain knowledge, while **DS** must assimilate information from the development and implementation of a **Cg.S**. The **Cg.An** internalise the domain knowledge when developing models, and the **DS** internalise the solution information when validating the models. Several tools support the management of two-way learning with the intention of improving knowledge acquisition on both sides [37].

[37]: Aljasim et al. (2020)

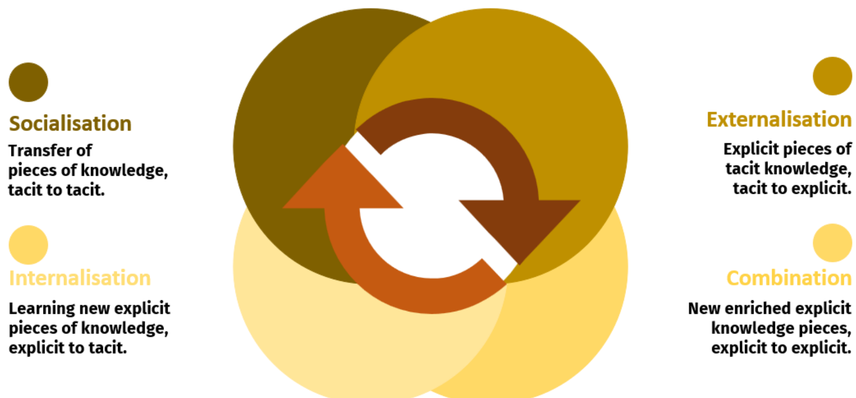

Figure A.1: SECI model of dynamic knowledge creation. Adapted from Nonaka et al. (1995). In this model, knowledge is continuously converted and created as people socialise, collaborate, interact and learn. The process should be seen as a continuous and dynamic swirl of knowledge, rather than a static model. It is essentially a visual representation of continuous and overlapping processes that take place—or should take place—in an organisation.

References from the area of **RAP** are mentioned below, only as an illustration of various works inspired by Nonaka's work or the *SECI* model, and which are also linked to the subject matter of this book:

- From the topic of requirements identification and organisational **KM**, three important points stand out: 1) requirements is a kind of knowledge, therefore, this knowledge is not directly tangible and is composed by a tacit part; 2) knowledge of the requirements does not equate to knowledge of the domain; 3) **RAP** implies a process of knowledge transfer and transformation. Although the problem of knowledge exchange is not new, [31] suggests its perspective, which includes specific techniques for understanding and facilitating knowledge transfer and transformation.
- Conversion of knowledge to minimise the asymmetry of ignorance between the **Cg.S Provider** (**Cg.S-P**) and **DS**. The conversion is based on the *SECI* model and considers the knowledge flow between the **DS** and the **Cg.S-P**, as well as presenting a new *actor* in the process—**Cg.An**. The **Cg.An** will act as an intermediary between the **DS** and **Cg.S-P** and is committed to gaining the confidence of those involved in the process. This process can be seen as a knowledge generator, but it is necessary that the **Cg.An** must have sufficient domain knowledge, which is extremely difficult [38].
- Completeness and accuracy are two criteria that should be incorporated into the existing set of parameters used to rank and select which elicitation technique to apply based on domain characteristics. Comprehensiveness refers to the degree to which each elicitation technique elicits domain, task and strategic requirements, and precision refers to the number of requirements **Cg.An** can elicit using each technique. It can be argued that completeness and accuracy are necessary to improve the selection of requirements elicitation techniques. A classification based on these criteria can minimise the difficulties of proper elicitation [39].

[31]: Giraldo et al. (2019)

[38]: Ponjuán-Dante G (2021)

[39]: Segura et al. (2017)

Today, the fields of research to which these references belong are still open and there is much work to be done and ideas yet to be proposed for those entering the **CE**, as well as for the **Cg.An**. This will allow for better **Cognitive Analysis** that acquires, represents, transfers and transforms knowledge requirements in order to design and build a **Cg.S** according to the customer needs.

A.2.2 Knowledge sharing and diffusion

For the *spiral of knowledge evolution* to deliver the expected results, it is crucial to facilitate the exchange of knowledge between the **ahCN**, which implies focusing on knowledge holders, especially in an **Informally Structured Domain** (**ISD**), where knowledge is predominantly tacit. This task is complex since the **Cg.S-P** must confront clients or **DS** whom they do not know and whom, consequently, do not know what they know. **KM** offers the concept of *mapping knowledge*; an artefact that points out knowledge but does not contain it, and which can be any structure of representation as a matrix or a social network. A knowledge map must be created at the beginning of a project and continuously updated as the knowledge spiral evolves. The usefulness of an artefact of this type is indisputable since it allows for the identification of the knowledge holders, facilitates the *spiral of knowledge evolution* and helps to distinguish which members of the project have certain knowledge, but also those project members who are unaware of knowledge. In an **ISD**, a map of knowledge can also be an artefact where the *tacit level* of each *piece of knowledge* is indicated.

A.2.3 Knowledge evolution model for RAP

nguyen2009

In an **ISD**, the **Cg.S-P** must analyse each problem from different perspectives because the solution is linked to the problem through the domain [**nguyen2009**]. To this end, the **Cg.An** must promote dialogue among the *actors* of the **ahCN**, since it is the network which, in a distributed form, has the **TK** related to the domain and where the prospect of the possible solution will be generated, allowing for it to evolve the knowledge of the *actors* of the **ahCN**. Although it is possible to return to previous stages at any time of the project, the knowledge of the **ahCN** is no longer the same as it will obtain additional or enriched knowledge that will allow them to explore other possible solutions. In short, the knowledge of the problem and its solution gradually evolves as the actors of the **ahCN** gain a more refined knowledge of the domain due to the social interaction and their participation in the processes of arduous negotiation.

To explain this behaviour, based on the *SECI* model, a **Cg.S-P** performs the following four steps:

- **Acquisition and elicitation of knowledge**. Obtains knowledge from the specialists of the domain and vice versa, predominating a process of socialisation between them.
- **Integration and application of knowledge**. Integration and application of knowledge. *SECI* integrates the knowledge and experience acquired into its models. This is a complex activity in which, in addition to modelling and

assimilation of domain knowledge, all modes of knowledge combination and externalisation are present.
- **Knowledge exchange and distribution**. Development and sharing and socialising with all the *actors* of the **ahCN**.
- **Knowledge validation stage**. The validation of models together with **DS**; because they must internalise the implicit knowledge of the models. This process leads to the acquisition of new knowledge.

A.2.4 TK identification

A dialogue is an organised and structured set of statements that allow the transfer of knowledge [40]. Dialogues can be analysed on several levels: lexical, syntactic, semantic, pragmatic,. . . in order to identify linguistic structures that could hide **TK**. Most of the information in an **ISD** is located and depends on the context and social interactions to be understood. It is therefore desirable that the processes, methods, techniques. . . for **Cognitive Analysis** incorporate sociolinguistic analysis techniques such as dialogue analysis to identify **TK** systematically [41].

[40]: S et al. (2015)

[41]: S et al. (2020)

Several works in **Knowledge Engineering** (**KE**) and **RAP** have used discourse analysis techniques to facilitate the identification of requirements [42]. In [43], sentences are classified as descriptive and prescriptive according to their grammatical mode and scope. Descriptive sentences condition properties on the system: they are in an indicative mode. The prescriptive sentences establish desirable properties on the system: they are in subjunctive mode. In an **ISD**, it is necessary to incorporate other linguistic triggers because of the large amounts of **TK** that are used. For example, the techniques of *presupossitions and Bloom's taxonomy* could be used in order to identify **TK**.

[42]: Lynch et al. (2020)

[43]: Alrajeh et al. (2016)

Presuppositions

A presupposition is an assumption or a deep belief related to a statement that:

- must be assumed by the speaker and the recipient of the utterance,
- will generally remain a necessary supposition if the statement is placed in the form of an assertion, negation or question, and
- can generally be associated with a particular lexical or syntactic structure, termed linguistic, in utterance [40].

[40]: S et al. (2015)

The statement: *Maria regrets having stopped training in basketball before leaving university* has the following presuppositions:

- There is a person identified as Mary.
- Maria stopped training in basketball before leaving university.
- Maria was training in basketball before leaving university.
- Maria left the university.
- Maria had been at the university.

One way to identify the presence of **TK** in a dialogue—spoken or written—is through *linguistic triggers* [44] in order to identify presuppositions as presupposi-

[44]: Gervasi et al. (2019)

tions such as *defined descriptions, factual verbs, implied verbs, expressions of repetition, temporal relations, comparisons and questions*, as mentioned below:

- **Defined description**. This consists of an article plus a noun: "the present king of France", "the first dog born in the sea", "the roof", "the smallest positive number that is greater than any multiple of 3 and divisible by 7", are examples of defined description. The expression "the present king of France" has the presupposition that there is a person who is currently the king of France.
- **Verbs de facto**. Some verbs relate predicates to knowledge, such as *knowing what, learning, remembering, regretting and doing*. These expressions assume the factual truth of their object. In the sentence "John did or did not realise that he was in debt", both first "did" and "did not realise" could trigger the presupposition "John was in debt".
- **Implicit verbs**. Implicit verbs involve presuppositions. The main sentence, with one of these verbs as a predicate, commits the speaker to an implicit proposition consisting of the semantic complement of the sentence. For example, *avoided* presupposes *was expected*, *forgot* presupposes *should have* and *succeed* presupposes *to intend to*.
- **Expressions of repetitions**. The expressions as *it returns, again, never, return, repeat and replenish* activate the presupposition that the event of the sentence has occurred before. In "POTUS did or did not show power again", first "did" or "did not show" triggers the presupposition "POTUS shows power".
- **Temporary relationships**. For example, in the sentence "While Chomsky was revolutionising linguistics, the rest of the social sciences *were* or *were not* asleep", the clause introduced by *While* triggers the presupposition that "Chomsky was revolutionising linguistics". Other conjunctions that trigger presuppositions are *after, like, before, during, from and always*.
- **Comparisons**. In the sentence "Carol is or is not a better linguist than Barbara", the comparison provokes the presupposition "Barbara is a linguist".
- **Questions**. There are two types of questions that trigger presuppositions: questions that present alternatives, and questions that contain *wh*-interrogatives (*wh*o, *wh*at, *wh*en, *wh*y and *wh*ere). The statement "Where is Newcastle, England or Australia?" triggers the presupposition "Newcastle is in England or Australia". On the other hand, the statement "Who is the professor of linguistics at MIT?", triggers the presupposition "Someone is a professor of linguistics at MIT".

Taxonomy of Bloom

As with presuppositions, Bloom's taxonomy can be used to identify TK. This is a framework for classifying, in the field of education, statements of what is expected or intended for students to learn as a result of instruction. The taxonomy provides a definition developed for three domains of learning activities:

- *Cognitive domain*. It is knowledge-based and consists of six levels, whose descriptions of skills are related to knowledge, understanding and critical thinking on a particular subject.

- *Affective domain*. It is based on attitude and consists of five levels, whose descriptions of skills in the emotional ambit describe how people react emotionally and their ability to feel pain or joy.
- *Psychomotor domain*. It is based on skills and consists of six levels, whose descriptions of skills in the psychomotor domain indicate the level of physical handling of a tool or instrument such as the hand or a hammer.

Bloom identified six levels within the cognitive domain, from simple recall or recognition of facts, as the lowest level, through increasingly complex and abstract levels of mind, to the highest order which is classified as evaluation (**Table A.2**).

Table A.2: Bloom's Cognitive Taxonomy.

Category	Description
Knowledge	Ability to remember previously learned material.
Comprehension	Ability to understand, explain and rethink ideas.
Application	Ability to use material learned in new situations.
Analysis	Ability to divide the material into main components and show the interactions between the components.
Synthesis	Ability to integrate new components into established components, resulting in new material.
Evaluation	Ability to evaluate a material based on well-defined criteria.

A description of the six levels, as well as verbal examples representing intellectual activity, is given in **Table A.3**.

In Bloom's hierarchical taxonomy, levels are ordered from simple to complex, from concrete to abstract and each level is subsumed by higher levels. Taxonomy has been used to support **KM** *processes* with **TK** [45]. An example could be when a verb used by an **DS** is in the higher order of the taxonomy, then it refers to *critical thinking* and a statement could be ambiguous and abstract. Therefore, an **Cg.An** must proceed to identify and elicit the knowledge hidden behind the verb. In **Table A.4**, a dialogue analysis of a fragment of the initial interview of the project is described. The text states "The idea is to develop a system that allows (1) *The person be*... (2) First of all, (3) *The system* must be accessible via the web so that when an evaluator user enters the system, it (4) *Evaluates* the level of performance of the person to be evaluated to be classified in a category. (5) Afterwards, the system (6) *must provide* information to redo the assessment... (7) *I do not know*... as soon as possible or within the time stipulated by the evaluator".

[45]: Charoensap et al. (2022)

In summary, it has mentioned three techniques to identify **TK**. Identification of *descriptive and prescriptive sentences* according to the time of prayer, identification of *presuppositions* and *classification of verbs according to Bloom's taxonomy*.

Table A.3: Actions (verbs) of Bloom's Cognitive Taxonomy.

Category	Description
Knowledge	Arrange, define, describe, identify, label, list, match, memorise, name, order, recognise, relate, recall, repeat, select, state. . .
Comprehension	Classify, defend, discuss, differentiate, estimate, explain, express, extend, generalise, give example(s), identify, indicate, infer, locate, predict, recognise, rewrite, report, restate, review, select, summarise. . .
Application	Apply, change, choose, calculate, demonstrate, discover, employ, illustrate, interpret, manipulate, modify, operate, practise, predict, prepare, plan, show, solve, use, write. . .
Analysis	Analyse, appraise, calculate, categorise, classify, compare, contrast, criticise, derive, diagram, differentiate, discriminate, distinguish, examine, experiment, identify, infer, interpret, model, outline, point out, question, relate, select, separate, subdivide, test. . .
Synthesis	Arrange, assemble, categorise, collect, combine, comply, compose, construct, create, design, develop, devise, explain, formulate, generate, plan, prepare, propose, rearrange, reconstruct, relate, reorganise, revise, rewrite, set up, summarise, synthesise, tell, write. . .
Evaluation	Appraise, argue, assess, choose, compare, conclude, contrast, defend, describe, discriminate, estimate, evaluate, explain, judge, justify, interpret, relate, predict, rate, select, summarise, support, value. . .

Table A.4: Dialogue analysis of an initial interview fragment.

Linguistic trigger	Type	Interpretation
(1) The person be	Defined description	The speaker assumes that everybody knows which *person* is being referred to.
(2) First of all	Expression of comparison	The speaker will say something important.
(3) The system	Defined description	The speaker assumes that everybody knows which *system* is being referred to.
(4) Evaluates	Level of performance	The **Cg.An** needs a more close examination to understand the meaning of *evaluates* in this context.
(5) Afterwards	Temporary relationship	Indicates task sequence.
(6) Must provide	Information to redo the assessment	The **Cg.An** needs a more close examination to understand the meaning of *must provide* in this context.
(7) I do not know	A reflexive question	The speaker is not sure about the restrictions of the application.

A.3 Appendix summary and reminders

This appendix communicated interesting information on some issues related to knowledge representation and **Knowledge Management** (**KM**) and the **Requirements Analysis Process** (**RAP**). The appendix has shown that knowledge representation is the key to making the **Cognitive Solution** (**Cg.S**) truly "smarter" than a solution that operates with poor knowledge representation. It is not trivial that one should bear in mind that when venturing into a cognitive project, one has to understand in depth what knowledge is needed about a topic in order to represent it adequately. If the "intelligence" of a **Cg.S** is to make it perform indistinguishably from human behaviour, adequate knowledge must be provided, and for this, a suitable knowledge representation is needed. Types of representation, properties of representation and representation techniques are briefly discussed. It is also stressed that an ontology can support the **RAP**. Finally, the appendix included information to be taken into account in **KM** such as knowledge transfer, knowledge evolution and its relation to the **RAP**. It can be concluded that as progress is made on these particular issues, it will allow more refined and appropriate knowledge to flow more quickly to other human or artificial cognitive entities.

B

Knowledge Management on a Systematic Process

As the **Cognitive Era** (**CE**) advances, the **Informally Structured Domain** (**ISD**) becomes more complex as the need for more *refined pieces of highly specialised knowledge* increases. Consequently, for the **Cg.S Provider** (**Cg.S-P**) to elicit **Suitable Knowledge Requirements** (**SKReqs**) for successful **Cognitive Solution** (**Cg.S**) implementation, they must invest more time, money and effort into improving domain understanding. Chapter 4 on page 51 communicates details of the **Conceptual Model for Cognitive-Innovation** (**CMCg.I**) model, which works with the **ISD** and supports the **Cg.S-P** in managing the *right pieces of knowledge* for the implementation of a **Cg.S**. Also, it is mentioned that the model incorporates a systematic process for such management, especially the elicitation of the **SKReqs**.

This appendix provides specific information on the **Knowledge Management on a Systematic process for Requirements Engineering** (**KMoS-RE**) (see Subsection 4.3.1 on page 56), a process that is part of the **CMCg.I** working model responsible for *eliciting*, *structuring*, *making explicit*, *obtaining* and *sharing* knowledge within the **ISD**. Correctly represented, this knowledge should meet the needs and expectations of the **Beneficiary**. The **KMoS-RE** process consists of a series of action sequences or trains that the **CMCg.I** model requires in order to achieve effective **Knowledge Management** (**KM**). **Figure B.1** illustrates three **open groups**[1] of actions: *Modelling of Knowledge* (*MK*), *Modelling Functional Aspects of the Solution-Proposal* (*MFA-SP*) and *Communicating the Specifications* (*CS*). In addition, the appendix presents trains of actions that are always present in solution-building projects, including *Modelling the Distribution of Reliable Tacit Knowledge* (*MDRTK*), *Beliefs Repository* (*BR*), *Structural & Linguistic Model* (*S&LM*), *Functional Requirements Specifications* (*FRS*), *Conceptual Model* (*CM*), *Non-Functional Requirements Specifications* (*NFRS*), *Previous Functional Model* (*PFM*), and *Future Functional Model* (*FFM*).

1: These are **open groups** because each **Cg.S** design and implementation project is unique and the **ISD** is particular. Therefore, the required trains of actions and activities must be carried out to achieve the objectives of each group. This appendix contains only those actions and activities that are most commonly used in practice.

Modelling of knowledge It is an open-ended group of actions and activities that aims to make *explicit*, and give structure to, as much of the *highly specialised domain knowledge* as possible. One of the most frequent initial activities consists of a *linguistic model*. This model is intended to facilitate the assimilation of the specific vocabulary of the *highly specialised knowledge*. It is also useful to reach a consensus for concepts that are not easy to define. This model can consist of a glossary of terms or a lexicon with a more specialised description of the terms. The *linguistic model* is the basis for developing a *conceptual model*, which represents the concepts and the relationships between them in a graphical form. The graphical format facilitates the validation of the model by the **Domain Specialists** (**DS**). Depending on the domain and its type, the **Cg.S-P** can select one of several models that

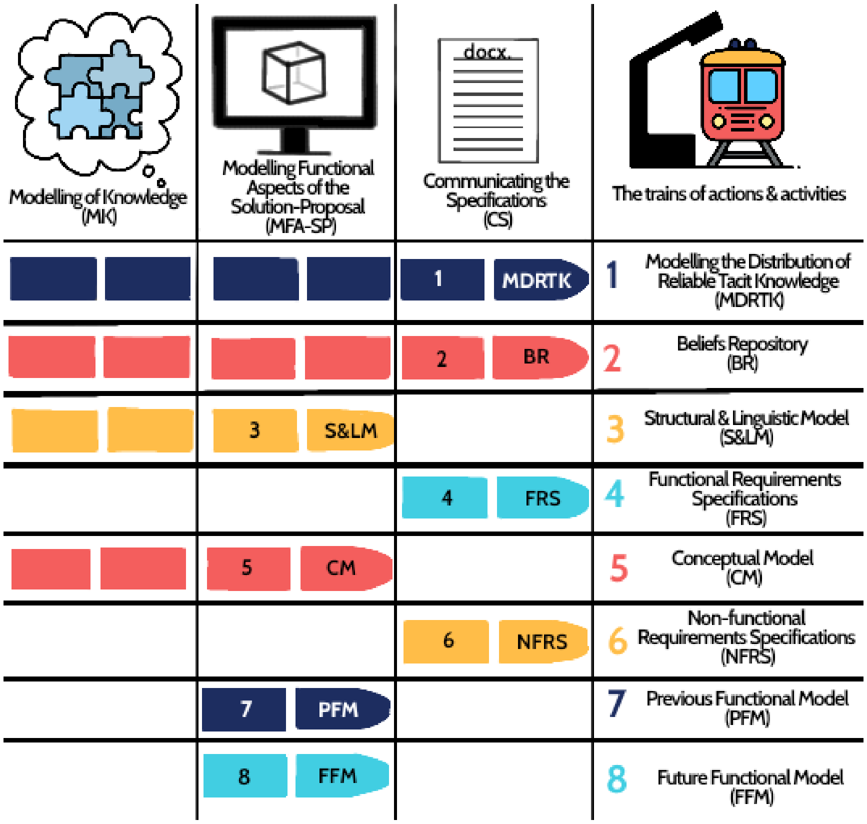

Figure B.1: This overview covers the three open groups of actions involved in the KMoS-RE process: *MK*, *MFA-SP* and *CS*. The figure also shows key trains of actions that are common in solution-building projects. These trains include *MDTCK*, *BR*, *S&LM*, *FRS*, *CM*, *NFRS*, *PFM* and *FFM*.

meet this representation objective, such as an *entity-relationship model*, an *oriented object model* or even an *ontology*. This last model is optional and is recommended when the behaviours of the domain are mostly informal or when there is no previous solution that could serve as a reference for the Cg.S. As can be seen in Figure B.1, the *linguistic model* and the *conceptual model* continue to evolve within the delimitation of the next group.

Modelling the functional aspects of the solution-proposal This group of actions and activities aims at obtaining a model of the functional aspects, which is considered as a *black box*, as it *represents only the external functionality* of the solution. This group of actions and activities is very creative, so a Cg.S-P must use its technical knowledge, combine it with the domain knowledge previously obtained and transform it into a functional model that represents the real needs of the Beneficiary. Generally, the Cg.S-P does not possess highly specialised knowledge of ISD; therefore, the first step in this group is to extend the *language model* by adding concepts and relationships between concepts in the ISD related to the Cg.S proposal. In the same way, the contextual model evolves with these new concepts and relations. In the case that there is a way to partially satisfy a problem, a *previous or current functional model* must be developed. This activity allows for a better understanding of the real needs of the Beneficiary. Finally, regardless of whether the situation is being addressed in any way, a *future functional model* must be developed, which is the most important output of the group.

Communicating the specifications In this group of actions and activities, the specification document of a Cg.S is developed. The first activity is to identify the *functional requirements*, which are derived from the *future functional model* of the previous group. The identified requirements are thoroughly examined and structured to initiate the explicit specification of *functional requirements*. Afterwards, *non-functional requirements* (*NF-requirements*) are acquired and both are integrated into the Cg.S requirements document (**Cg.S Requirements Specification**).

B.1 About models and other artefacts

The **KMoS-RE** can be thought of as a workshop for building, developing and transforming a set of models; a process that starts with the first interview. It leads systematically to the *requirements specification*. The evolution of a set of *fuzzy ideas* and information into a **Cg.S**—such as an intelligent application, the design of a technological product or an intelligent service or a new innovative knowledge process—is the result of a negotiation between the entity that has a need, the **DS** and the **Cognitive Analysts** (**Cg.An**). To facilitate the negotiation, **Tacit Knowledge** (**TK**) is gradually transformed into **Explicit Knowledge** (**EK**) throughout the process. The **KMoS-RE** process, linked to its models, implies that the **Cg.S-P** is responsible for selecting a specific model or **several models**[2] depending on the characteristics of the problem and the objectives to be achieved.

2: This appendix suggests only a **few models** to work with in the **KMoS-RE**.

Table B.1: This table shows the models and artefacts most frequently used during a **KMoS-RE** process. The left column shows the type of model or artefact and the right column specifies what the model or artefact is about.

KMoS-RE trains	Obtained models or artefacts
MDRTK.	The distribution of reliable **TK** from the **DS** and the level of tacitness persisting in them concerning each *piece of knowledge* is reported in a matrix.
BR.	Beliefs records.
S&LM.	Entity-relationship model & **Knowledge of Domain on an Extended Lexicon** (**KDEL**).
FRS.	Recordings, presentations, documents. . .
CM.	Workflow or workforce models, rapid application development, object-role modelling, unified modelling language, entity-relationship modelling and event-driven process chain.
NFRS.	Recordings, presentations, documents. . .
PFM.	Use-case model & behavioural model & scenarios
FFM.	Use-case model & behavioural model & scenarios

Based on **Figure B.1**, the models and artefacts that are most frequently used when performing a **KMoS-RE** process can be listed (see **Table B.1**). It is important to note, from the figure, that there are two trains of activities (trains 1 and 2) that fall within the three groups, i.e. they are carried out for the entire duration of the **KMoS-RE** process and the sets are the *modelling the distribution of reliable* **TK**, and the *belief repository*. The first one has objectives to identify *pieces of highly specialised knowledge*, their representation according to their distribution in the **ad hoc Collaborative Network** (**ahCN**), and to know the *degree of tacitness* for their later *explicitness*. In addition, it should compile the necessary information for the implementation of the **Cg.S**. The second one keeps track of *beliefs* that are detected during the project. This model aims to minimise the learning curve of new members joining the project and to prevent them from making design errors caused by unfamiliarity with the domain. Each of the models or artefacts in **Table B.1** are described in the following subsections.

B.1.1 Modelling the distribution of reliable TK

Facilitating the exchange of knowledge between those involved in the actions and activities of the **KMoS-RE** process is a very important task. This task implies that the **Cognitive Analysis** should focus especially on the holders of highly specialised knowledge, i.e. the **DS**. The **Cg.An** must be clear that each participant in the project—whether a **DS** or not—should have a different *degree of tacitness* concerning each **piece of knowledge**[3], and must therefore be able to identify these pieces.

3: A **piece of knowledge** can be a concept, a relationship or a behaviour.

Pieces of TK identification

The **Cognitive Analysis** uses techniques for *dialogue analysis*, such as *linguistic triggers of presuppositions* and *Bloom's Taxonomy*, to identify phrases that may hide knowledge. When the **Cognitive Analysis** identifies these linguistic triggers, questions and notes associated with the likely hidden knowledge should be recorded. Furthermore, the process uses *Bloom's Taxonomy* to identify whether verbs are among the highest cognitive levels; it would indicate that the *piece of knowledge* may be ambiguous and therefore *tacit*. The **Cg.An** should examine the utterances to determine whether the ambiguity is resolved by the complement. If ambiguity remains, the **Cg.An** should work with the **DS** to clarify. Any questions or comments should be documented, addressed and validated by the **DS** or relevant parties. This exercise should allow the **Cg.An** to build up a *beliefs repository* that should reveal **TK**. Therefore, questions, doubts or comments arising from this activity should be recorded on a case-by-case basis.

Building the distributed model of reliable TK

Subsequently, if a participant has mastered a *piece of knowledge*, he/she must be able to clearly and explicitly communicate that *piece of knowledge*; alternatively, the **Cg.An** must identify who is not knowledgeable about a *piece of knowledge*. Consequently, one of the outcomes of the **Cognitive Analysis** is to have a model that communicates what knowledge is held collectively, how it is distributed among the participants and their level of trust, even if it is the most highly qualified specialist. This model allows the team, for example, to budget whether it is necessary to invite more **DS** to join the project or to detect a *fake specialist* and dispense with his or her collaboration. So, this work is extremely complicated, even delicate, because the **Cg.An** are dealing with people they do not know at all and, in a certain sense, they have to evaluate them, even though they may be a **DS**, and determine their continuity in the project. The management of this *collective knowledge* is supported by the **Pieces of Knowledge Matrix** (**PoK-M**).

This *matrix* stores the relationship of each participant in the project—**Cg.S-P** or **DS**—with each *piece of knowledge*. Three possible values of the relationship between individuals and *pieces of knowledge* mentioned above are recorded in the **PoK-M**. If the participant does not possess a *piece of knowledge*, a value of -1 is assigned. A participant may have knowledge about a *piece of knowledge* but not be able to communicate it *fully and explicitly*, i.e. their level of knowledge communication could be on a continuum between *tacit* and *explicit*. So, if the knowledge is *most explicit*, it will be represented by a value of 1. If the knowledge is *mostly tacit*, it will be represented by a value of 0. However, at this point, there is no formal function to indicate the *degree of tacitness* of an individual about a *piece of knowledge*. Therefore, this degree is recorded in the matrix in a bivalued form (0 or 1). However, the more **TK** that is made explicit through **Cognitive Analysis**, the better the proposed **Cg.S** will be. In this sense, the objective of the **KMoS-RE** process is to find as many transformations from 0 to 1 in the **PoK-M** as possible. That is, to make as much **TK** as explicit as possible. Ideally, the **Cg.An** should be able to make all **TK** explicit. Nevertheless, if this is impossible, then all project participants must work collectively to find the most suitable **Cg.S** with the **EK** obtained.

Table B.2: A *PoK-M* fragment. The label *PoK-XX* stands for *piece of knowledge*, *DS-XXX* for **DS** and *SP* for **Cg.S-P**.

Participant/*piece of knowledge*	PoK-MS	PoK-EA	PoK-TA
DS-N	1	1	-1
DS-NP1	1	1	1
DS-NP2	1	1	0
DS-E	0	1	0
SP-1	-1	-1	-1

To start modelling the *distribution of reliability and tacitness*, the **PoK-M** is initialised by considering the **ahCN**, especially the **DS** and, on the other hand, the concepts, relations and behaviours known at that moment. The **PoK-M** is dynamic because as new knowledge is elicited, it is updated. The **PoK-M** is used as a reference to visualise which concepts, relationships or behaviours have been made *explicit* and which remain *tacit*. **Table B.2** represents a **PoK-M** fragment from **a real case**[4].

4: To communicate the fragment of **a real case** example of the matrix, it is not necessary to know the detail of the information. As this information is sensitive, the attribute and participant labels were encoded. To understand the table, the label *PoK-XX* stands for *piece of knowledge*, *DS-XXX* for **DS** and *SP* for **Cg.S-P**.

B.1.2 Beliefs Repository

Through experience with the **KMoS-RE** process, the use of the *BR* has been formalised (extract from a real **BR**[5] in **Table B.3**) and found to be highly beneficial. It is therefore crucial to document all the beliefs (right or wrong) held by the **Cg.An**, **DS**, **Beneficiary** or other project *actors* about *collective knowledge*, *specialised information* or *decision making* during the **Cognitive Analysis** phase. The purpose of this *BR* is to prevent future design or implementation errors that may be caused by a lack of domain knowledge. In this way, participants in subsequent project phases can avoid such errors and make well-informed decisions.

5: Sensitive information has been removed from the **BR** to enable the communication of a fragment of a real case example.

Table B.3: A real *BR* fragment.

Before validation	After validation	KMoS-RE trains
The system will diagnose if a person has a poor performance.	The system will evaluate the good performance degree.	*CM*.
The evaluator will be a user's system.	The person being assessed will be a user's system.	*CM*.
The evaluator proposes exercises to improve performance.	The advisor is the one who suggests exercises to improve the performance of rehabilitation exercises.	*CM*.
The tests can apply in any order.	The order of the tests is important and is designated by the assessor.	*PFM*.
The app will be developed for smart phones only.	The people tested do not always own a smart phone.	*FFM*.

B.1.3 Lexicon extended from domain knowledge

To talk about the knowledge in a domain is to refer to the set of *pieces of knowledge* as well as to refer to those concepts that support a particular topic and that are handled in a particular way by the DS. There is a correlation between knowledge and the everyday language of the DS. Consequently, to facilitate the understanding of the domain and to carry out a good **Cognitive Analysis**, there are some support tools, among the most common of which are glossaries of terms. These artefacts define the concepts through natural language and are considered a first approximation to give structure to the domain. Although the natural language is ambiguous and context-dependent, it is the only commonly readable and understandable notation for DS; therefore, glossaries facilitate the validation of terms, improve the communication of *pieces of knowledge* and promote the participation of all people involved in the project.

[46]: Razafindramintsa et al. (2015)

The KDEL is a glossary of specialised terms [46]. It aims to establish the language of the problem or need without worrying about understanding it. To achieve this goal, each significant term detected in the dialogue recordings is described by a notion (denotation) and a behavioural response (connotation). In addition, each term is classified as an object, subject or verb. Thus, the set of terms related to the possible Cg.S proposal forms the KDEL.

To carry out a KDEL in the ISD framework, first determine the significant terms, incorporate all the definitions of the terms and establish which are part of the textitNF-requirements. At the beginning of any Cg.S development project, DS and project participants do not have a clear idea of what they want. In many cases, they do not even have a clear idea of how the domain is delimited. It is therefore common for those with the need or problem to intersperse needs, desires, domain properties and current and future solution processes in their dialogue. To give a preliminary order to this information, KDEL characterises the domain in terms, definitions and distinguishes *NF-requirements*, as explained below:

- *Terms* are described by a notion (denotation) and a behavioural response (connotation). Each term is classified as an *object*, *subject*, *verb* or *state*. KDEL uses this classification with the difference that *state* is not considered a term, because it is inherently linked to subjects or objects. The set of domain-related terms is part of KDEL, which allows Cg.An to internalise domain knowledge by describing the language of DS.

- *Definitions* are statements that assign a precise or agreed meaning to concepts or auxiliary terms used in the application domain. In an ISD, definitions allow consensus to be established on the concepts in the domain. A definition cannot have a behavioural response.
- *Non-Functional (NF) requirements* refers to concerns not related to the functionality of the Cg.S, such as usability, flexibility, performance, interoperability and security. One of the objectives of the KMoS-RE is to capture the *NF-requirements* introduced in early dialogues with DS. In later stages of the process, the Cg.S-P can use this information to make design decisions, or they can include more *NF-requirements*.

The second aspect that KDEL modifies is the structure of the terms. The set of symbols or terms will be different in the current domain and in the future. In addition, some of the terms in the current domain will change their behavioural response. To handle this feature, each term is composed of a "notion", a "current behavioural response" and a "future behavioural response". This allows the Cg.An to gain more insight by understanding the problem and the structure of the possible Cg.S. In this way, other possible Cg.S proposals can be explored. It should be clarified that the future behavioural response is not mandatory; it is only added if it is evident in the early stages of the project. Figure B.2 shows a conceptual model of KDEL in a entity-relationship diagram.

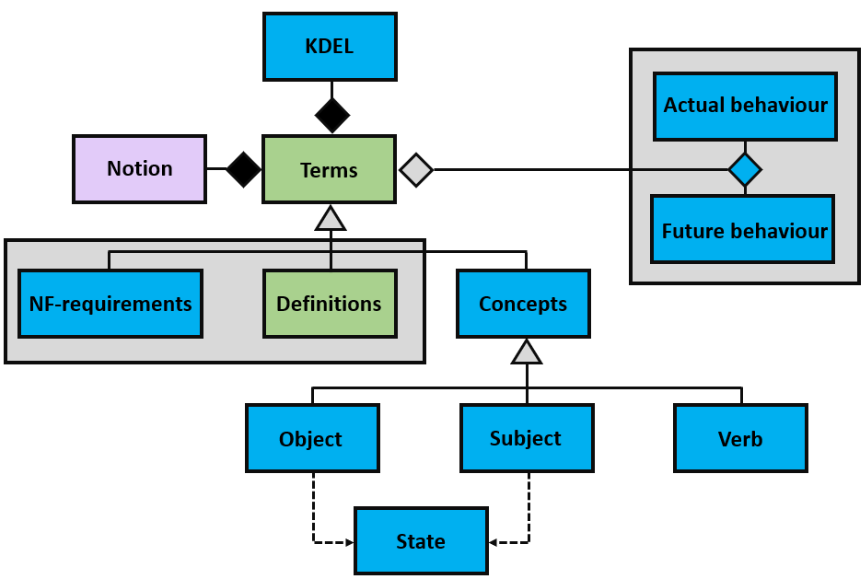

Figure B.2: Illustration of an extended lexicon representation in a sample domain. The diagram shows a general entity-relationship model that illustrates how different entities (such as people), objects or concepts are related to form what is commonly known as the KDEL or extended lexicon. This lexicon represents the knowledge about a sample domain and the relationships between the various entities within that domain.

Language units are distinguished into two types: those related to ISD knowledge and those related to Cg.S implementation experience. In this way, the Cg.S-P can focus on the structure of the ISD and, at the same time, have a record of preliminary Cg.S-related information, which can be used in later phases of the project. Table B.4 shows an extract of a real case[6] of the term "evaluator". The questions in the last part of the term description will be used as a guide in the next socialisation session.

6: To communicate the example of a real case, it is not necessary to know the details of the information. The sensitive information has been removed from Table B.4.

A set of empirical rules, derived from experience, for defining KDEL terms is described below. Table B.5 to Table B.9 provide the rules for objects, subjects, verbs, definitions and *NF-requirements*.

Table B.4: Description of the term *Evaluator* in KDEL.

Term:	**Evaluator**
Classification:	**Subject**
Notion:	The evaluator is a certified professional in the area of functional performance assessment.
Current behavioural response:	The evaluator administers the performance test battery to diagnose the level of functional performance of the person being evaluated. The evaluator proposes performance improvement exercises based on the results of the assessment. The evaluator indicates to the evaluated person how and when to perform the performance improvement exercises.
Future behavioural response:	The concept of the evaluator disappears in the future functional model. Its functionalities will be carried out by the Cg.S.
	Doubts arising from the analysis of the dialogue recording
	Does the evaluator have to be a certified professional? How does the evaluator determine that the person has poor performance? How does the evaluator conduct the assessment? How does the evaluator propose exercises for performance improvement?

B.1.4 Conceptual model

Based on experience, it can be affirmed that conceptual models are fundamental in the identification of problems or needs for any transformation project in the CE. The use of conceptual modelling in the KMoS-RE process has allowed:

1. Communication support between all the *actors* involved in the procurement and implementation of the Cg.S.
2. Detection of missing information and misinterpretations before moving forward with the design and implementation of the Cg.S.
3. Description of the context of the domain in the language and mindset of primarily the problem/need owner, the DS, and all other participants in the Cg.S implementation.
4. Helping the Cg.S-P to understand the domain.

Experience in implementing a Cg.S indicates that the likelihood of implementing a good quality and satisfying Cg.S for the implementer is directly related to making a good **conceptual model**[7]. Working with a *conceptual model* involves employing an ontological perspective, i.e. assumptions about the nature of concepts and the organisation of reality. In colloquial terms, the ontological perspective is the lens through which reality is perceived. The ontology of a model then describes the types of concepts that the model is capable of representing. For example, a domain can be considered to consist of static aspects, such as entities and

7: A **model** is an abstraction of a reality that represents a partial and simplified view of it. The **conceptual model** represents a generalised idea of a set of particular instances in a domain, and their most relevant relationships.

Table B.5: Rules for *object* definition.

Structural part	Description
Notion	Provide the high-order category to which the object belongs and describe its general characteristics.
Current behaviour	The actions performed in the current domain by any subject with the indicated object must be described. Subjects and actions must belong to the KDEL. All relationships of the object with other objects in the current domain must be described.
State	All possible states of the object must be described (optional).
Future behaviour	Actions taken in the future domain by any subject with the specified object must be described. All relationships the object has with other objects in the future domain must be described (optional).

Table B.6: Rules for *subject* definition.

Structural part	Description
Notion	Clearly state who the subject is and their general characteristics.
Current behaviour	All responsibilities, actions and relationships that the subject has with other subjects and objects in the current domain should be listed. Objects, subjects and actions must belong to the KDEL.
State	All possible states of the subject must be described.
Future behaviour	All responsibilities, actions and relationships that the subject would have in the future domain must be listed (optional).

relationships, or dynamic aspects, such as processes and goals. *Conceptual models* can also be classified according to their level of formality. *Informal conceptual models* can be represented by natural language. *Formal conceptual models* require a formal language that describes their syntax and semantics more strictly. These languages may use graphical symbols or terms to facilitate the visualisation of the model. Different types of *conceptual models* have been developed in various disciplines. In many of them, the *Unified Modelling Language* (*UML*) has established itself as the modelling language that allows all of them to be represented.

Conceptual models can also be classified in:

- Strategic models that identify and describe the tasks performed by the DS.
- Reasoning models that represent the "reasoning" to be performed by the Cg.S.
- Domain models that represent the structure of the domain that allows inferences to be made and tasks to be executed.

When embarking on the task of designing solutions to problems or addressing needs embedded in an ISD, *conceptual models* in it can serve two essential purposes (see **Figure B.3**): first, to support the Cg.S by providing a knowledge base of the domain, and second, to provide expertise and experience in implementing the Cg.S.

Table B.7: Rules for *verb* definition.

Structural part	Description
Notion	Clearly describe the action, who carries it out, when it takes place and all the information needed to carry it out.
Current behaviour	List all instructions and activities to carry out the current action. All situations that may prevent this action from being carried out are described.
Future behaviour	All instructions and activities to carry out the intended action are listed (optional). All situations that may prevent the intended action from being carried out are described (optional).

Table B.8: Rules for the *definition*.

Structural part	Description
Notion	The meaning of the term is described in a brief, clear and objective manner.

Graphical *conceptual models* have the advantage of visualising the structure of the ISD as a whole. However, their construction is not an easy task, since the analyst must elicit the *pieces of knowledge* from the ISD to be incorporated into the model, which must reflect the reality it intends to represent, i.e. the model must be correct and complete. On the other hand, although KDEL is predominantly informal and uses a textual representation, it has a great advantage in that its development is very simple. It is also very easy to read, both by the DS and the Cg.S-P of the Cg.S, which facilitates vocabulary acquisition, consensus on term definition and term validation. However, when the number of terms grows it becomes difficult to visualise the relationships between them, and therefore difficult to conceptualise the structure of the ISD as a whole.

The KMoS-RE process enhances the *knowledge representation* of its *CM* by incorporating graphical elements and using the KDEL. This approach improves communication, facilitates understanding, provides greater expressiveness and encourages the use of precise terminology specific to the domain represented. In particular, this *CM* allows for a pleasing visualisation that supports effective and efficient communication. As a result, Cg.An can collaborate more effectively, leading to a better understanding of the ISD and easier validation of its content.

Since the aim of the *MK* group is to understand what lies behind the implementation of a Cg.S through the consensual definition of concepts and the identification of the relationships between these concepts to define a structure of an ISD, it is recommended to use a *CM* with a simple ontological perspective. In this sense, an object-oriented structural model can be useful in that a domain consists of objects with similar characteristics and the relationships between them. This model can be represented by a *UML* class diagram. However, it is left to the Cg.An to select the *CM* that best suits the ISD or solution type.

Table B.9: Rules for *NF-requirements* definition.

Structural part	Description
Notion	The quality of the Cg.S is clearly described.
Goal	The impact of the quality of the Cg.S is described.

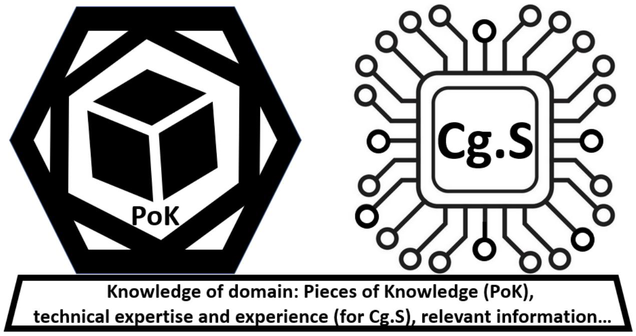

Figure B.3: **Knowledge of domain** includes highly specialised *pieces of knowledge*. In addition, it includes experience, expertise and relevant information related to the implementation of a Cg.S. Therefore, it is the **support** for both its *cognitive* and *technical* part.

B.1.5 Scenarios

Scenarios are an essential tool for understanding the behaviour of a Cg.S in a given situation. A *scenario* is a series of steps that demonstrate how the Cg.S interacts and performs actions to achieve a specific goal. *Scenarios* are often used to encourage reflection and critical thinking among DS and can serve a range of purposes, from understanding the *informal structure* of the *domain* to verifying the functionality of the Cg.S. The benefits of *scenarios* are many. They allow to reason and argue about concrete details through examples, which can help to learn about a topic inductively by associating it with a set of episodic events. *Scenarios* are particularly valuable in *domain modelling* when there is no previous solution on which to base the generation of a new one (innovation project). They help to identify how *actors* would behave in real-world scenarios of possible Cg.S, which can improve their understanding and inform making decisions.

To be effective, *scenarios* used in *domain modelling* should be presented in an informal narrative text that clearly expresses the relationship of the *actors* to the domain and, in particular, to the possible Cg.S. The *scenarios* implicitly contain the requirements of the Cg.S. In some cases, transforming the narrative text into an activity sequence diagram can facilitate validation, especially when the *scenarios* are complex and require an easier way to assess their validity.

In summary, *scenarios* are a powerful tool that can help turn abstract ideas into concrete, tangible examples. They are invaluable in *domain modelling*, especially when *innovation* is required to create a new Cg.S. By using *scenarios*, it can improve the understanding of the domain, verify the functionality of a possible Cg.S, and encourage critical thinking and reflection among DS.

B.1.6 Use-case model

Use-cases document, using simple models, the functionalities of either a possible Cg.S that is being designed and planned, or some other previously existing solution that is currently unsatisfactory. A use-case describes the visible behaviour of a **Cg.S** from the point of view of the *actor* who needs it. The **Cg.S** must lead the *actor* to achieve a specific goal; therefore, the use-case must reflect a series of actions performed, or to be performed, in a defined order. Use-cases are popular because they are relatively easy to set up and because, at the time of *model validation*, they greatly increase the interaction between the *actors* involved in implementing the **Cg.S**.

A **Cg.S** is developed to meet the objectives of the *actor* who has a problem. In an **ISD**, these objectives often cannot be clearly defined and, without a process such as **KMoS-RE**, this is bound to cause delays in the development process and increase project costs. This happens because the functional requirements have not been elicited correctly. A use-case helps to verify the functional requirements by grouping all possible scenarios that could occur when trying to achieve a goal. In that sense, the outcome of a use-case can mean a successful project, but also a failure or an abortion.

It is important to say that the use-case does not describe any internal functionality of the project, nor does it explain how it would be implemented. A scenario, as such, does not necessarily imply a **Cg.S**. Scenarios should have an appropriate level of detail, but be simple enough to facilitate their validation by all those involved in the implementation of the **Cg.S**.

The use-case models in the **KMoS-RE** process serve the following purpose:

Previous or current functional model A *PFM* communicates how the *actor* who has a need addresses it or solves the problem before having access to the **Cg.S**. Such a model encompasses all the activities already carried out by this *actor*.

Future functional model A *FFM* communicates how the *actor* who has a need will address or solve the problem when it has access to the **Cg.S**. Such a model should cover all foreseeable activities to be carried out by this *actor*.

B.2 KMoS-RE activity flow

As explained in Subsection 4.3.1 on page 56, the **Knowledge Evolution Cycles** (**KE-Cycles**) is a continuous spiral of knowledge development involving various activities and tasks, including knowledge elicitation, modelling, sharing and validation. Consequently, the set of activity trains in the **KMoS-RE** process is strongly linked to the **KE-Cycles**.

Figure B.4 shows essential activities typically performed by different *actors* during the process. The left section of the figure represents the *Model Validation* (*MV*) activity, which is carried out by the **Cg.S Architect** together with the **Beneficiary** and the **DS**. This activity is strongly linked to the *Knowledge Validation* (*KV*) activity. The middle section corresponds to the activities developed in a socialisation process corresponding to the **KE-Cycles**: *Knowledge Elicitation* (*KE*), *Initial Activity* (*IA*) and *Model Discussion* (*MD*). It is convenient to remember that the knowledge in the *MD* is updated and homogenised. The right section represents activities developed in the **Cognitive Analysis**, activities related to the development of models in the three open groups (see **Figure B.1**): *MK*, *MFA-SP* and *CS*. Although the author of the book may be easily distracted, the previously mentioned

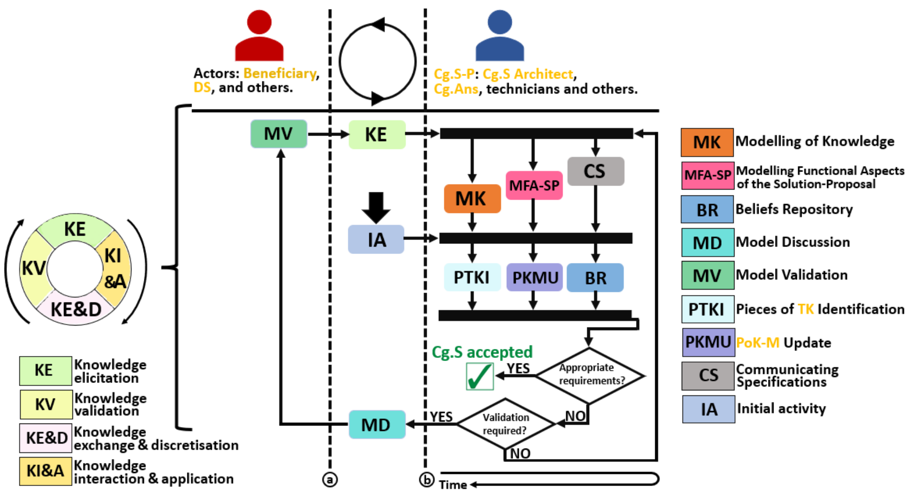

Figure B.4: This schema depicts the relationship between the KE-Cycles (a) and the KMoS-RE activity flow (b).

activities and tasks[8] are *essential* for the reader's understanding. However, this list is not exhaustive and there may be other activities and tasks that would be helpful in the integration and implementation of KE-Cycles. Therefore, Figure B.1 and Figure B.4 represent only a subset of these activities that commonly occur in the KMoS-RE.

8: Please note that the range of activities and tasks undertaken by KMoS-RE, particularly in relation to the implementation of the KE-Cycles, is flexible due to the uniqueness of each project. As a result, the number and type of actions, tasks and activities may vary from project to project. Some activities may be carried out explicitly, while others may be implied within explicit activities. In addition, some activities may be partially carried out or have variations in their execution.

As can be seen in Figure B.4 (middle section), the cycle starts with an *IA* in which a first interview is performed. After the interview, the Cg.An team begins various activities and tasks (*MK*) to identify DS, *concepts*, *relationships* and *behaviours* (*PTKI*, *PKMU* and *BR*). The team then records PoK-M values based on the *tacitness level* of knowledge and updates the *BR*. Once the interview is complete, the Cg.An start the *conceptual modelling* of the domain and the developed artefacts are socialised with the DS for validation by the Beneficiary (*MV*). By performing this process, more domain knowledge is elicited (*KE*), and the Cg.An set can decide whether to improve the models or continue with the following activities. These actions will be repeated by fulfilling the KE-Cycles until those involved in the project reach an agreement on the set of SKReqs.

Modelling of knowledge is the first group of KMoS-RE activities to be implemented

In order to model knowledge in a particular domain, the KMoS-RE process requires at least certain activities or tasks to be carried out. Often some of these tasks can be repeated as part of the *MFA-SP* and *CS* activities, which are the other two groups of KMoS-RE activities. The *MK* group always includes the following activities:

- *Identification of sources of information and knowledge*. The Cg.S Architect must explore both formal and informal sources of information and knowledge, and have the ability to discern the linguistic phenomena that can obscure the TK inherent in an ISD. For these explorations, it is usual to carry out between one and several interviews with all the *actors* of the ahCN to establish which DS will participate in the project and to establish other kinds of *actors* who have relevant information to help implement the **Cg.S**, as well as reliable and necessary sources of information and/or knowledge.

- *Information gathering*. The **Cognitive Analysts** should collect formal and informal information through interviews, focus groups and documents. It is common for a good deal of interviewing and discussion to take place among all *actors* in the **ahCN**. Any knowledge and information gathered from all *actors* can always be supplemented with **explicit knowledge sources**[9].
- *Pieces of Tacit Knowledge Identification (PTKI)*. The **KMoS-RE** process uses *dialogue analysis techniques*, such as linguistic triggers of presuppositions or Bloom's taxonomy, to identify phrases that may conceal **TK**. When the **Cg.An** identify linguistic triggers, they should record questions and notes associated with the likely hidden knowledge in order to extract it. These questions should be answered or clarified by the **DS**, or *appropriate actors*, in the following socialisation session. These socialisation sessions aim to externalise questions and gather information about **TK** pieces. This allows the **Cg.An** to create a formal record of this information, which may even include **EK**. Over time, as more sessions are conducted, more **TK** pieces become explicit, clearer and more comprehensive in both quantity and quality. Thus, these activities facilitate the identification, classification and description of *terms*, *definitions* and *NF-requirements*.
- *Conceptual Model (CM)*. It is a **model**[10] that represents how all direct and indirect actions and activities are, or should be, carried out in order to address a need or problem correctly. The **Cg.An** use the **KDEL** terms, which at a minimum reflect *previous or current performance*, and a graphical *CM* of the domain is built. Graphics are created—also interfaces and applications depending on the project—to facilitate the communication, learning and validation of the model by all the *actors involved*, especially the **DS**, and above all by the **Beneficiary**. *Conceptual models* usually appear early in the **KMoS-RE** process and are constantly consulted for guidance and inspiration throughout the process.

9: Examples of **explicit knowledge sources** are user manuals, policies, regulations, process documents. . .

10: The **conceptual model** is an abstract psychological, sociological representation of how tasks should be carried out. People often use *conceptual models* subconsciously and intuitively to systematise processes. For example, setting appointments involves calendars and agendas. The *CM* would guide an app designer in how to adapt to its users.

Modelling the functional aspects of the solution-proposal is the second group of KMoS-RE activities to be implemented

One of the first complex tasks for an organisation that intends to realise its transformation into the **CE** has to do with the development of the previous-current and future functional aspects model. A *past (or current) functional-aspects model*, represents the previous or current state of an organisation, or it may even represent the current problem situation itself. The primary objective of this model is to provide a visual representation that helps to understand how things functioned before the current situation and to identify the issues that need to be addressed or resolved. On the other hand, a *future functional-aspects model* enables the planning and design of a **Cg.S** (see **Figure B.5**) that can resolve the current problem situation and assists the organisation in its transformation.

A previous-current model will teach the whole set of *actors* involved in the implementation of the **Cg.S** about the organisation, and its situation, and guide the particular transformation of it. This work will require gathering information and knowledge about the actual functioning of the organisation and its processes. It will be necessary to interview each of the *actors* who contribute to the different

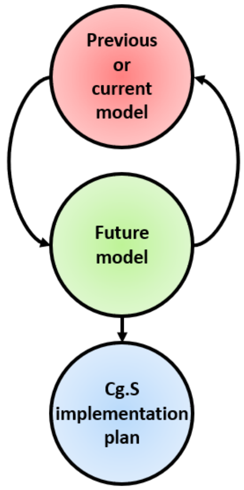

Figure B.5: This schema shows the process of functional aspects modelling, and that some activities for previous or current modelling can often overlap with future modelling, and vice versa.

processes that take place in the organisation to learn about each step they take. In doing so, an organisation that was not consciously known will begin to emerge. Once the previous-current model is developed, it is possible to compare it with the actual functioning of the organisation, i.e. the validation of the model. This will determine whether the model is a true reflection of reality. After the model has been validated, a future model is made with the knowledge that the previous-current model is accurate. The previous-current model can be useful in identifying current problems that might otherwise have gone unnoticed. By creating such a model, it becomes easier to identify areas in the organisation that need to be changed. It is therefore advisable to keep a record of the functional aspects that need to be changed promptly. It is worth noting that the same approach can be used to solve problems that are not specific to an organisation.

Therefore, to implement a **Cg.S**, the **Cg.An** must *model how the situation* was *previously*, or has *currently* been, *satisfied* and must also model how the **Cg.S** is expected to perform. In other words, the *previous or current situation* refers to how all the processes involved with the problem situation are currently performed, and the *future situation* refers to the expected behaviour of the proposed **Cg.S**.

Modelling of previous or current functional aspects

The modelling activities of the *previous* or *current* situation (*PFM train* in **Figure B.1**) refer to the realisation of all use-cases concerning the situation. In addition, the **PoK-M** and the **KDEL** are used as a source of information, as well as to identify those who have expertise in the *previous* or *current situation*.

1. *Situation boundary definition*. The general functionalities of the *previous or current situation* are identified to define the boundaries of the situation.
2. *Identification of actors and use-cases*. A list of all **KDEL** terms under the category of *subject* is compiled. The *actors* involved in the *previous or current situation* are then selected according to this list. Then, a list of all **KDEL** terms under the category of *verb* and *current behavioural response* is compiled. Subsequently, the use-cases are identified according to this list.
3. *Use-case diagram development*. The graphical representation of the functionality of the situation is developed, bearing in mind that it will facilitate

communication with the DS. Use-case diagrams are easy to discuss and validate with DS, and have proven their effectiveness over time.

4. *Main scenario description*. The sequence of actions carried out in order to achieve the objectives of each use-case is described.
5. TK *identification*. A *dialogue analysis* of the scenarios is performed to identify phrases that may hide TK. Questions and comments arising from this activity should be recorded for each use-case. This activity also facilitates the identification of alternative routes and extensions.
6. *Description of alternative routes and extensions*. An alternative route provides options to the main route. Extensions are used when there is an optional sequence of actions or activities.

Modelling of future functional aspects

The future model (*FFM train* in **Figure B.1**) represents the expected behaviour of the proposed **Cg.S**. It is a very creative phase in which the **Cg.S Architect** and his/her team combines the knowledge acquired from **DS**, their technical knowledge about the development of the **Cg.S** and the constraints imposed by the **ISD** properties. The activities are the same as for *PFM train* but are focused on what the **Cg.S** is expected to solve.

Communicating the specifications is the last group of KMoS-RE activities to be implemented

The **KMoS-RE** process supports by indicating activities for eliciting *functional* and *NF-requirements* to be able to communicate the **Cg.S Requirements Specification** (*FRS train* in **Figure B.1** and *CS* in **Figure B.4**). The activities for *functional requirements* are:

1. *Requirements elicitation*. The **Cg.An** work the previous or current and future functional aspect models to detect and list the functional requirements.
2. *Requirements description*. The requirements are prioritised and the feasibility and risk of each requirement is established.
3. *Requirements organisation*. The requirements are described in the **Cg.S Requirements Specification**.
4. *Requirements verification*. The **Cg.S Architect** and his/her team thoroughly review and check that the *specification document* covers all requirements to ensure that the requirements guarantee the functionality of the **Cg.S**.

In the case of *NF-requirements* elicitation—explaining **TK** *pieces*—Bloom's Taxonomy can be used to identify verbs at higher cognitive levels. This indicates that the knowledge requirement may be ambiguous and therefore tacit. The requirement statements should be checked to see if the ambiguity can be resolved by the complement of the statement. If not, the **Cg.An** should proceed to resolve the ambiguity and record the questions, doubts and annotations, which will be answered by the **DS**, or the *actors* involved, in the next socialisation session. The other activities to manage these requirements are essentially the same as functional requirements.

B.3 Brief examples of KMoS-RE support for Cg.Anlys

The **KMoS-RE** process has been used to support the **Cognitive Analysis** of **ISD**, such as the assessment of cognitive impairment and the optimisation of empirical processes for determining industrial design requirements. For example, the first domain involves the use of a software tool to assess cognitive impairment, while the second domain focuses on optimising the process for determining requirements for industrial air conditioning modules in the field of industrial design.

B.3.1 Background to the case of cognitive impairment assessment

The cognitive impairment assessment in patients diagnosed with multiple sclerosis is challenging and requires specialised psychological tests. In Latin American countries, access to these tests is limited because they can only be administered by certified psychologists, of which there are few. As a result, some patients in remote areas have not been assessed for impairment. To address this issue, the project aimed to automate the diagnostic assessment of cognitive impairment by developing an application that could replace the need for a specialist psychologist. The aim was to streamline the process and improve access to cognitive impairment assessment for patients in remote areas.

Start the KMoS-RE activity stream

The flow of activities in the **KMoS-RE** process is linked to the **KE-Cycles**, which are organised into three groups: *MK*, *MFA-SP* and *CS*. For example, the **Cg.An** team, in collaboration with the **Beneficiary** and **DS**, carries out activities related to knowledge elicitation, modelling, sharing and validation.

The process starts with an initial interview involving the company owner, decision makers, **DS** and the **Cg.S-P**, specifically the **Cg.An** team. The interview is recorded and transcribed for post-analysis.

After the interview, the **Cg.An** team initiates the **PoK-M** to identify **DS**, concepts, relationships and behaviours. For example, the first thing that was achieved was the identification of the characteristics of the **ISD** in this area:

- Area of knowledge related to cognitive impairment and rehabilitation of patients diagnosed with multiple sclerosis.
- Area of information and expertise concerning the development of intelligent applications in this or related areas.
- The need to automate the assessment of the cognitive impairment of a person with multiple sclerosis through the application of a set of specific tests without the presence of trained personnel. To obtain at least the same results as the traditional application of the tests; in addition, to be able to establish a prognosis.
- The participation in the project of **DS** is defined: a neurologist, two neuropsychologists and a test applicator-diagnostician.

- The participants of the **Cg.S-P** team are defined. A **Cg.S Architect**, a **Cg.An** and two **Information Technology** *engineers*.

Subsequently, the values of the **PoK-M** are then recorded according to the level of *knowledge tacitness*. The *Beliefs Repository* is updated and, once the interview is complete, the **Cg.An** team initiates domain modelling. The developed artefacts are then socialised with the **DS** and the **Beneficiary** for *model validation*. This process elicits more domain knowledge and allows the **Cg.An** team to decide whether to improve the models or move on to the next activity. The activities are repeated until all project participants agree on the set of requirements. Activities carried out, their descriptions and observations of what happened with them are listed in the following subsections.

B.3.2 Open group of activities for MK

Knowledge elicitation actions

Activities Interview sessions.

Methods and techniques Semi-structured interview.

Observations There was an observation that the dialogue between the **DS** and the **Cg.An** was not fluid. This was attributed to the fact that the **DS** did not have a clear idea of the techniques used to develop applications. It was also observed that there was a lack of agreement among the **DS** on the definition and use of concepts and the general characteristics of the application in question.

Information retrieval and analysis activities for integration into the domain knowledge

Activities Identify reliable information sources, organise and categorise information effectively, clarify and define key terms and concepts, identify and describe *NF-requirements*, uncover **TK** to complement explicit information and create a *CM* to improve the diagnostic assessment of multiple sclerosis.

Methods and techniques Some of the classifications were made according to Bloom's or Marzano's taxonomy.

Observations The **Cg.An** identified three documents that can support the process: the initial set of interviews, a document describing the use of the test battery and a medical dictionary. The **Cg.An** identified 16 terms (six subjects, six objects and four verbs), 32 definitions and three *NF-requirements*. The **Cg.An** identified 52 questions and realised that four of the terms described in the **KDEL** were incomplete.

Activities to analyse the cognitive dialogue in explaining models to domain specialists

Activities Explaining the models by the **Cg.An**.

Methods and techniques A semi-structured focus group was conducted to answer questions related to specific terms, and the *CM* was explained in detail. Both the answers to the questions and any corrections to the *CM* were recorded for further analysis.

Observations During the session, it was observed that the DS had different opinions on certain concepts, indicating differences in their level of knowledge and familiarity with the domain processes. In addition, some DS were not fully aware of certain concepts and processes, indicating a need for more information on specific topics related to the application. The session also facilitated a consensus among the DS on some of the domain concepts and processes. In addition, the session revealed that the formal document shared by the DS with the Cg.An was incomplete and inaccurate. On a positive note, the session showed an improvement in the fluency of the *cognitive dialogue*.
Note: These activities were carried out together in a focus group session.

Activities for knowledge integration and application

Activities The team worked on updating terms, *NF-requirements* and definitions, while also correcting the *CM*. In addition, the Cg.An provided an explanation of the models used.

Methods and techniques The team held a session to provide feedback and corrections.

Observations During the session, the Cg.An added three new definitions, nine verbs and four *NF-requirements*. The definitions of objects and subjects remained unchanged. The team also discovered five synonyms and realised that two terms that had been categorised as synonyms did not actually have synonyms. Based on this information, the Cg.An determined that they had sufficient data to proceed with modelling the functional aspects of the solution proposals.

B.3.3 Open group of activities for MFA-SP

Activities for current functional model

Activities Defining model boundaries and identifying use-cases are the first steps in developing a use-case diagram. This diagram should include a description of the primary scenarios as well as alternative routes of the current functional model. Identifying pieces of TK is also important to ensure a complete and accurate model.

Methods and techniques Intelligent dialogue analysis and audio recording of interactions can facilitate the collection of valuable information. Accurate reporting of all interactions and audio recordings between project *actors* is necessary for effective communication and collaboration.

Observations The use of KDEL was helpful in developing the current use-case model. The *actors* were identified based on the topics described in KDEL and the use-cases were identified based on the KDEL verbs. The Cg.An identified 24 questions about the current business processes described in the use-case model, which can help to refine and improve the model.

KDEL validation and analysis for neurological testing

Activities The team started with an explanation of KDEL and a detailed description of the use-case model using diagrams and text scenarios. They then validated the information and presented the changes made to the current use-case model, highlighting that only minor adjustments were required. In addition, the Cg.An provided an overview of the proposed model for future use-cases. The questions recorded during the language analysis phase were used to guide the discussion.

Methods and techniques To further understand the project requirements, the team conducted a focus group using a semi-structured session to answer newly recorded questions under each of the terms. The *CM* was also revised and analysed in detail. Both the answers to the questions and the corrections to the *CM* were recorded for future reference.

Observations During the discussion, the Cg.An explained the changes in the KDEL terms and the DS validated the information and made minor changes. The team then presented the use-case model and scenario descriptions, followed by questions from the *dialogue analysis*. A critical requirement was identified during the discussion, where the neurologist realised that the order of test application had a significant impact on the test results. The team noted that the TK identified is closely related to the transition from traditional testing methods to technology-based devices. This information can only be provided by DS, as any changes made may affect the diagnostic results. For example, some tests ask patients to repeat a series of newly heard words; the Cg.S-P had suggested that patients could write the words on a keyboard instead but according to the neurologist, the act of writing the words, rather than repeating them, activates different cognitive mechanisms that can affect the measurements. Due to the complexity of the proposed solution, the model for future use-cases was developed through two cycles of the KE-Cycles.

Note: These activities continue throughout much of the process and therefore appear as two groups of actions. After four cycles of this set of actions, the Cg.An team decided that they had enough information to move on to the set of actions for the communication of the specification.

Activities for knowledge integration and application

Activities Updating terms, *NF-requirements* and definitions. Correcting the *CM*. Explaining the models developed by the Cg.An. Updating the use-case diagram and describing main scenarios and alternative routes.

Methods and techniques Running a correction and feedback session.

Observations In order to complete the *PFM*, it was necessary to complete two more cycles of the knowledge flow model. However, the Cg.An decided to proceed with the next set of activities as sufficient information was already available. It is expected that the *FFM* can be developed based on the existing information.

Activities for the future functional model

Activities Definition of model boundaries, identification of use-cases, development of the use-case diagram and description of primary scenarios and alternative routes for the *FFM*.

Methods and techniques Cg.An team workshop sessions.

Observations As mentioned above, this is a highly creative activity requiring complex cognitive tasks. The Cg.An team have to combine the newly acquired knowledge about the application with their prior knowledge about the domain in order to obtain a set of **SKReqs** that takes into account the constraints imposed by the application information and meets the customer's expectations. The models generated so far, such as the **KDEL**, the *CM* and the *PFM*, made the transition to the *FFM* more natural.

B.3.4 Open group of activities for CS

Requirements specification document

Activities The future use-case scenarios were analysed to generate a preliminary list of functional requirements for the technical solution. The **Cg.S-P** was then responsible for describing, organising and verifying these functional requirements, as well as identifying any **TK** and integrating all requirements into one **Cg.S Requirements Specification** document. The knowledge integration and application process was used to ensure that all necessary information was considered before finalising the functional requirements.

Methods and techniques **Cg.An** team workshop sessions.

Observations The **Cg.An** team used Bloom's Taxonomy to identify verbs at the highest levels of the taxonomy that may indicate underlying knowledge. This **Cognitive Analysis** identified two ambiguous and undefined requirements. The **Cg.An** then worked with the **DS** to determine whether any knowledge had not yet been made *explicit*. After two cycles of validation, the **DS** approved the **Cg.S Requirements Specification** document.

B.3.5 Concluding on using KMoS-RE to assess cognitive impairment

Successful completion of the **KMoS-RE** ensures that the resulting requirements are accurate, appropriate and unambiguous. However, the ultimate test of the success of the process is the validation of the product, service or process delivered to the end user. In this particular case, the application was used to assess cognitive impairment in patients diagnosed with multiple sclerosis, and received high praise from users. It is worth noting that the artefacts generated during the **KMoS-RE** process also served as the basis for the design, coding and testing phases of the application, which saved time and added value to the process.

The use of the **KMoS-RE** process in this project has led to the following observations:

- It facilitates and accelerates the internalisation of domain knowledge, which helps to clarify the tecnical solution. It was observed that the knowledge of the **Cg.An** evolved as they developed the artefacts. At the same time, the solution alternatives were defined and refined as the process progressed.
- The process revealed that the knowledge of the **DS** was dispersed and inhomogeneous, and **KMoS-RE** reduced the *ignorance asymmetry* between **DS** and **Cg.An**. As the project progressed, it was found that the time spent on negotiation was significantly reduced. Reducing the *ignorance asymmetry* helped not only to identify and obtain the solution requirements but also to obtain a representation of the distributed knowledge of the **ahCN**.

- It helps to structure the application domain knowledge. At the beginning of the project, it was found that the knowledge of the **DS** was mostly *tacit*. Some **DS** found it difficult to explain why they did what they did, while others took much information for granted. The artefacts of **KDEL** and the conceptual model are an *explicit* representation of the structure of knowledge. Similarly, the descriptions of the use-case scenarios represent the knowledge of the domain processes and capitalise on the experience of the **DS**.
- It helps to identify incorrect assumptions about the application in the early stages of the project, minimising the risk of obtaining a solution that does not meet the domain constraints. If these incorrect assumptions were discovered in the final stages of the project, corrections could result in a loss of time and money.

In summary, this experience shows that **KMoS-RE** facilitates the internalisation and clarification of knowledge and information about application, reduces the *ignorance asymmetry*, structures the application domain knowledge, detects incorrect assumptions in the early stages of the project, and accelerates the evolution of knowledge in the network to obtain a **SKReqs** that are used in the design and development of a **Cg.S** that meets the expectations of the **Beneficiary**, patients and other users.

B.3.6 Background to the case of optimising the process for determining requirements for industrial heating and cooling modules in the field of industrial design

FLUTEC Design + Build Company is an international manufacturing company located in Juárez, Chihuahua, México, specialising in the design and manufacture of customised industrial heating and cooling modules for its clients. The design and manufacture of these modules is a complex task involving various processes such as heating, cooling, humidification, air purification, ventilation and air movement. The company has a team of specialists, including mechanical engineers, control engineers, civil engineers and architects, who work together to design and manufacture these modules. However, the design process can be challenging due to the amount of knowledge involved, the variety of solutions available and the vague or non-existent criteria used to determine the success of a project. To address these challenges, the company has developed an artefact called DNA (similar to deoxyribonucleic acid) to address the challenges of designing and manufacturing its modules. The DNA acts as a comprehensive specification document, filled in by requirements analysts with specific values for each project. However, the company has identified issues with the development and use of the DNA, such as its empirical development, lack of structure and formality and the fact that it is difficult for employees to use. In addition, the company does not have a systematic requirements process, the closest being the completion of the DNA document. These issues lead to production delays and increased costs, and employees view the DNA as an additional task that does not add much value to the process.

Start the KMoS-RE activity stream

The flow of activities in the **KMoS-RE** process begins with an initial set of interviews with the company owner or the **Beneficiary**, decision makers, **DS** and the **Cg.S-P**, specifically the **Cg.An** team. These interviews are recorded and transcribed for post-analysis. After the first interview, the **Cg.An** team initiates the **PoK-M** to identify **DS**, concepts, relationships and behaviours. The first thing that was achieved was to verify that it was an **ISD** based on the understanding of the needs of the company that were first externalised. FLUTEC needs to improve its requirements process to obtain a formal, unambiguous DNA document that is fully linked to all aspects of the design of the refrigeration units, and that will maintain or improve the quality of the refrigeration units. This document should serve as a real guide for the design and manufacture of the units. Therefore, the **Cg.An** team evaluated the possibility of using the **CMCg.I** working model to guide the definition of a new formal process for requirements elicitation that FLUTEC needed. The following activities were carried out to improve the FLUTEC requirements process:

1. Characterise the FLUTEC requirements analysis process as an **ISD**.
2. Modelling the cooling unit manufacturing domain using the **KMoS-RE** process.
3. Provide FLUTEC requirements analysts with the theoretical foundations of requirements analysis based on **KM** to ensure a comprehensive understanding of the process.
4. Together with the FLUTEC requirements analysts, determine the feasibility of implementing the **KMoS-RE** process in the company, and evaluate the potential benefits and challenges of implementation.

During the domain characterisation, it was determined whether the characteristics of an **ISD** were present in the company's situation of need:

- Area of knowledge related to the FLUTEC DNA, cooling unit design, environmental characteristics...
- Area of information and expertise concerning the development of the cooling unit design and related areas.
- Mandatory requirement to design and manufacture cooling modules that meet high customer-specific requirements.
- The participation in the project of **DS** is defined: FLUTEC engineers, architects and design specialists.
- The participants of the **Cg.S-P** team are defined. However, this unique situation requires both internal and external solution providers. The internal providers include FLUTEC electrical, control and mechanical engineers, project managers and other specialists directly involved in the design and manufacture of the cooling modules. External providers of specialised expertise and support include a **Cg.S Architect**, **Cg.An** and two business analysts who bring a unique perspective and specialised knowledge to the process, ensuring that the designs and manufacturing meet specific customer requirements.

Subsequently, the values of the **PoK-M** are then recorded according to the level of *knowledge tacitness*. The *Beliefs Repository* is updated and, once the interviews are complete, the Cg.An team initiates domain modelling. The developed artefacts are then socialised with the DS and the Beneficiary for model validation. This process elicits more domain knowledge and allows the Cg.An team to decide whether to improve the models or move on to the next activity. The activities are repeated until all project participants agree on the set of requirements. The activities carried out, their descriptions and observations of what happened with them are listed in the following subsections.

B.3.7 Open group of activities for MK

Knowledge elicitation actions

Activities Interview sessions.

Methods and techniques An in situ examination of a cooling module was carried out. In addition, a semi-structured interview was conducted to elicit and collect knowledge about the design and manufacture of the modules from FLUTEC engineers.

Observations It was found that the FLUTEC research team had limited knowledge of the design and manufacture of cooling modules. Although the FLUTEC engineers shared DNA documents from previous projects, there was a reluctance to share information and knowledge during the interviews. It was also apparent that the FLUTEC engineers lacked formal knowledge of requirements engineering.

Note: It is important to mention that open group knowledge modelling activities were used to reduce the *knowledge asymmetry* between the Cg.An team and the FLUTEC research team. These activities helped to improve the *cognitive dialogue* and understanding of the design and manufacturing process of air conditioning modules.

Knowledge source identification and CM development activities for KDEL

Activities Identification of knowledge sources, including the transcript of the first interview and DNA documents from previous projects, classification and description of key terms and definitions related to KDEL, identification of TK and development of a *CM*.

Methods and techniques Some of the classifications were made according to Bloom's or Marzano's taxonomy.

Observations The transcript of the first interview and the DNA documents of previous projects were identified as the main sources of knowledge. The Cg.An team identified 55 terms used in the design and production process of the modules. However, the team also found 81 questions and four terms with incomplete information, indicating a lack of clarity and consistency in the use of these terms. To address this, the team will need to clarify definitions and ensure consistency in their use to improve communication and knowledge sharing.

KDEL terms validation and improvement of domain understanding

Activities Explaining the models provided by the Cg.An, then each term of the KDEL was validated by the engineers.

Methods and techniques A focus group was conducted with a semi-structured session to answer the questions recorded in each of the terms. In addition, the *CM* was explained. In order to be analysed in detail, both the answers to the questions and the corrections to the *CM* were recorded. To speed up the validation process of the terms, the questions identified in the previous activity were used as a reference to provide a structured approach to the validation process.

Observations Initially, the FLUTEC engineers did not fully understand the benefits and importance of the KDEL. However, during the validation process, they realised that the FLUTEC research team had several misconceptions about the design and manufacturing process of the modules. Rather than simply answering the questions, the engineers provided a detailed explanation of the process and recommended reference materials to aid in the understanding of the field. This helped the research team to better understand the design and manufacturing process and improve the KDEL terms accordingly.

Activities for knowledge integration and application

Activities Updating terms, *NF-requirements* and definitions. Correcting the *CM*. Explaining the models provided by the Cg.An.

Methods and techniques A session of correction and feedback.

Observations The FLUTEC research team identified 15 more terms and improved the description of all the others.

B.3.8 Open group of activities for MFA-SP

Activities for the current functional model

Activities Defining model boundaries, description of primary scenarios of the *PFM* and identification of pieces of TK.

Methods and techniques Intelligent dialogue analysis and audio recording of interactions facilitate the collection of valuable information. Accurate reporting of all interactions and audio recordings between all project *actors*.

Observations The use of KDEL helped to develop the current model. The *actors* were identified according to the subjects described in the KDEL and the use-cases according to the KDEL verbs. The Cg.An identified 17 questions about the current business processes described in the use-case model.

Validation of the CM and improvement of the communication in FLUTEC

Activities The Cg.An team conducted structured interviews with FLUTEC engineers to validate the terminology in the KDEL and provided explanations and demonstrations of the *CM* structure and notation. The team ensured that FLUTEC engineers fully understood the final version of the *CM* before proceeding.

Methods and techniques Structured interviews were used as the primary method for knowledge gathering and information elicitation. The team used a set of pre-defined questions to guide the process and both the answers to the questions and the corrections to the conceptual model were recorded.

The *CM* was also revised based on the information gathered during the interviews.

Observations The validation process revealed that knowledge within the organisation was mostly tacit and dispersed. FLUTEC engineers were more willing to share information and collaborate with the **Cg.An** during the process. However, many of them were not familiar with the concepts and processes of other parts of the company. Communication between the **Cg.An** and the FLUTEC engineers improved as they gained a better understanding of the *CM* notation. The engineers validated most of the classes and relationships in the *CM*, but suggested updates to certain attributes. The DNA document had been produced in isolation by each department and lacked a comprehensive overview. The phenomenon of distributed knowledge was evident when the project manager had to consult other engineers to validate the model. Overall, the validation of the *CM* by the FLUTEC engineers improved communication within the **ahCN**.
Note: These activities continue throughout much of the process and therefore appear as two groups of actions. After three cycles of this set of actions, the **Cg.An** team decided that they had enough information to move on to the set of actions for the communication of the specification.

Activities for knowledge integration and application

Activities The **Cg.An** team performed a **Cognitive Analysis** and updated all previously generated artefacts, including *NF-requirements*, definitions and the *CM*. In addition, the team explained the models they had developed to the rest of the *actors*.

Methods and techniques The team held a correction and feedback session to ensure that all updates and changes were accurate.

Observations Although only minor changes were made to the *CM*, the FLUTEC research team reviewed, updated and modified it. They felt that sufficient information was already available to develop the *FFM*.

Activities for the future functional model

Activities Define model boundaries and describe primary scenarios for the *FFM*.

Methods and techniques Conducting workshop sessions with the **Cg.An** team.

Observations This activity requires a high degree of creativity and complex cognitive tasks. The **Cg.An** team has to combine their new knowledge of the FLUTEC DNA process with their existing domain expertise to create a set of **SKReqs** that meet FLUTEC's expectations, taking into account the constraints that its own needs expose. The **KDEL**, *CM* and *PFM* models developed so far have facilitated a smooth transition to the *FFM*.

B.3.9 Open group of activities for CS

Requirements specification document

Activities A comprehensive **Cg.S Requirements Specification** document has been created, incorporating the **Cognitive Analysis** of the original DNA document, the theoretical concepts of the requirements analysis training programme and the integration of the **KMoS-RE** process into FLUTEC.

This document outlines the current DNA requirements process and serves as a guide for future development and implementation.

Observations The workshop aimed to discuss and review the contents of the specification document, including the analysis of the original DNA document, the theoretical concepts of the **Cognitive Analysis** training programme and the implementation of the **KMoS-RE** process at FLUTEC to shape the new DNA requirements process. Participants were encouraged to provide feedback and suggestions for improvement, and to participate in the implementation of the new process. The workshop aimed to ensure that all *actors* had a clear understanding of the new process and were able to actively contribute to its successful implementation within the FLUTEC company.

B.3.10 Conclusion on the use of KMoS-RE for the optimisation of the requirements elicitation process at FLUTEC

The **KMoS-RE** was implemented to support the **Cognitive Analysis** of an **ISD** by generating models and artefacts used to analyse and verify the FLUTEC DNA process and document. The **Cognitive Analysis** revealed deficiencies in the previous process and document, leading to the creation of a formal and unambiguous specification document. The new process, including the **KMoS-RE** process, was compared with the previous one and a cost-benefit analysis was carried out. This **Cognitive Analysis** recommended the adoption of the new process, which required training for FLUTEC engineers. Practical exercises using the new process resulted in improved formalisation, clarity and completeness of documents. Overall, the **KMoS-RE** process supported the restructuring of FLUTEC's domain knowledge, improved knowledge representation and raised awareness among project *actors* of the value of **Cognitive Analysis** in **KM**. The experience shows that the **KMoS-RE** process is useful in any context where **ISD** characteristics are present.

B.4 Appendix summary and reminders

This appendix has communicated additional information on the **Knowledge Management on a Systematic process for Requirements Engineering** (**KMoS-RE**) process (Subsection 4.3.1) by providing more detail on the groups of activities (*Modelling of Knowledge* (*MK*), *Modelling Functional Aspects of the Solution-Proposal* (*MFA-SP*) and *Communicating the Specifications* (*CS*)) and actions it undertakes in support of the **Cognitive Analysis** (see Chapter 3). It is worth remembering that **Cognitive Analysis** involves a series of complex and intense activities involving diverse and ever-expanding knowledge, which should be supported by some systematic **Knowledge Management** process. In this sense, these processes must keep at least five fundamentals in mind: *identification of knowledge pieces*, *knowledge representation*, *knowledge sharing*, *validation* and *support to distributed knowledge management*. Accordingly, it is reported that the **KMoS-RE** process does include all five fundamentals:

- *Identification of pieces of knowledge*. The adaptation of **Knowledge Evolution Cycles** (**KE-Cycles**) supports the conversion of **Tacit Knowledge** (**TK**) into

Explicit Knowledge (**EK**) and, therefore, to the activities of identification of **TK** in each group of activities of the **KMoS-RE** process.

- *Knowledge representation*. Knowledge representation aims at an efficient communication of knowledge and added information. The **KMoS-RE** process makes use of tools such as a *lexicon*, *conceptual model*, *use-case model*, *scenario*, *ontology*, *Beliefs Repository* and the **Pieces of Knowledge Matrix** (**PoK-M**).
- *Knowledge sharing*. Socialisation activities, i.e. discussion and validation, encourage knowledge sharing through the **KE-Cycles**. In addition, the **PoK-M** keeps a dynamic record of the knowledge, and the level of tacitness, of the knowledge pieces of **DS** and other *actors* involved in the implementation of the **Cognitive Solution** (**Cg.S**).
- *Validation*. The different products of the process, together with the socialisation activities, allow the **Cg.S Architect** and his/her team to discuss and analyse the pieces of knowledge, and the functional requirements and their interdependencies, in order to detect inconsistencies and gain new knowledge.
- *Support to distributed* **Knowledge Management**. In addition to being able to pinpoint knowledge holders, the **PoK-M** can be used as an intelligent support to infer knowledge-related issues, such as identifying which person possesses the knowledge and who lacks certain knowledge, which person can make *explicit* what knowledge and which person could be considered more specialist than another, among others. In this way, reducing the overexertion to manage the knowledge of the whole **ad hoc Collaborative Network**.

Based on the open nature of the **Conceptual Model for Cognitive-Innovation** (**CMCg.I**) working model, its tools, actions and the **KMoS-RE** process, it is possible to customise and adapt activities and actions to address any problem within a **ISD**. This flexibility allows the development of innovative **Cg.S** tailored to specific challenges. It can therefore be concluded that the **CMCg.I** model provides a versatile framework for problem solving and **Knowledge Management** in complex environments.

C

Developing KDEL and Ontology: Basic Notes

Digital Transformation (**DT**) is the adoption of digital technologies to fundamentally change how an organisation operates and delivers value to its customers. It involves integrating various technologies such as automation, analytics and cloud computing to streamline processes, improve efficiency and increase agility. It is essential for organisations to undergo **DT** in order to remain competitive and relevant in the fast-paced business environment of today. Embracing **DT** enables businesses to better meet the evolving needs of their customers, drive innovation and position themselves for long-term success. Failure to transform digitally can lead to falling behind and potentially facing obsolescence. This transformation involves the automation of business processes to gather valuable data and improve the services and products offered. By analysing this data, organisations can gain insights and knowledge that can be used to enhance the user experience. By embracing transformation, businesses are able to streamline their operations and improve their offerings to better meet the needs of their customers [47].

[47]: Osuszek et al. (2016)

The process of gaining knowledge begins with raw data, which has no inherent meaning or value. By sorting and understanding the data, it becomes information. However, for this information to be considered knowledge, it must be contextualised and given meaning within a specific environment. This process of representation allows for a deeper understanding and utilisation of the knowledge. It is therefore important to be able to effectively represent and communicate knowledge in order to fully understand and utilise it. In this sense, an **Informally Structured Domain** (**ISD**) presents a particular challenge for knowledge representation due to the informal nature of the knowledge contained within it. Many concepts and relationships are not formally defined, and solutions to problems in these domains are often diverse, consensual and unverifiable. As a result, algorithms cannot be used to arrive at these solutions. To address this, **Cognitive Analysts** (**Cg.An**) in an **ISD** often rely on a combination of **Explicit Knowledge** and a large amount of **Tacit Knowledge** (**TK**), which is generated with the help of **Domain Specialists** (**DS**). This **TK** is critical for obtaining an acceptable **Cognitive Solution** (**Cg.S**) to problems in an **ISD** [26].

[26]: Rodas-Osollo et al. (2017)

C.1 Knowledge representation: the goal of the ontology

Knowledge representation involves the use of symbols, languages and techniques to represent and communicate knowledge in a structured and understandable way. Thus, *knowledge representation*, is a variety of forms for effectively communicating and using knowledge within a specific *domain*, and it enables the representation and understanding of complex ideas and concepts as well as the facilitation of decision making and problem solving. There are various approaches to *knowledge representation*, such as *ontologies*, *semantic networks*, *logics* and *rules*. An *ontology* is a specific type of *knowledge representation* that aims to make the *knowledge* of a given *domain explicit*. It is typically created by collecting knowledge from various sources, including **DS**, theories, documents and more. This knowledge is then analysed and used to extract the relevant concepts of the **ISD** that are to be represented. The process of building an *ontology* usually involves several steps, including development of a **Knowledge of Domain on an Extended Lexicon** (**KDEL**), construction of a *conceptual model* and implementation of the *ontology* itself. These steps are described in further detail below.

C.2 KDEL process

A **KDEL** is a comprehensive and structured collection of terms and concepts that are relevant to a particular **ISD**. It is typically developed as part of the process of constructing an *ontology*, which is a specific method of *representing knowledge* that aims to make the understanding of a given **ISD** *explicit*. The **KDEL** is created by gathering and analysing data from various sources such as **DS**, *theories*, *documents*... This process enables the creation of a graphical *conceptual model*, which provides a visual means of validation by **DS** and serves as a foundation for the *ontology*. The **KDEL** (**Figure B.2**) ensures that all important concepts and terms are consistently structured and can be used to facilitate communication within the **ISD**, as well as ensuring that *all actors* in it are using the same terminology and definitions.

The goal of this process is to make it easier to understand the complex and unstructured nature of the **ISD**. It helps those who need to understand the *domain*, such as those undergoing cognitive transformation, to clearly articulate their needs and allows those supporting them to fully grasp the necessary knowledge and information to solve the problem. By facilitating empathetic communication and establishing a shared vocabulary and terminology among *all actors* involved in a project, the **KDEL** helps to avoid misunderstandings during the elicitation, modelling and validation of knowledge and functional requirements. It is important for those involved in a cognitive transformation project to have a thorough understanding of the **ISD** and its terminology to avoid confusion, as solution developers may not have extensive knowledge of the concepts and terminology used in the *domain* they are trying to address.

C.2.1 Characteristics of the KDEL

The terms of the **KDEL** are part of the language used by *domain actors*, particularly **DS**. These terms frequently include repeated words and phrases as well as those that are relevant to the **ISD** where a problem or need is present, regardless of their frequency of use. The terms are identified through various means such as analysing interviews, conducting observations, reading documents and searching specialised information, resulting in a list of all identified terms.

During the identification and **Cognitive Analysis** process, the **Cg.An** strive to comprehend the significance of each term. Each term is characterised by its *label*, *notion* and *potential impact*. The *notion* represents the meaning of the term, while the *impact*, if applicable, illustrates its influence on the **ISD**. Both attributes are evaluated in relation to addressing a problem or fulfilling a requirement. The collection of terms can be arranged into a network, enabling the representation of the **KDEL** in hypertext format, and facilitating navigation through the vocabulary of the **ISD**.

In the process of defining *notion* and *impacts*, there are two basic principles to be followed simultaneously. The *principle of circularity* aims to maximise the use of terms in the meaning of other terms, using one term to define another. The *principle of minimum vocabulary* aims to minimise the use of terms external to the language of the application.

C.2.2 Building the KDEL

The first step in the building of the **KDEL** is to delimit the **ISD**. To do this, **Cg.An** conduct interviews with *all actors* in the **ISD**. The goal of these interviews is to gather information about the **ISD** where the problem or need is present, as well as to gain a detailed understanding of the functions and organisational structure of the *domain*, especially in the case of a company.

During the interviews, it is important to try to gather as much information as possible by having at least two *analysts* present to compare observations and to record the interviews in order to analyse them multiple times. The set of terms and a preliminary *conceptual map* are also built during this stage.

After the preliminary interview, sectoral interviews are conducted in the case of a company, institution or organisation. The goal of these interviews is to understand the detailed functioning of each sector of the company. The type of interview and questions may vary depending on the nature of the **ISD** or specific project, but a description of the functioning of the sector is always requested. Care should be taken to clarify any ambiguous or doubtful terms during the interviews.

The materials obtained from the interviews are used to delimit the **ISD** and a document is created that transcribes the recordings and transcriptions of the interviews.

The construction of the **KDEL** consists of three sets of several activities, which can be interdependent and even parallel. They are mentioned below in summary form:

- Interviews and terms list: These activities aim to gather information about the vocabulary used in the **ISD** and to understand how the actors use it. From the information gathered during the interviews, a list of terms is generated without taking into account their descriptions.
- Classification and description of the terms: To ensure completeness and consistency, terms are classified and grouped in a logical way, and the notion and impact of each term is established based on the information gathered during the previous steps.

- Terms validation and KDEL control with *all actors* of the ISD: The term descriptions are reviewed with *all actors* to ensure their accuracy and to make any necessary corrections or revisions.

It is important to note that the boundaries between the activities can be blurred.

Interviews and terms list

Once the ISD has been delimited, the KDEL is initialised:

- Candidate entries are listed by identifying words or phrases, most frequently repeated, extremely specific to the ISD area and consequently there are "different languages" among *actors* and Cg.An.
- Second sectoral interview. The objective of this interview is to refine and deepen the knowledge of those who participated in the previous sectoral interview. An additional effort should be made to identify and register candidate terms for the KDEL.
- List of terms and preliminary KDEL. A list of KDEL terms is defined and possible contents of the notions and impacts are sketched to have a brief description of the term.
- Validation with *all actors* in the ISD, especially DS, decision-makers and the Beneficiary.

Another thing to note is that the ideas and effects are often extended with very technical details that are particular to their experience, which makes it hard to communicate.

Classification and description of terms

Technical and more specific language is often a major problem for the Cg.An. The ISD requires a special effort to understand the meaning of all its terminology. To implement the KDEL, the Cg.An have to elaborate a taxonomy specific to the ISD under consideration. The idea behind this is the best possible identification and description of terms. For example, a division of the terms into subject, verb, object and state can be considered. This taxonomy depends on the specific *domain* and case, and is best suited to the project at hand. Table C.1 shows an example of a generic taxonomy.

Table C.1: Example of a taxonomy used for term classification.

Type	Verb or description
Label	Description: short note
Synonym	Description: short note
Acronym	Description: short note
Notion	Description: short note
Intention	Description: short note
Source	Description: short note

Terms validation and KDEL control

The validation of terms is crucial and involves consulting with *all actors* in the **ISD**, particularly **DS**, decision-makers and the **Beneficiary**. This is typically accomplished through a series of meetings where any terms, processes or actions that are unclear or ambiguous are discussed. In the case of working with companies, confidentiality agreements are put in place to protect the safety and security of all parties involved. At the beginning of each meeting, it is important to clearly explain the purpose and importance of understanding the language, processes and other relevant aspects of the company that pertain to the problem or need at hand. As the meetings progress, *actors* may provide additional insights and technical details, which can greatly enhance understanding of the terms and concepts.

Controlling the **KDEL** means having a formal, complete, unambiguous document. To achieve this, several revisions of all of the above must be made with *all actors* until there are no more modifications and everything done is clear and complete for all of them. A good instrument to support the reviews is to make a template from the taxonomy (**Table C.1**) to review each term in order.

C.3 Conceptual model in support of ontology

A *conceptual model* is a simplified representation of a complex system or process that is used to understand and communicate the key components and relationships within that system or process. It is typically used to aid the understanding of how different elements of a system or process interact and work together, and it is often created as part of the process of developing an *ontology*, which is a specific type of knowledge representation that aims to make the *knowledge* of a given *domain explicit*. *Conceptual models* are often developed using graphical or diagrammatic representations, such as flowcharts, mind maps or entity-relationship diagrams. They may also include text descriptions or definitions of the various elements and relationships within the system or process being represented. These models can be used to clarify and simplify complex systems or processes, to facilitate communication and understanding among *all actors* of the **ISD** and to guide the development of more detailed and technical models or representations of the system or process. A *conceptual model* serves as an extension of the **KDEL** by providing a more detailed and structured representation of the concepts and relationships within a particular *domain* of knowledge. It is designed to help those involved in the process to understand the environment in which they will be working, even if they are not specialists in the *domain*. There are several structured approaches for generating *conceptual models* from the **KDEL**, such as the use of a metamodel or class diagrams. **Figure C.1** illustrates the process of constructing the *conceptual model* from the **KDEL**.

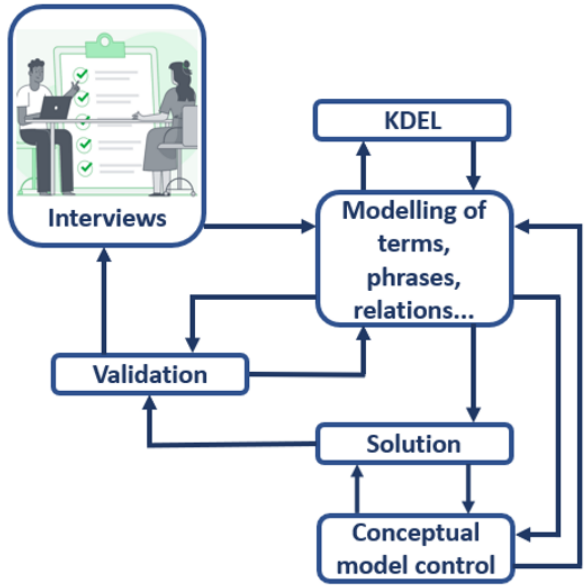

Figure C.1: Process of building the conceptual model based on the KDEL.

C.4 Ontology

Once the KDEL and *conceptual model* activities have been completed and validated, *ontology* development can proceed. An *ontology* is a formal representation of a set of concepts and relationships within a particular *domain of knowledge*. It is used to represent and organise knowledge in a *structured* and *explicit* way, enabling computers and other artificial entities to understand and process that knowledge. *Ontologies* are typically created for specific ISD, such as healthcare, finance or manufacturing, and they are used to represent the concepts, terms and relationships that are relevant to that ISD. *Ontologies* are often developed using formal languages, such as the OWL[1], which enables them to be machine-readable and interoperable with other systems. They typically consist of a set of concepts that are defined using attributes and relationships, and they may also include rules and axioms that define the relationships between concepts and the logical structure of the *ontology*. *Ontologies* can be used for a variety of purposes, including Knowledge Management (KM), data integration, natural language processing and decision support. They seek to generate a knowledge representation with the help of a semantic web language in a way that is processable and interpretable by a computer.

1: OWL: The Web Ontology Language is a language for defining ontologies on the web. An OWL ontology describes a domain in terms of classes, properties and individuals, and may include rich descriptions of the characteristics of those objects.

C.5 Brief introduction to two different ISD areas that exemplify the use of the KDEL, conceptual model and ontology

The above activities outlined for the KDEL, *conceptual model* and *ontology* were carried out to *represent knowledge* from two different areas of an ISD.

The first corresponds to the area of *Electroconvulsive therapy (ECT)*. *ECT* is a medical treatment that involves the use of electrical currents to stimulate the brain in oder to treat certain mental health conditions. It is typically used to treat severe depression, mania and schizophrenia, and it may also be used to treat catatonia and some forms of dementia. It is administered under the supervision of a trained healthcare professional. During the procedure, a patient is given a general anaesthetic and muscle relaxant, and electrodes are placed on the head to deliver the electrical current. The electrical current is then passed through the brain, inducing a seizure that lasts for about a minute. The seizure is thought to produce changes in brain chemistry that can alleviate symptoms of the mental health condition being treated. *ECT* is generally considered to be a safe and effective treatment for certain mental health conditions, although it can have some side effects, such as temporary confusion, disorientation and memory loss. It is typically reserved for cases where other treatments, such as medication and therapy, have been unsuccessful. The domain of *ECT* is considered an **ISD** because it meets the characteristics discussed in Subsection 2.2.1. In this domain, there are a variety of attributes, such as the amount and intensity of the electroshock delivered to the patient and the measurement of responses obtained using reaction tests, which present a challenge to the expertise and knowledge of medical specialists in using *ECT* effectively and minimising side effects [21].

[21]: Rodas-Osollo et al. (2022)

The other area is *Work-Related Stress (WRS)*, particularly how individuals interact with the demands and challenges of their work environment. The interaction experience comprises workload, time pressure, job insecurity and poor working conditions. *WRS* can adversely affect an individual's physical and mental health, work performance and overall well-being. To foster a healthy and productive work environment, organisations should recognise and tackle the sources of *WRS*. The investigation of this area should incorporate input from organisations studying *WRS*, as well as the knowledge of *specialists in WRS and associated fields* who research the different stressors impacting workers.

C.6 Carrying out the series of activities related to the KDEL, conceptual model and ontology

The process of carrying out the activities mentioned in the previous sections includes a set of knowledge search, extraction and elicitation tasks. This process is shown in **Figure C.2**. Thus, the process of developing an *ontology* for a domain involves several steps, including domain analysis, knowledge search and extraction and elicitation tasks. These activities involve validation by **DS** and aim to confirm concepts and relationships, as well as to minimise ambiguity in communication when constructing the *ontology*. This process is not linear, but rather *cyclical* and *evolutionary*, as it continues until an adequate level of knowledge is reached that meets the needs of all participants. Ultimately, this process formalises the knowledge of the domain, transforming the experience of specialists and available information into a structured representation known as an *ontology*.

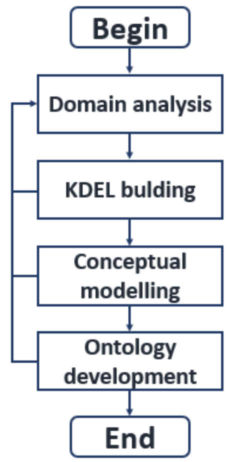

Figure C.2: Ontology development process.

C.6.1 Analysis of the domain of interest

Usually, the domain analysis starts by making use of existing resources in the literature, for example, by studying documents suggested by DS, specialised readings. . . This usually provides enough information, including knowledge, for the ISD newbies to take part in the activities to reduce the level of misunderstanding in the *domain* discussion.

Subsequently, to start the building of an *ontology*, the components that it should include must be known:

- Concepts: Key ideas that are intended to formalise the ISD.
- Relationships: Interactions between the concepts of the ISD.
- Functions: A specific type of relation, which identifies an element through the calculation of a function.
- Instances: Represent objects of a concept.
- Axioms: Statements or statements of the relationships to be affected by the elements of the *ontology*.

After identifying all the components, and with the help of the DS, the iterative process of activities and tasks begins. The process will end when the knowledge is represented in a way that means no variation or ambiguity is left in the language of the *domain*.

C.6.2 Elaboration of the KDEL

To the elaboration of the KDEL, a list of concepts or terms that are identified as relevant or specific to a particular domain must be created. These concepts are documented with definitions that are meant to be understood by all participants in the activities related to the KDEL. The characteristics were discussed in Section C.2. The KDEL may be enhanced with detailed descriptions and sources of information to provide a deeper understanding of the *domain* to *all actors* involved in the *ontology*. This enhances the development of a more extensive KDEL, which can foster improved understanding and cooperation.

C.6.3 Conceptual model development

While there are works that discuss the fundamental aspects of the modelling process, the reality is that the quality of the input information—in this case, the **KDEL**—and the experience of the **Cg.An** conducting the **Cognitive Analysis** are the main factors that will affect the results. The modelling process involves capturing the concepts identified in the **KDEL** development and identifying the relationships between them based on their definitions. It is an iterative process that requires careful consideration and attention to detail. When identifying relationships in the knowledge *domain*, it is important to categorise them as hierarchical or taxonomic. This allows for the differentiation of relationship types, such as specialisation, generalisation, all-part, aggregation and composition, as well as pairwise associations. This information can then be used to construct a class diagram that depicts the identified concepts and their relationships. This approach can help to ensure a clear and accurate representation of the knowledge *domain*. Although multiple tools can assist in modelling, the **UML**[2] is often used for its functionality and practicality. Once the first model is complete, it must be validated by all the participants, mainly the specialist, to identify others that are missing, make corrections and check if any **KDEL** terms were not added to the model. In this way, a cycle will be formed between modelling and validation. The cycle will continue until the best version has been reached by all participants.

2: UML: is a standardised Unified Modelling Language comprising of an integrated collection of diagrams developed to assist system and software developers in specifying, visualising, constructing and documenting the artefacts of software systems, as well as for business modelling and other non-software systems.

C.6.4 Ontology development

Ontology development represents the last activity in the process. It requires extensive experience and expertise in existing formalisms and tools to realise the best representations of knowledge through *ontology*. The development is essentially carried out in two ways: a complex method that involves even the conformation and editing of files, and another method that uses *ontology* editors. In the first case, a high level of skill is needed to handle the semantic rules of the file, which will be more demanding depending on the language being used. For example, in the case of the web ontology language, an OWL file and an XML structure are needed to define the *ontology*.

C.7 Results

The above-mentioned activities and tasks were carried out by **Cg.An** and other participants who provided support, feedback and validation throughout the development of the *ontologies*. Some results obtained thanks to them are described below.

C.7.1 ECT case

To develop the *ontology*, explicit information from various documents and the expertise of *ECT specialists* was gathered through multiple interviews. The information was then organised into an Excel template, which served as the structure for the **KDEL**. A total of 53 terms were identified and recorded, along with acronyms, references and synonyms, which were classified into definition, object, subject and verb categories. The concepts of these terms were reviewed and validated by the DS until the vocabulary was finalised and the KDEL accurately reflected the existing domain knowledge to the satisfaction of the DS. An example of the representation of the "ECT" concept in the KDEL can be seen in Table C.2.

Table C.2: Entry extracted from ECT-KDEL.

Type	Description
Label	Electroconvulsive therapy.
Synonym	Electroshock therapy.
Acronym	ECT.
Notion	The procedure of electroconvulsive therapy (ECT) involves the application of electrical currents to the brain in order to induce a controlled seizure. This treatment has been shown to cause neurophysiological changes that can alleviate the symptoms of certain mental illnesses, such as schizophrenia and severe depression. ECT may also be used in patients with delusions and other psychotic symptoms. It is important to note that ECT is a medical procedure and should only be performed by trained medical professionals.
Intention	Electroshock application.
Source	Mayo Clinic.

Subsequently, the *conceptual model* was developed in an iterative revision-correction-validation process. After a few modelling cycles, the best version of the *domain knowledge* was achieved and the *ECT ontology* was developed using the OWL web ontology language. Excerpts of both the representation and the *ontology* are given in Figure C.3 and Figure C.4.

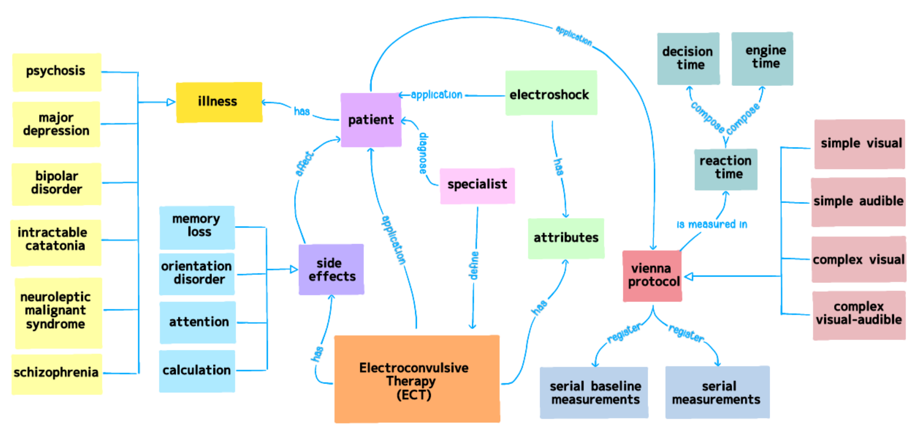

Figure C.3: Extract from the conceptual model for the ECT.

C.7.2 WRS case

kain2010

To develop the *ontology* for the *WRS domain*, the *Job Content Questionnaire (JCQ)* from Karasek's theory was studied **[kain2010]**. Subsequently, interviews were conducted with DS to determine which terms should be represented by the *ontology*. From the survey and interviews, 137 terms were identified. Each term

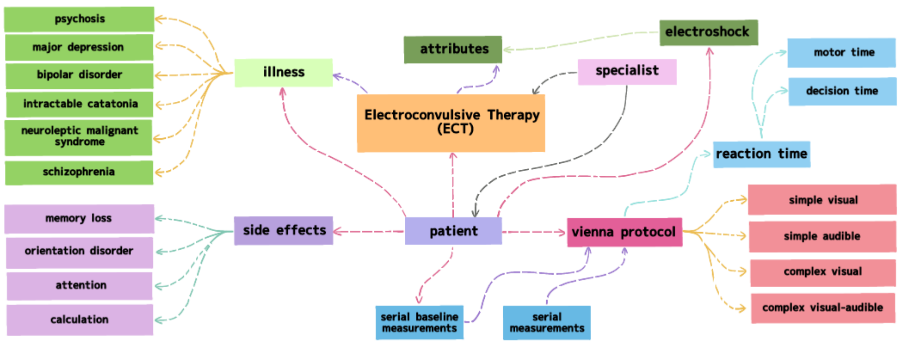

Figure C.4: Extract from the ontology for the ECT.

was duly recorded, including synonyms, acronyms, descriptions, intent and source. **Table C.3** shows an example representation of the term "work content questionnaire" in the **KDEL**.

Table C.3: Entry extracted from WRS-KDEL.

Type	Description
Label	Questionnaire Job Content
Synonym	Job Content Questionnaire
Acronym	QJC, JCQ
Notion	Job stress questionnaire, which states that job stress is a predictor of increased risk of mental stress and illness in employees. The purpose of the questionnaire is to find out how stressful a job is
Intention	The company applies the job content questionnaire. The job content questionnaire assesses the job stress of workers. The job content questionnaire considers decision latitude, job demands, social support, and job insecurity
Source	Tania Maria de Araújo, Robert Karasek, validity and reliability of the job content questionnaire in formal and informal jobs in Brazil @Araújo

Once the **KDEL** was validated, the *conceptual model* was developed. The relationships between the terms were identified, the diagram was constructed and the adjustments requested in the iterative revision-correction-validation process were made. **Figure C.5** shows an extract of the *conceptual model* obtained. Subsequently, the *ontology* was developed, and an extract of it is shown in **Figure C.6**.

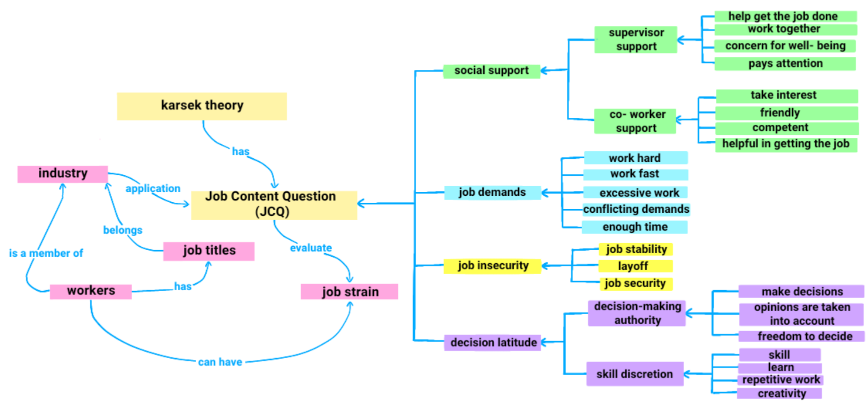

Figure C.5: Extract from the conceptual model for WRS.

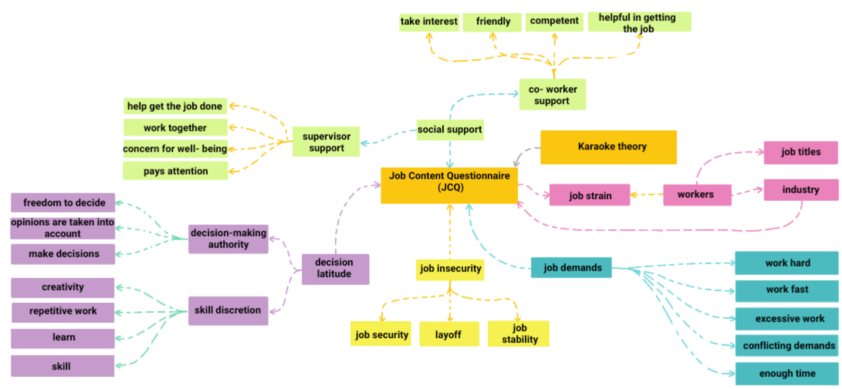

Figure C.6: Extract from the ontology for WRS.

C.8 Conclusions

The conclusion can be broken down into three parts, with two of them focusing on different aspects of *organisational knowledge* in the Cognitive Era.

The first part emphasises the importance of knowledge as a primary form of capital for an organisation. It highlights how the use of available knowledge and the acquisition of new knowledge in a *systematic* and *structured way* generates new knowledge that often constitutes a large investment capital for the constant transformation of the organisation. Furthermore, it notes that when a company faces increased competitive pressure, it makes more effective use of all of its resources, especially knowledge, in order to survive and achieve efficiency by offering products and services with better quality than the competition. Furthermore, it must underline that knowledge must be shared at all levels of an organisation to keep it in continuous improvement and that, without the guidance of knowledge, the efforts of the organisation will surely lead to ruin.

The second part of the conclusion emphasises the importance of identifying and managing different types of knowledge and information related to an organisation. In this sense, it notes that an *ontology* is a structure that facilitates and supports the management and use of information, and current knowledge for the subsequent generation of new knowledge. It also supports the maintenance of a robust knowledge base that will support the continuous learning process in an organisation. In essence, a good knowledge representation should not do without any knowledge, nor create redundancies, and should allow knowledge to evolve, abstract, share and infer, facilitating cognitive transformation by making good use of organisational knowledge. Thus, acquiring, managing and effectively disseminating knowledge is crucial for organisations to foster continuous learning and growth. Implementing effective methods and procedures for these processes is essential in order to harness the full potential of knowledge as a valuable asset.

The last part concludes a process that started with a **KDEL**, followed by a *conceptual model* for the construction of an *ontology* of the **ISD**, such as the examples of *ECT* or *WRS*. The process was essential to represent and communicate knowledge in these areas. It includes the identification and definition of key concepts, the formalisation of a structured representation of the relationships between these concepts and the validation of the resulting structure through consultation with **DS**. The end result is a comprehensive and accurate *ontology* that serves as a valuable resource for understanding and navigating the complexities of these subjects.

The process can be very challenging, especially in an **ISD** such as the *ECT* and *WRS* examples mentioned here. Both presented difficulties, for example in accurately representing the relationships of the attributes involved in short, repeated serial measurements, or in defining certain terms that do not easily fit into the categories used in the **KDEL**. Despite these challenges, it can be deduced that the activities commented on in this appendix can effectively support the formalisation and representation of the knowledge of an **ISD**, including both the creation of the *conceptual model* and the *ontology* itself.

C.9 Appendix summary and reminders

This appendix provides additional information on the **Knowledge of Domain on an Extended Lexicon**, *conceptual model* and *ontology* in the context of the **Informally Structured Domain** (**ISD**). It is important to note that solutions for the **Cognitive Era** (**CE**) must be tailored to the specific situation of the **ISD** in question. This appendix highlights the importance of using a common language and creating an *ontology* to facilitate **KM** and communication within an organisation. In the **CE**, effective **KM** is crucial for success.

D

Agile Prototyping: Basic Notes

Projects to develop new products, services or processes, or even projects aiming to innovate existing products, services or processes, are finding the environment of the **Cognitive Era** (**CE**) increasingly challenging. In particular, owing to **Artificial Intelligence**, all *actors* within the **Beneficiary** group of these projects are communicating knowledge and functional requirements to a greater extent. They have high-quality expectations and anticipate exceptional performance, despite shorter and highly complex life cycles. These market and technology conditions make the environment volatile, uncertain, complex and ambiguous. As a result, traditional project development methods are too rigid and linear. In such an environment, Agile and Lean, which can deliver product prototypes or first versions of services or processes in a shorter time, can help to achieve faster time-to-market, high levels of flexibility and closer integration with the **Beneficiary**.

What are Agile methodologies?

Agile methodology[1] can be thought of as a set of iterative and flexible approaches originally developed for software development but now used in other types of development. The approach is to deliver the final product incrementally, incorporating feedback from all project *actors*, especially the **Beneficiary**, throughout the process. The iterative process involves multiple deliveries of functional prototypes until all requirements are met to the satisfaction of the **Beneficiary**. Agile development encourages team collaboration, continuous planning and learning and respects the project development cycle, making it easier to identify and resolve bugs or new requirements. The main advantage of using Agile methods is the continuous delivery of “value” to the **Beneficiary**, not just the rapid delivery of a *solution*.

1: Agile methodology is a "step-by-step" dynamic that focuses on short-term visibility but never loses sight of the long-term product goal. Agile methodologies include Scrum, Kanban, eXtreme Programming (XP), Lean Development and Crystal.

Today, given the speed of change in technology, non-software development projects have also adopted Agile approaches. However, projects involving physical parts or components face challenges due to lead times in the supply chain, which compromises the performance of an Agile process. As a result, hybridisations between Agile and traditional approaches have been developed.

The Agile manifesto, developed by a **Cg.S Provider** (**Cg.S-P**) community, outlines the principles and good practices of Agile methodologies. The manifesto argues that client satisfaction should be sought through the continuous delivery of value-adding software by staying in constant communication with the client and focusing on communication between all actors of the development. Agile methodology is not characterised by the complete definition of a product, but rather "step-by-step" and constant delivery, focused on "near-shore" visibility but never losing the long-term product goal.

According to the Agile manifesto and its 12 principles, client or **Beneficiary** satisfaction is the top priority, and changes to requirements should be accepted. The **Beneficiary** and the **Cg.S-P** team should work together daily, and a pleasant environment and good support should be provided to development teams. Agile processes promote sustainable development due to their constant rhythm and technical excellence, which in turn improves productivity. Therefore, in order to make the necessary adjustments and promote effectiveness, retrospective moments within the team are essential.

Efficiency has made Agile methods attractive, and they have even become popular in business management, demonstrating that these practices can enrich more than just software development. Cognitive business development is becoming an increasingly unpredictable playground, and the challenge is to implement Agile methodologies in cognitive business process management. Agile methods are adaptable, allowing for rapid decision making and instant influence on business development.

D.1 Pre-Agile new product development

Before the **CE**, project implementation follows a linear progression in which analysis for planning, development and validation testing takes place sequentially and is popularly known as the waterfall development model, (**Figure D.1**) [**ruparelia2010**]. The main problem is the rigidity of the model, as it leads to a high probability of costly redesigns, especially if the requirements analysis is not done properly before starting.

ruparelia2010

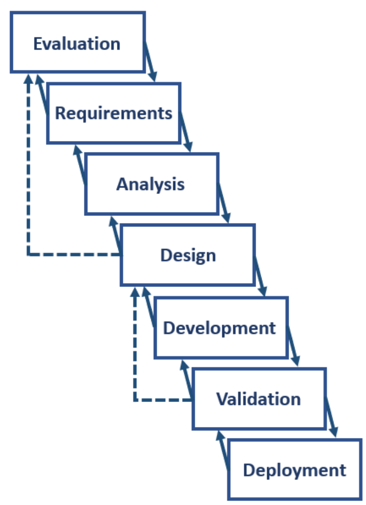

Figure D.1: Royce-based cascade model. The figure shows the linear model or programme life cycle model proposed by Royce. In essence, it is a methodological approach that consists of arranging the various stages to be followed in the development of a project linearly.

Another linear implement process, known as the Stage Model, divides the project into several stages—Discovery and Scope (of the idea and concept), Business Case, Development, Testing and Launch—each with a gate at which the decision to continue or abandon the project is made (**Figure D.2**) [48]. It consists of a multi-stage process connected by gates. Each stage is designed to collect specific information and the gates act as quality control points to move from one stage to the next. This stage-gate process involves extensive documentation to ensure a smooth

[48]: Franken et al. (2020)

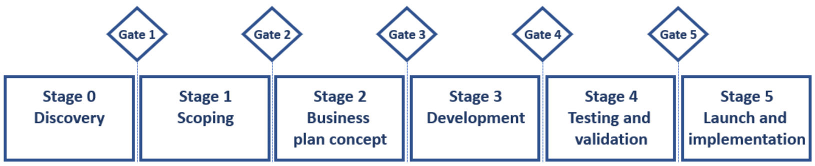

Figure D.2: Cooper-based stage gate model. The figure shows Cooper's stage model. It is a model focused on large projects that require innovation. Depending on the size of the project, two, three or all five stages are completed. In general, a product would go through all five stages. A simple project may go through stage 1 (scoping) and stage 2 (business plan concept) and reach stage 4 (testing and validation). In the case of very small or simple adaptations to already functioning processes, stage 3 (development) and stage 4 (testing and validation) may only be carried out for commercialisation cases or to modify an existing product.

transition between the various stakeholders and stages. Product characteristics, schedule and allocated budgets are decided at the beginning of the process. Ultimate success is defined by the degree to which the final product meets the defined deadline with the initially specified requirements, at minimum cost. This requires known conditions and a stable technology base.

Traditional sequential development methods are reliable, but they struggle in volatile and complex environments where customer needs change rapidly and disruptive technologies emerge frequently. Increasingly complex requirements and shorter product lifecycles make it difficult to select the right customer requirements at the planning stage. In addition, many innovation projects fail because technical feasibility becomes apparent too late in the development process [49, 50]. These traditional methods are seen as too rigid and do not meet many of the challenges of the CE.

[49]: Boehm (1976)

[50]: Gaubinger et al. (2015)

D.2 Agile product, service and process development

Compared to its traditional counterparts, an Agile environment has the inherent ability to generate change quickly, adapt to change proactively or reactively and learn from change while contributing to customer-perceived values in terms of economy, quality and simplicity.

Agile development transforms projects incrementally through short iterations, resulting in an increment after each iteration. Testing and planning are done incrementally, allowing for rapid failure and learning. Ongoing customer involvement and feedback ensures that the final product meets changing customer needs. Collaborative, self-organising, cross-functional teams use visualisation tools to support communication and allow distributed measurement of success after each incremental delivery. This approach allows progress to be adjusted throughout the project development phase, reducing the risk of customer disagreement and unsatisfactory project completion.

The way this is done depends on the method chosen; Scrum, Kanban, eXtreme Programming, Lean Development and Crystal are some of the most popular methods. However, only the Scrum method explicitly focuses on managing the entire project development process, whether or not the end of the process is the release of software. Therefore, in this appendix, alluding to Scrum is equivalent to alluding to Agile.

D.2.1 Lean and Agile

Another way of managing a project that is closely related to Agile is Lean. Both concepts focus on customer value, shortening development cycles, reducing waste and minimising defects, but they are aimed at different audiences. While Agile focuses more on the development team and the rapid delivery of a functional product, Lean is applied from a top-down management perspective to optimise workflows. Agile also defines specific methodologies, whereas Lean does not. Although the nature of each project is different, experience suggests that the benefits of both concepts should be combined in new projects.

D.2.2 Scrum

Scrum is an Agile methodology framework that focuses on iterative and incremental development. It involves a team of developers working together to deliver a product in increments, building on each increment to create a final product that meets the customer's needs. Scrum is organised around a series of time-bound events and roles designed to ensure effective teamwork and customer satisfaction. The key roles in Scrum are the product owner, the Scrum master and the development team. The key events in Scrum are the sprint, sprint planning, daily Scrum, sprint review and sprint retrospective. Scrum revolves around iterative cycles of problem solving and is flexible and adaptable to the needs of the team and the project, emphasising collaboration, communication and delivering value to the customer. By adopting Scrum, teams can benefit from increased collaboration, flexibility and adaptability to deliver high quality products that meet the evolving needs of their customers. A visualisation of the process is shown in Figure D.3 [**schwaber2011**].

schwaber2011

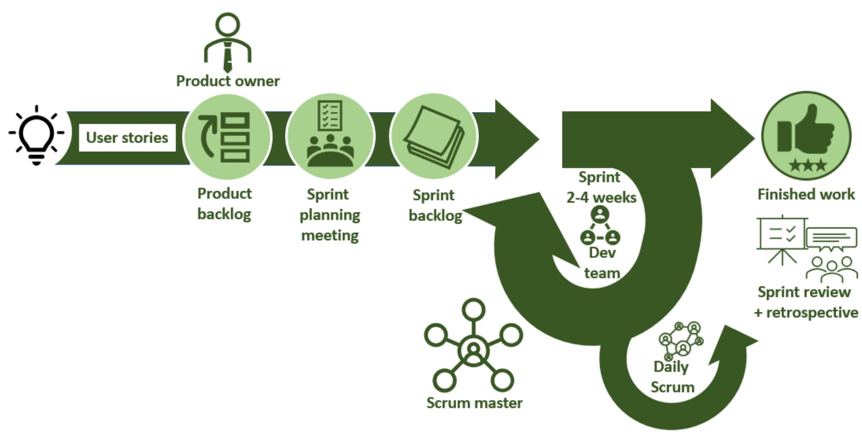

Figure D.3: Scrum process. Scrum is an Agile project management process, a way of doing teamwork in small chunks at a time, with continuous experimentation and feedback loops along the way to learn and improve as you go. This figure communicates that Scrum provides a structure for individuals and teams to work incrementally and collaboratively, adding appropriate practices to optimise their specific needs. It consists of a multi-stage process connected by gates. Each stage is designed to collect specific information and the gates act as quality control points to move from one stage to the next.

The Scrum method offers several benefits to software development teams, including:

- *Motivation*: The Scrum framework's focus on sprints and deadlines helps to motivate team members to achieve their goals on time.
- *Transparency*: The methodology emphasises transparency, allowing all team members, as well as stakeholders throughout the organisation, to monitor progress and stay informed about the status of the project.

- *Quality*: Scrum prioritises quality, which helps to reduce the number of errors and defects in the final product.
- *Flexibility*: Scrum's dynamic approach allows teams to adjust priorities and reorganise tasks between sprints, ensuring that the most critical tasks receive the attention they need.
- *Planning*: Effective sprint planning ensures that the entire team understands the "why, what and how" of each task, leading to better collaboration and results.

Although the Scrum methodology offers many benefits, it is not without its limitations. These include:

- *Fragmentation*: The iterative and segmented nature of the Scrum framework can sometimes cause teams to lose sight of the overall project and become overly focused on individual tasks or sprints.
- *Role confusion*: The lack of clear role definition can lead to confusion and misunderstanding among team members, especially when responsibilities overlap or are unclear.

D.2.3 Kanban

Kanban is a team-based method of just-in-time production in which a board is divided into columns to represent different stages of a project. The method focuses on team skills and requires good communication and transparency. Its advantages include the ability to track progress and limit the number of tasks in progress at any one time, which helps with continuous improvement. However, misinterpretation of the board and time management issues can arise, so regular updates and strong team coordination are essential.

D.2.4 eXtreme Programming

The eXtreme Programming (XP) methodology is an Agile development framework that focuses on software-oriented development and values communication, simplicity, feedback, value and respect. XP emphasises testing software from day one and puts customer satisfaction above all else. It promotes teamwork and encourages discussion and engagement, breaking down communication barriers and making everyone an important piece of the same puzzle. XP has visible development processes and encourages an energetic way of working. However, it can overlook design and may not work optimally if team members are not in the same location. XP may also fail to record potential errors, which could lead to similar errors in the future.

D.2.5 Lean Development

Lean Development is an Agile development framework that values simplicity, quality, and rapid delivery. Its core principle is to ruthlessly eliminate activities that do not add value to the final product. It emphasises building simple solutions and gathering customer feedback to incrementally improve the product.

However, Lean Development also requires discipline and documentation to eliminate defects in the code and maintain effective communication and conflict management practices. It is scalable and adaptable to projects of any size but requires commitment from the development team to follow its principles, to avoid splitting tasks into too many elements and to prioritise documentation in order to avoid faulty development.

D.2.6 Crystal

Crystal is a flexible methodology that emphasises people and their interactions in order to empower teams to create their own processes. It prioritises communication, community, skills, talent and frequent hand-offs to identify potential problems and improve features over time. While it may not work well for geographically dispersed teams and may need to be adapted for larger and more complex projects, its focus on adaptation and continuous improvement allows for knowledge sharing and success.

D.3 Scaling frameworks

In general, Scrum is a framework for organising small projects and teams, but it does not consider projects with multiple teams working on different aspects of a product. In the case of large projects, these are handled under scaling frameworks. There are several scaling frameworks, which are summarised in **Table D.1** [51, 52]. The most common is the Scaled Agile Framework (SAFe), the Large-Scale Scrum (Less) and the emerging Scrum@Scale [53].

[51]: Kalenda et al. (2018)

[52]: Diebold et al. (2018)

[53]: Alqudah et al. (2016)

Table D.1: Basic information of Agile scaling frameworks.

Characteristic	SAFe	Less	Scrum@Scale
Target size	Large to enterprise.	Medium to large.	Small to large.
Based on	Scrum, XP, Kanban.	Scrum.	Scrum.
Project control	Top-down approach. Distributed ownership of "how".	Centralised prioritisation, distributed coordination.	Distributed, more "agile".
Industry adoption	High.	Medium.	Medium.
Advantages	Focus on big picture, very prescriptive.	Effective product owner scaling, based on suggestions.	Lightweight, closest to pure Scrum.
Challenges	Requires extensive training, not as Agile as other frameworks.	Difficult to implement in large organisations as considered "radical".	Newest framework, still evolving.
Team sizes	50–120.	10 teams with seven members each.	Varies depending on use-case.
Complexity	High.	Medium, low if Scrum-trained.	Medium/low, more around guidelines.

D.4 What to do with Agile strategies and when?

The development of a project can produce both tangible and intangible results, with some projects having both components. Tangible components often require a significantly longer lead time than intangible ones. This is because capital investment is often committed at the start of the project, as initial decisions about manufacturing processes are made during the development of the tangible product. As a result, this type of project tends to have longer lead times and a higher level of complexity due to physical constraints.

There are several challenges associated with dividing deliverables to fit into an iteration period, particularly when dealing with tangible products that have dependencies that make prototyping and testing difficult. Conversely, purely intangible increments can be tested and deployed with relative ease. Another challenge is the division of development tasks, especially in areas with a higher **Tacit Knowledge** load, where more specialists, developers, test engineers, production engineers and other experts are involved. Estimating the time and resources required for tasks is also a challenge, as small design changes in the tangible domain can have a significant impact on cost and schedule. In addition, lack of process and product flexibility, such as long lead times from suppliers, can present further challenges.

Despite these differences, experience shows that many of the elements of Agile can be adapted to any type of project development. Ultimately, it is possible to blend Agile and traditional practices in hybrid models. The first approach is to integrate Agile and stage-gate (as they are compatible) with Agile, providing powerful micro-planning and day-to-day operational control, and stage-gate providing team coordination and communication between stakeholders. More recent models include the Agile-stage-gate model, where Agile development methods are used within stages for all subsystems, whereas the Scrum method includes getting a "prototype" for customer feedback. Secondly, these methods require a dedicated and co-located team. Finally, communication must follow a diamond pattern, with each member being connected. This is in stark contrast to the pure stage-gate process, where there is a central point through which information flows. A similar model is called the visual iterative project management method. It divides the project into several levels, the first of which is the high-level stage process with milestones and development phases. Level 2 defines the deliverables of each phase for iterative development. At level 3, the deliverables are broken down into tasks and assigned to team members. At the final level, Key Performance Indicators (KPIs) are measured. The proper functioning of this model depends on the use of project management support software. Another approach is to abandon the notion of using Agile only in stages. While Agile team releases and project gates should be synchronised, sprints can be allowed to span gates. Gates act as indicators of project status and are defined as closing knowledge gaps or making key decisions to enable changes to specifications. Releases are intended for knowledge sharing and validation, ideally using Minimum Viable Products (MVPs). This model seeks the optimal relationship between Agile and project development.

When to use Agile?

Experience shows that Agile is often used for specific scenarios or products. However, there are those who use Agile in all types of projects, but only when they are small and tailored to suit. Although the flexibility and interpretation of Agile is often abused, the way it is implemented can vary from project to project and as the project progresses. Today, there is no formal technique for determining when to use Agile; it is decided informally on an ad hoc basis, project by project. However, it is possible to guide the applicability of Agile using a 2D array called the **Stacey matrix**[2]

2: The Stacey matrix is an approach that supports decision making based on contingency linked to two variables: certainty (cause and effect of the decision) and consistency (degree of agreement between stakeholders).

D.4.1 Adapting Agile to project development

Once the decision has been made to use Agile, the main question is how to use it. A variety of approaches can be used and, in this context, three general approaches to implementing Agile are shown in **Figure D.4**.

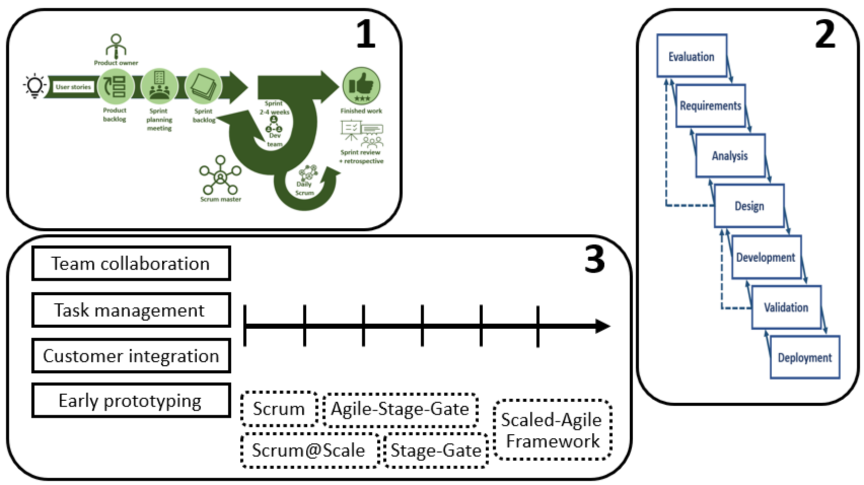

Figure D.4: Approaches to integrating sequential processes with Agile. The figure shows three general approaches to implementing Agile. The first approach is to understand the Agile principles, understand the pure Scrum process and then assess how this process can be modified to fit the constraints. The second approach is to analyse the current sequential process and consider which Agile tools can be used to take advantage of the benefits of Agile. The final option is to simply use an existing Agile framework. Some use multiple approaches throughout the project development process. For example, a project may start with Scrum for certain parts and then use the SAFe framework to scale the development of the whole project.

The first approach of understanding the Agile principles and the Scrum process, and modifying it to fit the constraints, can be useful if the team has a good understanding of the Agile philosophy and principles. This approach is suitable for teams that are open to experimentation and willing to adapt their process to suit their needs. This approach can be time-consuming as it requires a deep understanding of the Scrum framework, but it can lead to a customised process that is tailored to the specific needs of the team.

The second approach—analysing the current sequential process and identifying which Agile tools can be used—is useful when the team has an existing process and it is not feasible to completely overhaul the process. This approach is suitable for teams that want to gradually introduce Agile practices into their existing process. The team can identify the areas where Agile practices can be applied and then gradually introduce these practices, which can help to minimise disruption to the existing process.

The third option—using an existing Agile framework—is suitable for teams that are new to, or have limited experience of, Agile. An existing framework, such as Scrum or Kanban, provides a structure for the team to follow. This approach is useful if the team is looking to adopt Agile practices quickly and does not have the resources or expertise to develop a bespoke process.

In reality, teams may use a combination of these approaches throughout the project development process, depending on the specific needs and constraints of the project. Ultimately, the most effective approach will depend on the team's goals, the project's requirements and the team's level of experience with Agile.

Agile implementations can be broken down into three mutually exclusive elements: roles, artefacts and events.

The roles

As is usual in project development, projects involve cross-functional teams working as an Agile team. Higher complexity deliverables typically involve **Domain Specialists** (DS) and other non-DS such as programmers, test engineers. . . Lower complexity deliverables focus more on the domain experts, as the engineering and testing is usually done by the DS themselves. When projects are large, it is difficult to maintain a high level of engagement from the specialist team. This problem is usually solved by having the same team working on several projects at the same time. For this reason, a shared services approach, adapted from SAFe, is used in several project developments. Shared services are flexibly onboarded and off-boarded at specific project phases. Furthermore, the Agile functions in the process are orchestrated by the Scrum Master (SM) or Process Facilitator, just like a Product Owner or Manager (PO/PM). Finally, it should be remembered that the role of the customer is an essential part of Agile. When a project is commissioned, the developers involve the customer directly and sometimes to co-develop. When it comes to commercial work, there are different implementations, each with its own rationale:

- *Commercial*: Evaluate product progress based on market research; plan marketing activities.
- *Customer service*: Enabling new business models; designing for service.
- *Product and programme management*: Understand product progress; align with other projects/programmes.
- *Senior management*: Understand product progress; increase management buy-in for Agile.

Artefacts

For all project development, you should use a task management tool such as Monday, Atlassian JIRA, Wrike, ClickUp, Smartsheet. These tools support Agile project management by conveniently organising the Product Backlog (PB) and Sprint Backlog (SB). Micro Soft Office tools can also be used, but this depends on the nature and size of the project. Another aspect is the Definition of Done (DoD) for an increment, and this can take several forms:

- Tasks performed
- Digital mock-up (rendering)
- Pretendotype
- Pretotype
- Prototype
- Data package

- Product maturity
- Supporting documents

Interpretation is important, e.g. if a sprint is focused on task management, the DoD may be interpreted as tasks completed. The DoD can change throughout the project and should be specified at the beginning of each sprint. It is suggested to distinguish between sprint deliverables and product increments. For example, in SAFe the DoD of the Project Increment (PI) is a testable and usable and the sprint deliverables are extracted from the PI requirements. In other words, the PI deliverable is the set of sprint deliverables. Finally, it is useful to record the number of events that are performed throughout the Scrum or SAFe process to support the optimisation and performance of all Agile activities.

Governance model

Governance is management, protocols, relationships, rules and structures that serve as the framework within which decisions are made to fulfil a business or strategic motivations. In terms of project development, governance includes some assets:

- Physical facilities
- Financial structures
- Information systems
- Reward systems
- Roles and responsibilities

Project development usually has a steering committee, a project manager and a project team. The steering committee is responsible for strategic decisions (WHY, WHAT) and the project manager is responsible for tactical (WHAT) and operational (HOW) decisions. The project team executes the assigned tasks without decision-making authority. The client is in contact with the steering committee. Governance avoids conflicts, maximises team autonomy and aligns all participating *actors*.

Several key Agile roles and responsibilities

The Agile methodology is based on collaboration and flexibility, and the key roles are the Agile development team, the PO/PM and the customer. The Agile development team has decision-making autonomy and is responsible for breaking down requirements into tasks, estimating time and assigning tasks to team members. The PO/PM manages the project and combines the voices of the customer, management and team to prioritise tasks. The customer communicates their needs and requirements directly to the PO/PM to ensure accurate representation in the project. Collaboration and communication between these roles is critical to the success of an Agile project.

Summary

Agile is a popular project management approach that emphasises flexibility and collaboration, with a focus on delivering value to the customer. Here are some of the key characteristics of Agile:

- Agile requires strong team collaboration and communication throughout the project development process.

- The customer is involved in the project development process, providing feedback and helping to prioritise features and functionality.
- Agile uses iterative and incremental development, breaking tasks into smaller pieces that can be completed in short cycles.
- Agile encourages early prototyping and testing to learn and improve throughout the project.

When considering Agile, it is important to understand when and how to use it effectively, and what KPIs to measure to ensure success.

In general, Agile is best suited to projects that require flexibility and responsiveness to changing market conditions or evolving technology. For smaller projects, teams can use Agile tools and techniques, as needed, to achieve their goals.

Agile can be adapted to different project contexts using one of three approaches: adapting the "ideal" Scrum process to the project's constraints, adding Agile elements to an existing sequential process or using an Agile framework. Whatever the approach, Agile typically involves cross-functional teams, with roles such as project manager and PO/PM, and artefacts such as product backlogs and sprint plans.

In terms of governance, Agile teams need autonomy and trust to effectively achieve their goals. The PO/PM should have control over the direction and priorities of the project, while the development team should have autonomy over how they complete their tasks. Agile teams also need a safe space in terms of budget, design change and purchasing autonomy to ensure they can work effectively without unnecessary constraints.

In short, Agile provides a flexible and collaborative approach to project management that can be adapted to different contexts and project needs. To use Agile effectively, it is important to understand its key characteristics, choose the right approach and provide the necessary autonomy and resources for the team to succeed.

D.5 Prototyping

Prototyping is a critical aspect of the development process, especially in Agile methodologies. A prototype is a preliminary representation of a proposed solution that allows developers and designers to validate their ideas with the intended audience. There are different types of prototyping, such as rapid prototyping, evolutionary prototyping and incremental prototyping, each with its own advantages and disadvantages.

Rapid prototyping, also known as disposable prototyping, is a widely used approach that involves creating a basic prototype that can be easily modified to incorporate user feedback. It is a quick and efficient way to test and refine ideas before committing to a final design. Although disposable prototypes are short-lived, they still provide valuable insights that inform the development process.

Evolutionary prototyping, on the other hand, is a more iterative approach that involves creating a basic prototype with limited functionality and gradually adding features as the requirements become clearer. This approach is particularly useful when requirements are not well defined and the project needs to evolve.

Incremental prototyping involves building small, separate prototypes in parallel and then merging them into a cohesive whole. This approach is ideal for complex projects with multiple loosely related components, but it requires careful planning and coordination to ensure consistency across the prototypes.

Regardless of the type of prototyping used, the objective remains the same: to provide a tangible representation of a proposed solution that can be evaluated, tested and refined. By involving stakeholders in the development process and incorporating feedback early and often, prototyping can save time, money and frustration down the line. It is a powerful tool for ensuring that the final product meets the needs of its intended users.

D.5.1 Practical prototyping

Why start on a napkin?

Napkin prototyping is a powerful tool for communicating and testing product or business ideas. It emphasises that anyone can create a successful napkin prototype, as the aim is to communicate the idea with a few strokes or doodles. Napkin prototyping is a simple yet effective way to communicate hypotheses for a product, service or process, allowing for quick testing and validation. It is highly recommended to take a napkin and start prototyping to refine a concept.

Benefits of prototyping on a napkin

1. *Quickly translate an idea into something visual*. When sharing a new idea, make it easy for others to understand by drawing a picture on a napkin. Show how the idea can be improved in the future prototype.
2. *Allow for dialogue between team members*. To develop an idea successfully, it is important to have a dialogue with all stakeholders. The focus should be on discussing the pros and cons and finding macro solutions without getting bogged down in the details. The details can be worked out later. The visualisation needs to communicate its value to engage stakeholders and ensure alignment on the scope of the change. This opens up the possibility of new solutions and ideas.
3. *Improve the initial idea quickly*. To improve an original idea, it is important to explore its pros and cons and iterate. Sketching the idea on a napkin can help to identify weaknesses and focus on refinements. A quick sketch can gather stakeholders' inputs and explore alternatives. Saving the sketches can provide a record for future consideration.
4. *Costs 0*. Innovation does not have to be expensive. A future prototype may not be a final product, but it can project what it could be and provide improvements to current products or services. A napkin sketch can be the start of a service that will grow a business or launch a start-up. Therefore, a napkin sketch should be given a chance, as it can provide favourable results at a low cost.

5. *Anywhere*. Sometimes good ideas can be generated in informal settings, such as a coffee shop or bar, but the "napkin" is just a metaphor for any medium that can be used to record ideas. It could be a blank piece of paper or a formal presentation. It's also possible to generate ideas or improvements at home or in the office, but it's important to choose the right occasion. For example, dinner with the family may not be the best time, but meeting with interested parties for a chat and a drink could be a relaxed moment where ideas flow naturally.
6. *Have fun*. Drawing future prototypes should be both productive and enjoyable. It is important not to force creativity, but to allow it to flow naturally, as good ideas often come unexpectedly. When faced with new problems, putting ideas into drawings may help.
7. *Anyone can do it*. Anyone can draw simple shapes and scribble a few lines on a piece of paper to express an idea, without being an engineer, programmer or artist. Being creative does not depend on being a good draughtsman and good at drawing, it only depends on wanting to communicate the idea effectively.
8. *It is a starting point*. Creating a prototype is only the beginning of turning an idea into reality. It takes hard work and a dedicated team to make it happen. Ideas alone are not enough, they need to be developed properly. Even simple sketches are worthless without a team that is enthusiastic, knowledgeable and willing to take them forward. If you want to start a new project, especially one related to a **Cognitive Solution**, creating a prototype is a useful and fun way to quickly communicate your ideas for products, services or processes.

D.5.2 Stages in the development of a prototype

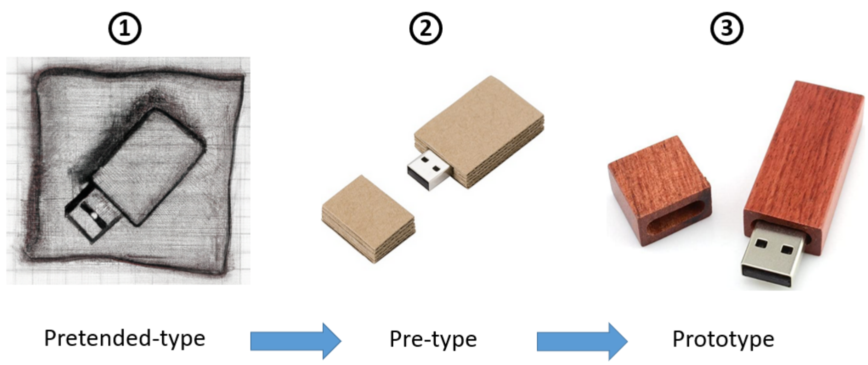

Figure D.5: Prototyping of a USB flash drive. Images of the evolution of the prototyping of a USB flash drive through the stages of the pretended-type, the pre-type and the prototype.

Prototyping is an essential part of project development and experience has shown that hands-on prototyping is the most effective approach. There are three stages to the process: pre-model (pretended-type), pre-design (pre-type) and prototype (**Figure D.5**).

Basic characteristics of pretended-type development

The first stage, known as pretended-type development, is a creative phase focused on generating possible solutions. It is here that the characteristics, functional requirements and knowledge requirements of potential solutions are conceptualised with a list of realisable requirements, attributes and functionalities. This stage typically involves sketching, drawing, laying out or ideating what the potential solutions might look like.

One of the main advantages of this stage is that it does not require a significant financial investment, only time spent brainstorming. The emphasis is on expressing ideas in the simplest way possible, often on a "napkin", as ideas generated during a brainstorming session may not always be clear or complete.

To support the ideation process, a document is usually created that outlines the solution idea selected during the brainstorming session. This **support tool**[3] is a document that includes the name of the idea, an outline of the idea, the target audience, the innovative aspect of the idea and the value that the idea has for an organisation and/or target users (**Figure D.6**). Tools like this are essential to initiate innovation, the aim of which is to transform what is no longer valuable into something valuable for the client. Innovation can only be achieved if it is desired by decision-makers, economically viable and technically feasible. Balancing these three factors is critical to creating value for clients, responding flexibly to market demands and fostering a culture of continuous innovation.

3: An example of a supporting tool is the Idea Napkin. It is a document that helps a team detail out a solution idea selected during a brainstorming session.

Perhaps the most difficult part of implementing an innovative and cognitive transformation project is dealing with the person or group of people in a company who make decisions, especially those related to costs. It is therefore essential to empathise with the decision-makers and, if the project involves them, with the target consumer. It is worth remembering that designing products, services or processes that meet users' needs is more effective than simply satisfying the desires of these *actors*. A tool to support empathy is called an **empathy map**[4]. This is a powerful tool for gaining an in-depth understanding of the target users and their needs. Synthesising the observations from this mapping will help to draw often unexpected conclusions about the target users.

4: An empathy map is a simple tool that can help you to empathise, extract insights about and synthesise the needs of your users.

An empathy map (**Figure D.6**) has four quadrants: say, do, think and feel. What users say and do can easily be placed in the first two quadrants, but determining what they think and feel requires careful observation and analysis.

To fill in an empathy map, the notes, images, audio and video from the data collection need to be reviewed and each of the four quadrants filled in. The needs and perceptions of the target user are then synthesised.

When synthesising the target user's needs, the focus should be on verbs or activities that require satisfaction rather than solutions (a **hierarchy of needs**[5] can help to identify underlying needs).

5: A hierarchy of needs helps to visualise which are the needs that motivate a person's behaviour and how they are organised. This organisation of needs shows that the most basic needs must be satisfied to a greater or lesser extent (rather than all or none) before the greater needs. The order of needs is not rigid, but can be flexible according to external circumstances or individual differences. Most behaviours are polymotor, i.e. they are determined by more than one basic need at the same time.

Synthesising insights involves looking for key insights that can help to solve the current design challenge. Insights can be found within a quadrant or by comparing two different quadrants.

Overall, an empathy map is a powerful tool to help any type of *solution provider* empathise with its target users, synthesise the information the *provider* receives from users and gain a deep understanding of users' needs and opinions.

Basic characteristics of pre-type development

The second phase of the solution development process is called pre-type development, where the selected solution idea is transformed into a working solution—the

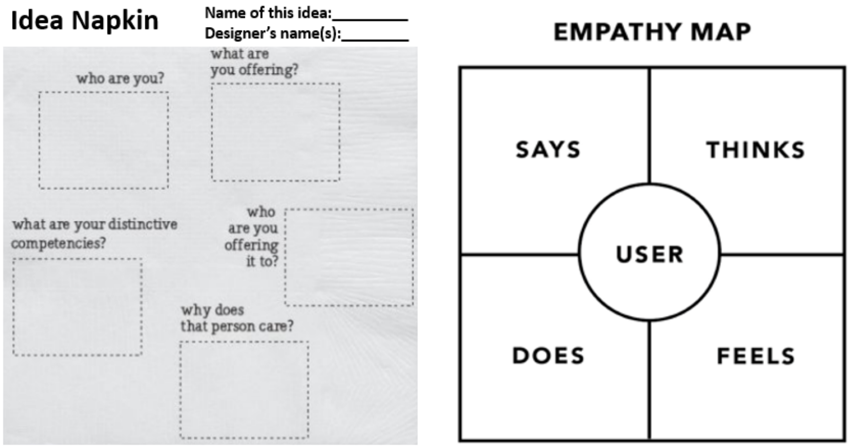

Figure D.6: Examples of an idea napkin and an empathy map. Image of examples of tools for the napkin and the map (the image on the left, the napkin, was taken from https://apphaus.sap.com/wp-content/uploads/sites/2/2021/06/IdeaNapkin.pdf and the image on the right, map, was taken from https://www.nngroup.com/articles/empathy-mapping/).

key feature of which is the development of the MVP—a partially working prototype that can solve the **Beneficiary**'s highest priority problem and generate a return for the **Beneficiary**. The MVP must demonstrate the form of the product, service or process and is validated with the target market. This stage involves estimating development costs, validating progress and using some **supporting tool**[6] (**Figure D.7**) to assess feasibility and modelling ideas. Several factors should be considered, including all the actors, owners, customers, competencies, value proposition and problems solved.

6: An example of a supporting tool is the Really Big Idea Sketch Pad. It is a document to assess feasibility and model ideas.

Once all these factors have been analysed, all actors must agree that the proposed solution represents a genuine business opportunity. The work does not end there, however, and customer information must be gathered on an ongoing basis to understand who the customers are, what channels they use to interact with the company and whether the proposed solution truly adds value. The **validation board**[7] (**Figure D.7**), based on Lean start-up principles, is a useful tool to support this process.

7: The Lean validation board is a tool used to organise, structure and develop thoughts and ideas in one place. It helps both to understand if the potential solution is a good fit for a market and to validate ideas and make sure that possible solution thinking about building it makes sense prior to building.

Validation is essential to confirm that there are real customers who will use the product, service or process, and so the following steps should be taken:

1. Identify the customers and problems to solve by creating a predictive persona to describe the characteristics of someone who might become a real customer.
2. Define the hypotheses about the customers or problems that need to be tested and validated, then determine which hypothesis is the riskiest and test it first.
3. Define the testing method and success criteria, starting simple and increasing in cost and effort as more satisfactory validations are obtained.
4. Test the riskiest hypothesis, stepping out of the comfort zone to validate the idea.
5. Move on, pivot or abandon the hypothesis based on the results of the tests.
6. Once the riskiest customer and problem hypotheses have been successfully validated, test the remaining hypotheses, then move on to testing the solution hypotheses.

At the end of the process, there should be a group of customers who are excited about the solution to their problems and have enough validation to invest financial resources in order to build it.

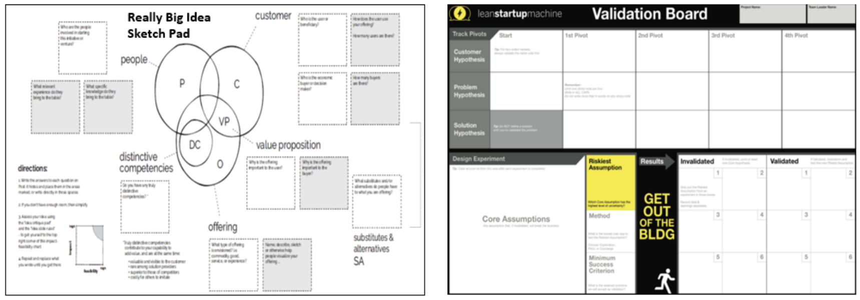

Figure D.7: **Idea sketch pad and validation board.** Image of examples of tools used to support modelling, feasibility verification and validation of ideas (the image on the left, the idea sketch pad, was taken from https://blogs.babson.edu/entrepreneurship/-2014/10/17/what-to-do-with-a-really-big-idea/ and the image on the right, the validation board, was taken from https://www.starteer.com/how-to-validate-your-startup-idea-in-6-easy-steps/).

The process of developing a prototype's functionality typically begins at this stage, and it is crucial to establish a prototype development model in order to achieve this goal. While Agile options are often practical for projects in the CE, it is advisable to evaluate the unique characteristics of each project to ensure that the most appropriate working model is selected.

Several models are available for prototype development, including:

1. *Waterfall model*. A traditional and effective model that follows a sequential approach with clearly defined phases and objectives. Interim reviews are conducted to ensure that the requirements of each phase are met before proceeding to the next.
2. *Iterative model*. This model adopts an incremental approach to project development, particularly in software development. It begins with a partially completed system and gradually integrates more functionality until the complete system is developed. The iterative method provides greater flexibility in the development process than the waterfall model, making it easier to incorporate new features and implement changes.
3. *Agile model*. This model involves making progress in small chunks and stages, similar to the iterative model. The process is faster, making it a popular option that improves collaboration and flexibility in the development process.

How to decide which model is best?

1. Determine the degree of flexibility in the requirements. Agile and iterative models are ideal for web and application development where changes are frequently introduced. The Agile model is ideal for classic applications where stability and predictability are important at different stages of development.
2. Define end users. A controlled group of end users is likely to have a fixed set of requirements to work with, making the waterfall approach ideal. However, if the end users are dispersed, there will be feedback to deal with after the application is released by asking for new features to be added, so Agile or serial iteration methods are the best models in this case.
3. Consider the size and scope of the project. The size of a project determines the number of developers needed to manage it. The larger the project, the larger the development team. Larger projects require more elaborate and

orderly management plans, so the old waterfall model may be the best option.

4. Find out what works best. For project development through sprints, Agile and iterative methods are best because they make it easier to roll out sometimes complex systems to give the impression of rapid progress. However, if the development period is long and delivery dates are not fast approaching, the waterfall method is an option.
5. Location of the development team. If the development team is distributed around the world, a higher level of coordination and accountability will be required. In this case, a more rigid project management regime may be the best option, and this is where the waterfall model shines brightest. The model requires more frequent contact and tighter-knit teams, as a dispersed team of developers could be working with a lot of confusion and errors in the development process if Agile is the model of choice.

With the above in mind, it is possible to recognise the importance of understanding how project development models work in order to get the most out of the time invested.

Basic characteristics of prototype development

The final stage of the solution development process is called prototype development. During this stage, the selected solution idea is transformed into a working prototype
the commercial version). The aim of this stage is to achieve a clear, complete and unambiguous definition of the prototype's functionality, knowledge and market requirements.

Considerable effort is put into implementing the full working prototype (beta version) and continuously validating (and re-validating) its functionality and attributes with the target or potential users. This validation process enables continuous improvement of the product to ensure that it meets the needs of the users.

In addition, during the prototype development phase, an estimate is made of the investment in time, human resources, costs and other resources required to implement the first version of the solution. The prototype development phase is critical to the success of any solution development process. By creating a functional prototype that meets the minimum requirements of the users, the team can work towards developing a commercial version that is optimised for the market. Tools such as the **business model canvas**[8] (**Figure D.8**) can be useful to support the commercial part of the project.

8: The business model canvas is a tool to help you understand a business model in a straightforward and structured way. Using the canvas provides information about the customers you serve, the value propositions you offer and the benefits that can be achieved. The business model canvas can also be used to understand any other type of business.

In addition to commercial preparation, it is crucial to work on product communication. This appendix provides recommendations for crafting a short pitch. The main objective of a pitch is to connect, to share ideas and emotions and to communicate the project attractively and powerfully. The expected achievement is to pique genuine interest and secure the opportunity to formally present the project. One effective strategy is the AIDA model, which stands for Attention, Interest, Desire and Action [54]. To grab the listener's attention, start with impactful information that delves into the project's background. For instance, "In North America, 800,000 people die of cancer annually, and today alone, 2190 Americans will lose their lives to this disease". The message at the outset must

[54]: Mind Tools Content Team (2022)

be clear and impactful. Next, present an argument with emotional details that increase the listener's interest and keep them engaged. For example, "Cancer is a very expensive disease, and over 90% of Americans cannot afford to pay for it themselves. Each chemotherapy session costs between $1000 and $2000 per week, plus the cost of specialised drugs". After capturing their interest, show the listener how this idea can make a difference. Offer a close-up of your proposal with a few interesting details that hook them. For example, "With this project, more low-income Americans suffering from cancer could access chemotherapy treatments and have a chance to be cured. We plan to build specialised medical units for this purpose". Finally, call for concrete action and encourage the listener to invest in the project or participate in its development. For example: "To build these units, we need the participation of engineers, architects and an investment of 500 million dollars. We invite you to join us with your talents and an investment of 50 million dollars". It is advisable to write the pitch down and read it out loud to enrich both its form and content. This process can help to find more attractive phrases, improve the wording and even reduce its length. It is crucial to deliver the pitch with conviction, as it is impossible to convince others if you are not convinced. Practices the pitch until you get it right and then present it to the interviewer for feedback.

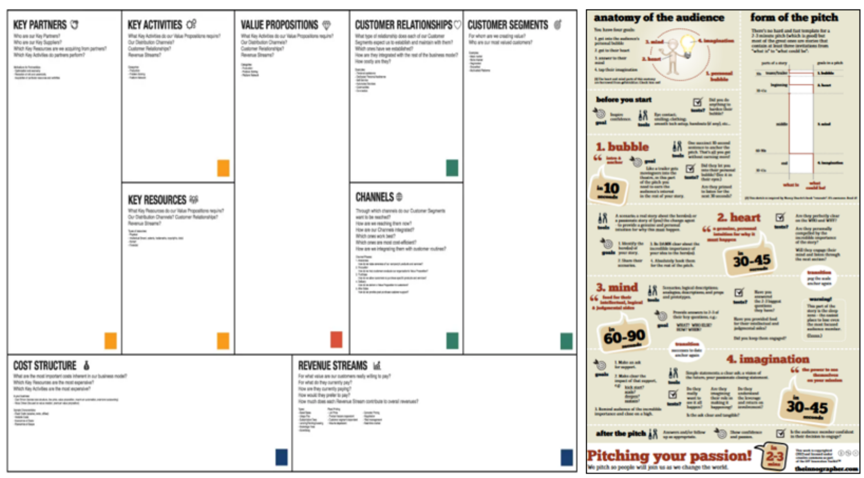

Figure D.8: **Business model canvas and pitch.** Image of examples of tools to support a business model, and short communication (the image on the left, the business model canvas, was taken from https://www.businessmodelsinc.com/en/inspiration/tools/business-model-canvas and the image on the right, the pitch, was taken from https://www.eg.bucknell.edu/~amm042/wsn-/wp-content/uploads/2015/02/Pitching-your-passion-in-2-3-minutes-Infographic-v1.pdf).

Once you have written the pitch, think about what the target user might want. Imagining different requirements can force improvements to the prototype. However, it is important to remain practical and ensure the feasibility and motivation of the project. All information provided in the pitch must be properly substantiated. Researching the target user is crucial, as it is essential to know their personality, history, way of thinking, values and interests in projects. In conclusion, creating a pitch and communicating it effectively requires commitment, discipline and practice. It does not require superpowers, but it does require thorough preparation and a deep understanding of the target user's needs and interests. There are several **pitching**[9] support tools available (**Figure D.8**) so you can choose the one that best suits your project communication needs.

9: A pitch is a short presentation describing a project, a product, a company, its impact and how it can benefit.

D.6 Conclusions

The appendix provides valuable insights into the benefits of Agile methodologies and prototyping in project management. Agile methodologies enable flexible and efficient project management, resulting in improved product quality, increased customer satisfaction and cost reduction. Similarly, prototyping is a critical step in realising design concepts and testing the viability of a product or process.

Prototyping offers many benefits, including early identification of design and manufacturing problems, estimation of production costs and time, testing to make adjustments, obtaining customer feedback, identifying opportunities for improvement, and determining the function and design of the final version of the solution. Prototype testing also helps to resolve issues such as whether the solution can be implemented with existing resources or whether external resources are required.

In conclusion, the use of Agile methodologies and a prototyping culture can significantly benefit the development of cognitive transformation projects by enabling faster and higher quality project delivery.

D.7 Appendix summary and reminders

This appendix serves as a comprehensive mini guide to prototyping and Agile methodologies, based on extensive experience in developing cognitive solutions and supporting organisations in their digital transformation. It provides guidance and perspectives to help individuals and organisations to commit to using these methods and prototyping.

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Special Terms

A

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Beneficiary A **Beneficiary** is a person or entity (company, organisation, group of persons. . .) that intends to take advantage of the benefits of the **Cognitive Era** for its own support. Thus, their problems or needs are solved or satisfied by the **Cognitive Solution** (**Cg.S**). The **Beneficiary** will have to invest time and money during the process of obtaining the **Cg.S**, and is consequently the main decision-maker during the process, meaning they also make decisions about the present ongoing project as well as the future of the project in order to reach the solution.. 6–9, 16, 18–21, 23–45, 47–49, 51, 54–61, 64, 71, 75, 76, 84–89, 98–102, 111, 130, 153, 154, 157, 164–166, 169, 170, 174–176, 184, 185, 195, 196, 209, 219, 220, 223, 224

C

Cg.S Architect The **Cognitive Solution Architect** establishes the infrastructure necessary to deliver solutions based on any combination of technologies, processes, analytics, marketing, internal organisational environment or consulting.. 7, 30, 31, 54, 55, 59–61, 63, 75, 85, 99, 102, 108, 113, 127, 131, 164, 165, 168, 170, 175, 180, 219, 223

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D

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Acronyms or Abbreviations

A

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AI Artificial Intelligence.. 4–6, 8, 15, 18, 19, 21–23, 61, 74, 95, 117–127, 129, 141, 195

C

CE Cognitive Era.. 3–6, 8–10, 15–18, 20, 23, 24, 26, 28, 32, 33, 35, 37, 46, 48, 49, 51, 54–56, 58, 61–64, 73, 84, 93–96, 99, 102, 104, 107, 111, 115, 117, 118, 123, 125–127, 129, 130, 139, 146, 153, 160, 166, 192, 193, 195–197, 210, 219, 220, 223, 224

Cg.An Cognitive Analysts. 7, 16, 19, 24–27, 29–31, 33, 34, 36, 38–44, 51, 54, 56, 59–61, 63, 75, 85, 86, 95, 102, 111, 139, 144–146, 149, 150, 155–157, 159, 162, 165–173, 175–178, 181, 183, 184, 189, 219, 223, 227, **Glossary:** Cognitive Analysts

Cg.Arch Cognitive Architecture. 9, 17, 19, 20, 27, 47, 49, 51–54, 56, 59–64, 75, 76, 83, 85, 86, 96, 99, 101, 102, 108–112, 114, 115, 117, 123, 127, 128, 131, 227, **Glossary:** Cognitive Architecture

Cg.Eco Cognitive Ecosystem. 9, 15–20, 29, 31, 48, 53, 54, 62, 112, 117, 123, 124, 227, **Glossary:** Cognitive Ecosystem

Cg.S Cognitive Solution. 6–10, 15, 17, 18, 20, 23–25, 27–38, 40–43, 45–49, 51–64, 71, 73–75, 84–88, 93, 96, 99, 102–104, 107–114, 117, 123–126, 128–130, 139–146, 151, 153–164, 166–168, 174, 180, 181, 207, 219–221, 223–225, 227, **Glossary:** Cognitive Solution

Cg.S-P Cg.S Provider. 7, 8, 16, 19–21, 25, 26, 28–30, 35, 38, 47, 52–56, 61–64, 73–75, 84–86, 96, 98, 99, 101, 102, 104, 108, 109, 113, 145, 146, 153–155, 157, 159, 160, 162, 169, 170, 172, 173, 175, 195, 196, 219, 220, 223, 224, 227, **Glossary:** Cg.S Provider

CMCg.I Conceptual Model for Cognitive-Innovation. 9, 19, 49, 51–53, 61, 64, 71, 75, 86–88, 93–97, 99, 103, 104, 107–110, 112–115, 117, 124–130, 153, 175, 180, 227, **Glossary:** Conceptual Model for Cognitive-Innovation

CT Cognitive transformation.. 5, 6, 9, 93, 117, 119, 120, 124–126, 128–130

D

Deep Blue IBM Deep Blue chess computer.. 4

DS Domain Specialists. 7, 16, 18, 19, 23, 24, 29–31, 33–36, 40–43, 54, 55, 58–60, 62, 71, 74–78, 81, 82, 84–87, 89, 100–102, 109–113, 129, 144–147, 149, 153, 155–166, 168–176, 180–182, 184, 185, 187, 188, 190, 193, 203, 219, 220, 223, 224, 227, **Glossary:** Domain Specialists

DT Digital transformation.. 3, 5, 94, 117–120, 181

DTK Distributed Tacit Knowledge. 108, 112, 227, **Glossary:** Distributed Tacit Knowledge

E

ECT Electroconvulsive therapy.. 10, 71, 73–79, 87–89

EK Explicit Knowledge.. 16, 17, 19–21, 23, 24, 34, 47, 53, 57, 58, 96, 108, 109, 112, 123, 143, 144, 155, 157, 166, 180, 181

I

IBM International Business Machines.. 4, 5

IBM Watson IBM Watson entity.. 4, 5

ISD Informally Structured Domain. 3, 8–10, 15–18, 26, 27, 31–37, 39–43, 47, 49, 51, 53, 56, 57, 59, 61, 63, 64, 74, 75, 78–80, 87, 95, 96, 98, 99, 108, 109, 111, 112, 117–119, 123–126, 128–130, 146, 147, 153, 154, 158, 159, 161, 162, 164, 165, 168, 169, 175, 179–188, 193, 220, 224, 227, **Glossary:** Informally Structured Domain

Alphabetical Index

Step into the future of technology and unlock the power of the Cognitive Era!

This engaging book communicates that Cognitive Transformation is a journey through innovation that often incorporates at least one aspect of Artificial Intelligence. Discover a world in which processes, real-time responses and desired behaviours shape a cognitive way of solving problems and making decisions.

Be aware of the fact that information and knowledge are on a fascinating evolutionary journey through the current Cognitive Era. Get rid of the old ways of doing things and embrace the new paradigms brought about by Cognitive Transformation through critical and analytical thinking.

Contrary to popular belief, the Cognitive Era is not about replacing human intelligence with Artificial Intelligence. It is about augmenting human cognition and decision-making with cognitive entities that provide knowledge and support. By harnessing the expertise of those who know, by analysing knowledge, organisations must benefit from this change.

The power of cognitive technology is already solving complex problems in Informally Structured Domains. The integration of this technology into operations, problem-solving and decision-making has impacted time, error and cost reduction. This impact invites a better understanding of the distinction between Artificial Intelligence and human intelligence and the ethical considerations involved.

This book also addresses questions about cognitive solutions implemented in different domains, their impact on Informal Structured Domains and the governance challenges of the Cognitive Era. Ultimately, it urges you to immerse yourself in Cognitive Transformation projects that enhance human cognition, improve processes and promote benevolent and healthy behaviours.

In the Cognitive Era, responsible and ethical use of Artificial Intelligence is paramount. This book is, if anything, a monocle for a slightly better view of an immediate future in which cognitive technology will enhance our capabilities, inspire creativity and reshape the world for the benefit of all. Don't miss the opportunity to be part of this Cognitive Transformation.

Author bio

Jorge is a cognitive architect known for a career dedicated to driving Cognitive Transformation. Over more than 25 years, he has authored 40 research papers, 28 scientific book chapters and four books. His commitment to the dissemination of his knowledge is manifested in the publication of papers on culture, science and technology, as well as in the organisation of conferences for various audiences.

Rodas-Osollo has led and actively participated in Cognitive Transformation projects for companies in northern Mexico, such as Grupo Financiero Banorte, Flutec and Grupo Cementos de Chihuahua. In addition, he has supported Cognitive Transformation initiatives in the public health sector, contributing his experience to institutions such as the Children's Hospital of the State of Chihuahua and the General Hospital of Chihuahua, driven solely by his dedication and altruism.

His contributions have been recognised, and he currently holds various noteworthy positions. For example, he is a member of the National System of Researchers of the National Council for Humanities and Science and Technology of Mexico, a member of the Research System of the Government of the State of Chihuahua, a certified international evaluator for the National Council for Humanities and Science and Technology, and a member of the Catalan Association of Artificial Intelligence. He is also Vice-President of the Binational Artificial Intelligence Cluster (Mexico-USA) and holds a respected position in the Ethics and Research Committee of the Health Research Unit.

Rodas-Osollo's commitment to applying science and technology to public health and the economy was recognised with the 2002 Chihuahua Prize. Jorge Rodas-Osollo is not a genius, a guru or a savant in any field, but his conviction to make the world a better place commits him to using his knowledge, experience and energy to contribute to this vision and distinguishes him as a highly collaborative individual.