A guide for the analysis of complex systems

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A guide for the analysis of complex systems

A toolkit to support the analysis and the design process in complex systems, in the context of the Digital Creativity for Developing Digital Maturity Future Skills Project.

Integrated Product Design
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Abstract

Digital Transformation has increasingly developed the complexity of the systems in which people work and design daily. This happened as the result of the connection of many different types of systems together. The result has been the formation of new categories of interconnected systems, more precisely digital ecosystems. These are defined as a complex network of stakeholders that connect online and interact digitally to create value (Frank & Simon, 2019). These systems can be identified as complex as they are characterised by great values of diversity, multiplicity and interdependence, which are the three main properties of complexity (Sargut & McGrath, 2011).

It is within this context of rapid change triggered by Digital Transformation, and more specifically within the context of digital ecosystems, that the work explained in this thesis takes place. The main objective of the project is to find a way to deal with the complexity of these new types of systems and to support their analysis, in order to facilitate a more agile and smooth design process.

These conclusions were drawn from the work carried out during the Bootcamp together with the Digital Creativity for developing Digital Maturity future skills (DC4DM) Project partners. At this point, in order to achieve the intended results, an initial research was carried out. This analysis was aimed at studying all existing methodologies and tools with the same objectives as the resource to be developed. From this initial research, it emerged that the existing resources do not start from the analysis of complexity and its features. In addition, they are aimed more at a corporate and managerial environment.

For this reason, it was decided to develop an educational resource. This should be aimed at teaching a useful process for the analysis of the target system. Given this educational objective, it seemed appropriate to include the resource in the initial phase of the DC4DM process: the Pre-Process. However, it was also considered appropriate to provide a layout on which to base the analysis of complex systems, to be included in the Process phase. The resource, starting from the definition of complexity, analyses its three main properties, referring to the given context. This activity is designed to be carried out by one person or in a group and is based on three steps. The first step aims to analyse two properties of complexity: diversity and multiplicity. The second step aims at analysing the relationships between the elements

of the system, thus addressing the interdependence property. Moreover, the last step is included to help preventing ethical and sustainable issues, two areas of critical importance in the DC4DM Project. To support these activities, a set of cards and questions is developed. In addition, to facilitate the understanding and the learning of the resource, it is developed a support guide for the learner. The guide is available in two versions: a text version and a video tutorial.

Abstract

La trasformazione digitale ha reso sempre più complessi i sistemi in cui si è chiamati a lavorare e progettare quotidianamente, connettendone numerose tipologie, ciascuna diversa dalle altre. Come risultato si è ottenuta la formazione di nuove categorie di sistemi interconnessi, più precisamente ecosistemi digitali. Questi sono definiti come una rete complessa di stakeholder che si connette online e interagisce in modo digitale per creare valore (Frank & Simon, 2019). Questi sistemi si possono identificare come sistemi complessi in quanto sono caratterizzati da grandi valori di diversità, molteplicità e interconnessione, ossia le tre proprietà principali della complessità (Sargut & McGrath, 2011).

È proprio in questo contesto di rapido cambiamento innescato dalla trasformazione digitale, e più nello specifico nell'ambito degli ecosistemi digitali, che si inserisce il lavoro spiegato in questa tesi. L'obiettivo principale del lavoro svolto è stato quello di trovare un modo per affrontare la complessità di queste nuove tipologie di sistemi e supportarne l'analisi per favorire una progettazione più agile e fluida.

Queste conclusioni sono state tratte dal lavoro svolto durante i Bootcamp insieme ai partner del progetto Digital Creativity for Developing Digital Maturity Future Skills (DC4DM). A seguito di queste giornate di lavoro, si è condotta una prima ricerca per ottenere i risultati prefissati. L'analisi svolta è stata focalizzata sullo studio di tutte le metodologie e strumenti esistenti aventi gli stessi obiettivi della risorsa da sviluppare. Da questa ricerca iniziale si è notato come le risorse esistenti non partissero dall'analisi della complessità e delle sue caratteristiche. Inoltre, si è evinto come queste fossero mirate più a un ambito aziendale e manageriale.

Per questo motivo si è deciso di sviluppare una risorsa educativa finalizzata a insegnare un processo utile per l'analisi del sistema di riferimento. Dato questo obiettivo formativo, si è immaginato di inserire la risorsa nella fase iniziale del processo DC4DM, nel Pre-Process. Tuttavia, è stato ritenuto opportuno fornire anche un layout su cui basare l'analisi dei sistemi complessi, da inserire dunque nella fase di Process. La risorsa, partendo dalla definizione di complessità, ne analizza le tre proprietà principali, facendo riferimento al contesto considerato. Questa attività è

stata pensata per poter essere svolta da una sola persona o in gruppo, ed è basata su tre passi. Il primo passo mira ad analizzare due proprietà della complessità: diversità e molteplicità. Il secondo passo ha come obiettivo l'analisi delle relazioni tra gli elementi del sistema, dunque ricopre la proprietà interdependence. Infine, l'ultimo passo è stato inserito per aiutare a prevenire problematiche etiche e sostenibili, due ambiti di importanza critica nel progetto DC4DM. A supporto di queste attività, sono state sviluppate delle carte e delle domande. Inoltre, per facilitare la comprensione e l'apprendimento della risorsa, si è sviluppata una guida di supporto all'apprendista. Essa è declinata in due versioni: una testuale e una sotto forma di video tutorial.

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FRAMING THE PROJECT

1 INTRODUCTION

1.1 Thesis purpose

The work developed for this thesis is framed within the context of the DC4DM project, a European project aimed at enhancing the creative digital skills of professionals in order to train experts capable of driving digital transformation. Thus, the DC4DM model will be enriched by cross-functional methods, tools and skills from across the consortium of partners, encouraging cross-cultural knowledge sharing from academia to industry and vice versa.

Therefore, this thesis work is aimed at analysing the skills needed for the training of digital experts and identifying and analysing the tools and strategies used to date. These two steps are necessary to be able to develop a method or tool that focuses on developing skills and supporting the work in the digital field to be included in the DC4DM toolkit.

1.2 Thesis approach

The thesis work is based on a process consisting of three distinct phases, as reflected in the structure of this paper. The first phase was characterised by the joint work with the European project partners. This was a first introduction to the project and a preliminary active research concerning the digital domain. The next step was to conduct desk research on a specific topic, in this specific case complexity. During this phase, the tools and methods used to support the work in this field were investigated, and an analysis of the chosen topic was carried out. This step was useful to identify the needs and opportunities upon which to build the project. As a matter of fact, the last step of this work consisted in the development of a method for the analysis of complex systems, aimed at helping to improve their understanding and decreasing their overall complexity.

2 CONTEXT

2.1 Keeping up with the Digital Transformation: increasing complexity

The past few decades have been marked by a deep transformation, triggered by continuous and fervent activity of research and development of new technologies. This ongoing digital evolution, which is already widely spread, not only is impacting the industrial sector, but is also changing people's mindsets together with their behavioural and social attitudes.

One of the major consequences of this phenomenon has been the change brought about in certain systems, which were initially separate, but have subsequently become interconnected, thus depending on each other (Sargut & McGrath, 2011). As it will be explained during this thesis, this also means that the complexity of the system itself increases. Moreover, being in the Digital Age, where constant innovation drives rapid and continuous change, the co-evolution of these systems has dramatically increased (McKelvey et al., 2021). In fact, the Digital Age and the spreading of new technologies have triggered an increasingly rapid and continuous iterative process. This process, as it is represented in the diagram, is characterised by a circular structure, where the event that initially causes an effect then becomes its consequence. More specifically, the evolution of systems together with the spread of technologies has led to an acceleration of the flow of information and has also facilitated the possibility of accessing it, which in turn trigger the development of the system itself, and so on. Undoubtedly, this process is due to the fact that greater accessibility and distribution of information leads to an increased knowledge and opportunities for confrontation and exchange, facilitating the creative process through which new solutions and ideas are formed.

Certainly, this new process stimulates and facilitates creativity considerably. However, in a professional perspective this opportunity is not yet fully exploited. To date many businesses are unable to take advantage of the boost given by the Digital Transformation and are stuck with more traditional methods. Recent studies (Scheytt, 2018) have highlighted how the inability to manage complex scenarios and keep up with the Digital Transition not only slow down the business but also cost 10% of profits. Furthermore, it emerges that these firms invest mainly in trying to solve technological

complexities, when they should instead focus on the human level, teaching new skills to achieve Digital Maturity, thus enabling the team to perform better in a digital context.

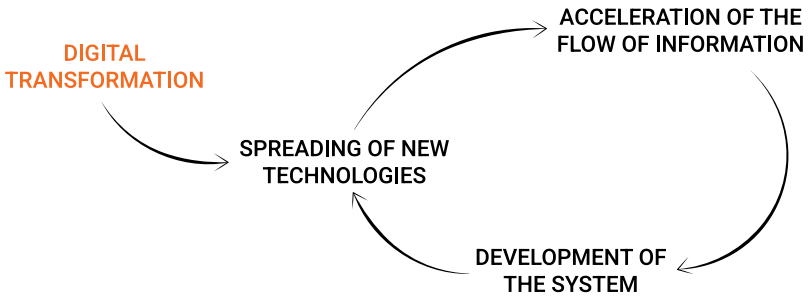


Fig. 2.1
Digital Transformation changes current systems, accelerating their development process.

It is clear how important is the need to define a new comprehensive method to achieve Digital Maturity that has to be taught to students in early stages of their careers. This approach should be designed to allow everyone to navigate properly through the digital context, by strategically weighing and managing all the significant opportunities and threats that arise in the development of the projects.

2.2 A new task for students: become Digital Maturity Enabler

It is in this context that design emerges as an important part of the definition of this new methodology, given the need to focus on the human factor and train new dynamic skills. Given the high pace at which any system evolves, it appeared very difficult, if not impossible, to act directly on figures already embedded in the given context. The only possible solution at this point was to shift the focus to students. Therefore, it was decided to enrich the standard educational process with the training of new skills that would enable them to achieve Digital Maturity. In this way, the figure of

the Digital Maturity Enabler was born. When brought into the organisation, this figure will be able to push the company towards continuous innovation, making everyone reach Digital Maturity. This is the main objective of the Digital Creativity for Digital Maturity (DC4DM) Project: to speed up the dissemination and learning of specific skills within companies through the introduction of new and digital mature figures.

DEFINITION: Digital Maturity

Digital Maturity means enabling people to continuously adapt to a changing digital landscape, learning how to collaborate with digital technologies and how to use them to serve the human needs in any field.

More technically, the Digital Creativity for Digital Maturity (DC4DM) Project is a three-year research programme funded by the European Commission under the Erasmus + Programme, which is aimed at implementing, applying and diffusing the DC4DM educational model.

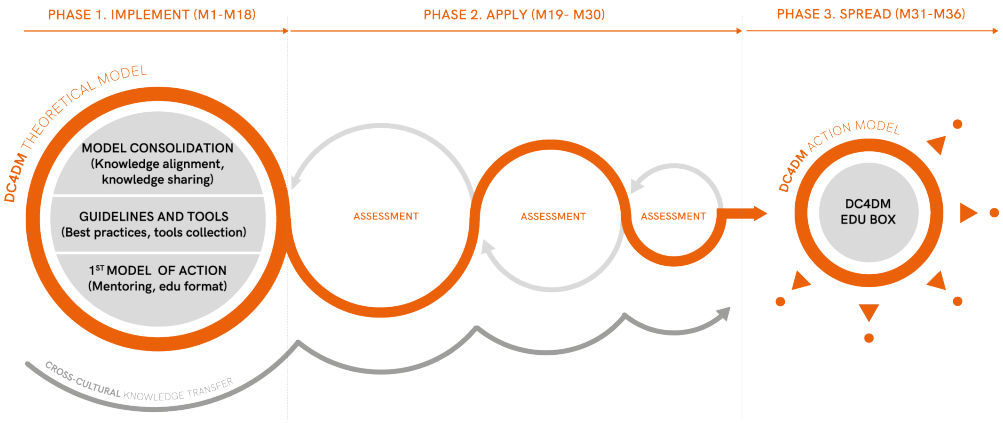


Fig. 2.2
DC4DM Project methodology.

2.3 DC4DM Model

The core of the DC4DM Project is the DC4DM Model, a human-centred educational model to develop and empower Digital Creative Abilities (DCAs) to strategically drive the application of future emerging digital technologies in any fields, achieving a Digital Maturity. As highlighted in the paper "Design and Creativity for developing Digital Maturity Skills" (Canina & Bruno, 2021), the model aims to train students to gain expertise in three main domains: understand the potentialities of digital technologies and apply them to design digital solutions with a human-centred approach; develop individual abilities of creative self-enhancement, a digital minded culture and team-working abilities; acquire skills in future and anticipatory thinking.

DEFINITION: Digital Creative Abilities

Digital Creative Abilities are a set of digital and human skills that empower people to express their creative potential, to think and act in a nonpredictable digital world. (Canina & Bruno, 2021)

As studies have shown (Canina & Bruno, 2021), the model has several critical points, the main one being that it needs to be easily understood and adopted by educators, students and companies. To tackle this problem and to boost the implementation of the model, it has been adopted a co-design method comprising around 20 people with different backgrounds, who are part of a European network of Universities, Start-ups, Research Centres, and Technological Providers.

As shown in Fig. 2.3, the DC4DM Model is structured following an iterative logic and is divided in three main sequential steps: Pre-Process, Process and Post-Process.
The Pre-Process is the part of the model where the attention is directed on the skills and knowledge propaedeutic to the process, which are needed

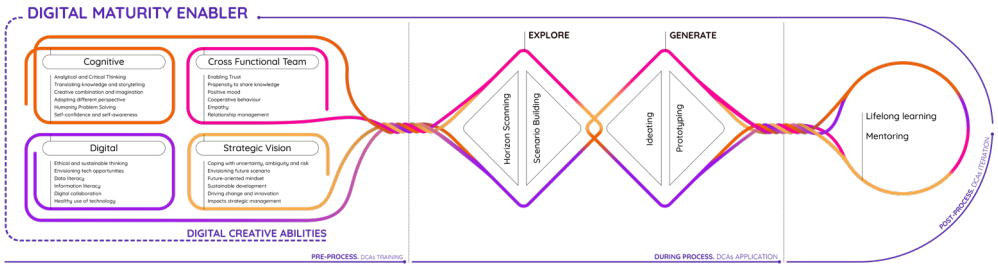


Fig. 2.3
DC4DM Model.

both to single individuals and to cross-functional teams to succeed through the development of the project.
The Process is based on the common creative and design thinking process. This method allows to generate innovative solutions and is divided in two main parts, which are characterised by a divergent and convergent procedure. In this part of the model, specific DCAs affect both the outcome of the process and the individual and team performance.
In the Post-Process the team has reached a shared mental model and is able to nurture all the skills that allow the Digital Maturity Enablers to iterate the learning process and to scale their own abilities to other people within the systems and organizations they are part of. This final iterative step is needed in order to boost the spreading of all the abilities needed to achieve a Digital Maturity.

The wireframe of the model has been deeply studied and analysed to highlight the importance of the DCAs, which, as depicted in the figure, are the indispensable skills for the education of the Digital Maturity Enabler. Moreover, the model shows how the DCAs are integrated in the process and how they are grouped in four specific areas: Cognitive, Cross-Functional Team, Digital and Strategic Vision.

THE RESEARCH

3 RESEARCH ACTIVITY

3.1 A proactive and innovative approach to carry out research: the bootcamp

As described before, the DC4DM Project is a three years long journey divided into several steps. Together with a group made up of four university colleagues, this thesis work started approximately one year after the DC4DM's kick-off. As shown in Fig. 3.1, this period coincides with the Digital Maturity Days, a series of talks and roundtables facilitated by experts in the field, and the bootcamp. The latter turned out to be very useful to the candidate students because, thanks to the active participation of the project partners, it was possible to investigate areas of interest for the final thesis. Moreover, the students participated actively in the definition of the activities to be carried out in these days. Therefore, this chapter is intended to be a description of what happened during the bootcamp sessions, highlighting and analysing what emerged from the joint work of the partners.

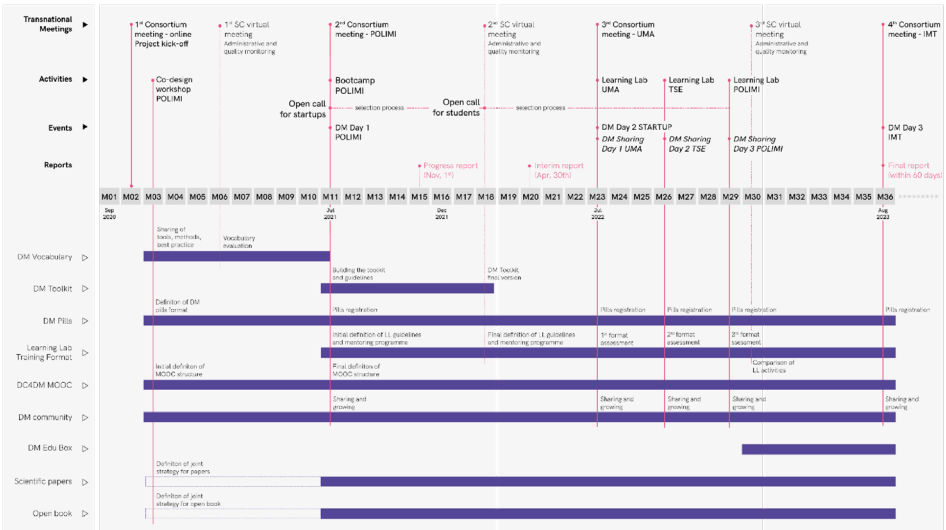


Fig. 3.1
DC4DM Project timeline.

3.2 Bootcamp 1: getting to know the Digital Creative Abilities

The bootcamp was divided into two main parts: one day in July and three days in September. This chapter focuses on the July session, which, due to persistent travel restrictions for Covid-19, took place in online mode. The main objective of this one-day activity was to let the partners discover and get acquainted with the DC4DM model and the DCAs. Moreover, it was also sought to find links between the different DCAs, so that they could be grouped into clusters. This step was essential to allow the teaching of the DCAs to run more smoothly and quickly.

3.2.1 Focus on the DCAs

Together with the group of students, it was decided to structure the working day into three main parts, each with an activity to be carried out in groups. Therefore, for each activity, working groups of about four European partners were created. The definition of these teams was based on the need to cover each area comprising the DCAs: one team for Cognitive, one for Digital, another for Cross Functional Team and, eventually, one for Strategic Vision. As a result of the first activity, the cards related to the DCAs of the area under analysis were created. Moreover, thanks to the group discussion, many different considerations emerged for each skill. During this first part of the work, the personal work focused on the Digital group, while the colleagues worked on the others. Hereafter, the six DCAs belonging to the Digital group will be presented, each with its corresponding card.

Ethical and sustainable thinking

DEFINITION

The ability to understand and assess the ethical and sustainable implication of digital ideas, opportunities and projects.

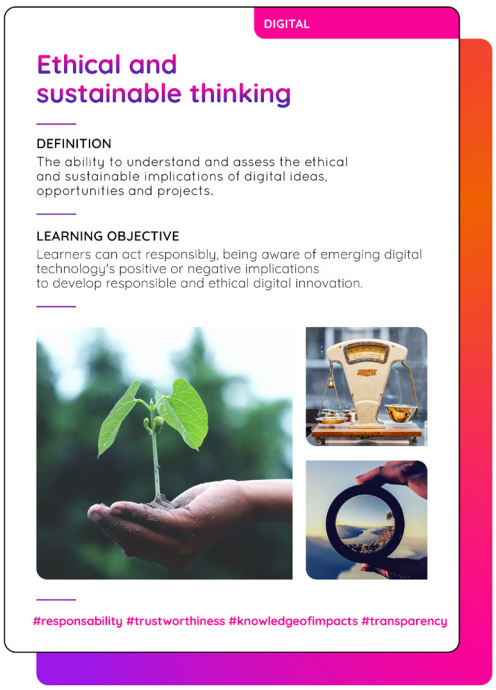


Fig. 3.2
Ethical and sustainable thinking card.

This DCA triggered two main points of debate: the first concerning the ethical issue of artificial intelligence; the second regarding the possibility of finding an absolute value of sustainability, since it is always relative to the context in which it is embedded.

Envisioning tech opportunities

DEFINITION

The ability to observe digital technologies' application and understand their potentialities in terms of social and cultural opportunities to innovate in a sustainable digital scenario

Fig. 3.3
Envision tech opportunities card.

This DCA has helped to highlight two topics of fundamental importance when talking about the digital world and innovation. The first concerns the importance of anticipation, being able to read the future by analysing current

trends and contexts. The second concerns the importance of being able to analyse the market and benchmarking all current technologies. This not only speeds up the innovation process, but could also help to solve complex scenarios

Data literacy

DEFINITION

The ability to collect, generate, process, analyse a large amount of complex and interconnected data provides meaningful information to guide informed, optimised and contextually relevant decision-making processes.

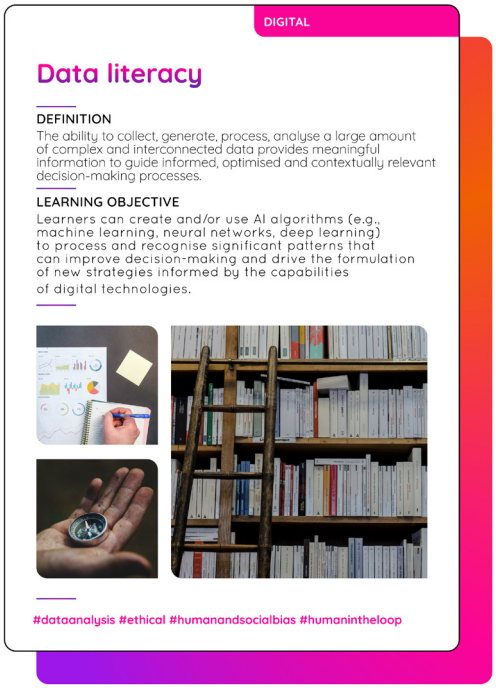


Fig. 3.4
Data literacy card.

This DCA drawn attention back to the centrality of the human figure as a pivotal factor in defining new solutions. Also in this case, the concept of ethics has been addressed, alongside the ability to analyse big data.

Information literacy

DEFINITION

The ability to effectively transform data into usable information.

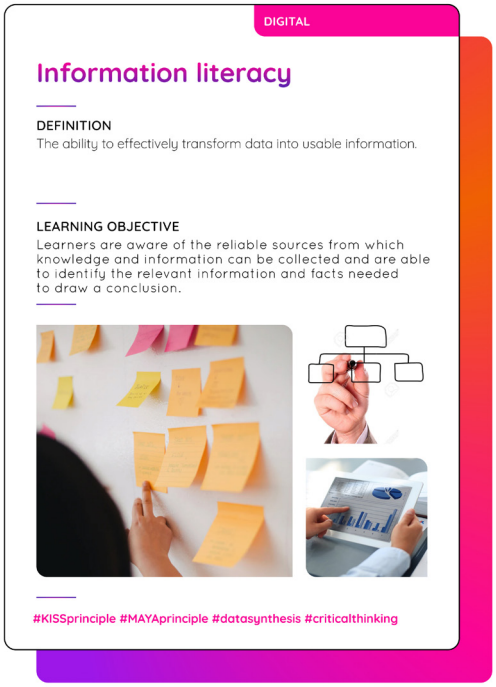


Fig. 3.5
Information literacy card.

In this case attention has been drawn to two concepts: the MAYA principle and the KISS principle. the former, attributed to Raymond Loewy (Friis Dam, 2021), emphasises the importance of using technologies as advanced as possible bearing in mind that everyone has to use it. Therefore, it is crucial to design in a future-oriented vision, balancing it with the users' present. The latter, credited to Kelly Johnson (The Interaction Design Foundation, 2021), emphasises that the simpler the explanation and the simpler the product, the more likely it is that the output will be useful to others.

Digital collaboration

DEFINITION

The ability to communicate and collaborate effectively through digital channels.

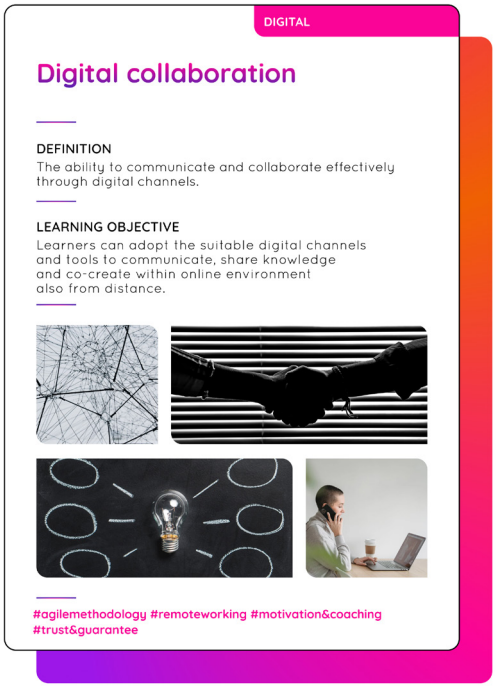


Fig. 3.6
Digital collaboration card.

This DCA highlighted two key points: the first emphasising the importance of defining policies and rights in order to ensure trust and guarantee in the team; the second stressing the need of having all the resources open source, to form an even more cohesive working group that works in the same way and with the same tools.

Healthy use of technology

DEFINITION

The ability to understand the benefits and harms of technology on one's mental and physical health and to use technology use while prioritizing health and well-being.

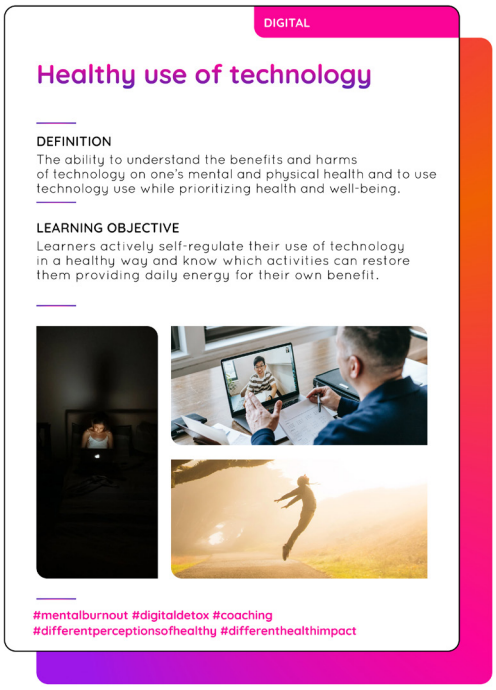


Fig. 3.7
Healthy use of technology card.

The discussion about this DCA led to two main considerations: first, that there are different perceptions of healthy, so we need to understand how to identify a scale and understand when and how the use of a certain technology is considered healthy; second, the uniqueness of the impacts caused by technology: everyone responds in a certain way to external stimuli. These considerations led the group to define the need to establish a method of coaching how to approach new technologies and how to use them in a correct and healthy way.

As it can be seen the cards are structured in such a way to describe in depth, but at the same time schematically, each DCA. In fact, each card contains the definition, the learning objective, a series of pictures and key words. These cards are designed to be used as training tools, for this reason it has been tried to schematize as much information as possible in an effective and intuitive way. In the following pages it is possible to find an overview of the other DCAs cards, grouped by their respective areas: Cognitive, Cross-Functional Team and Strategic Vision.

Cognitive

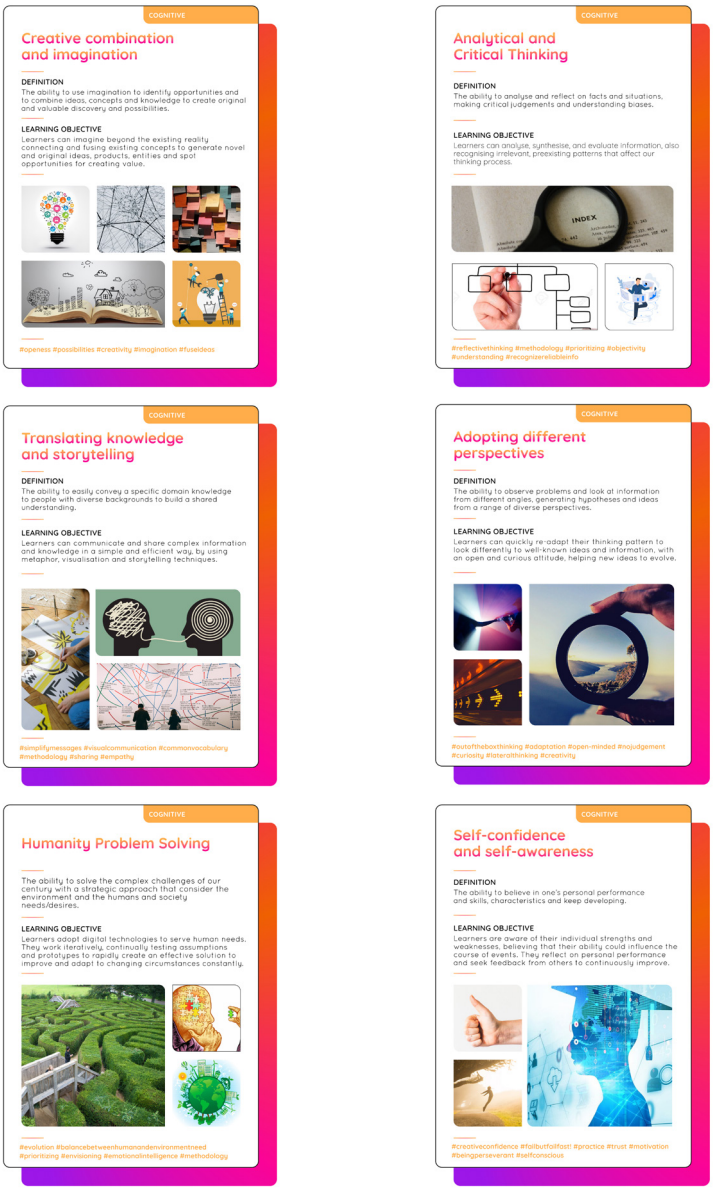


Fig. 3.8
The DCAs belonging to the Cognitive area.

Cross-Functional Team

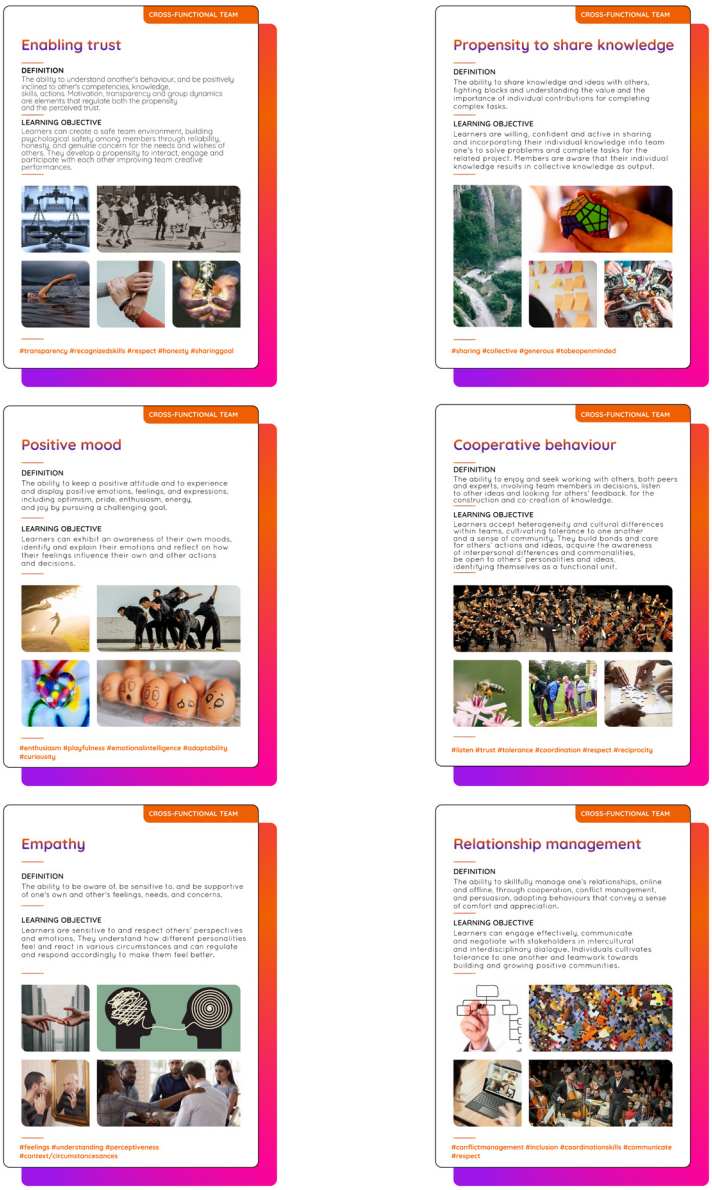


Fig. 3.9
The DCAs belonging to the Cross-Functional Team area.

Strategic Vision

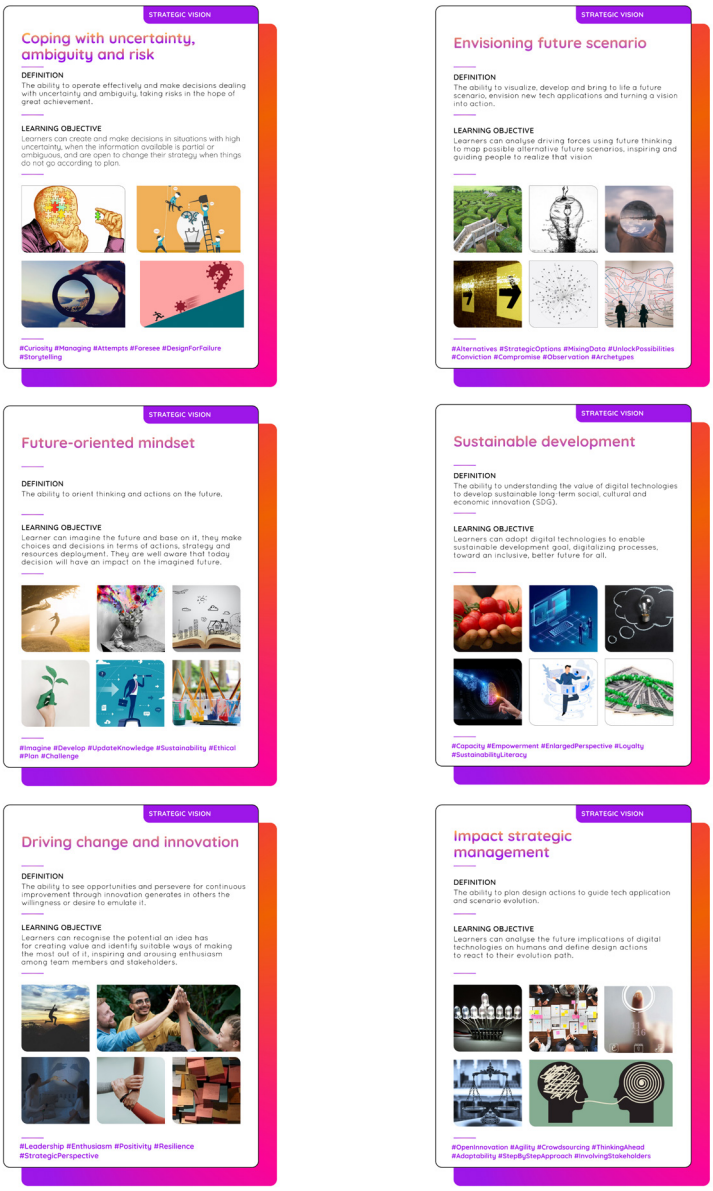


Fig. 3.10
The DCAs belonging to the Strategic Vision area.

3.2.2 Clusters of DCAs

The last part of the working day was oriented towards the definition of clusters of DCA. For this activity, two groups were joined at a time to work on possible connections between the different DCAs belonging to their own areas. As shown in Fig. 3.2, two approaches were used to carry out this activity: the first one groups the DCAs according to a common topic, whilst the other one defines some skills that are necessary to achieve a specific DCA. This is because the second approach tends to prioritise certain DCAs, whereas all of them have the same importance and need to be developed equally.

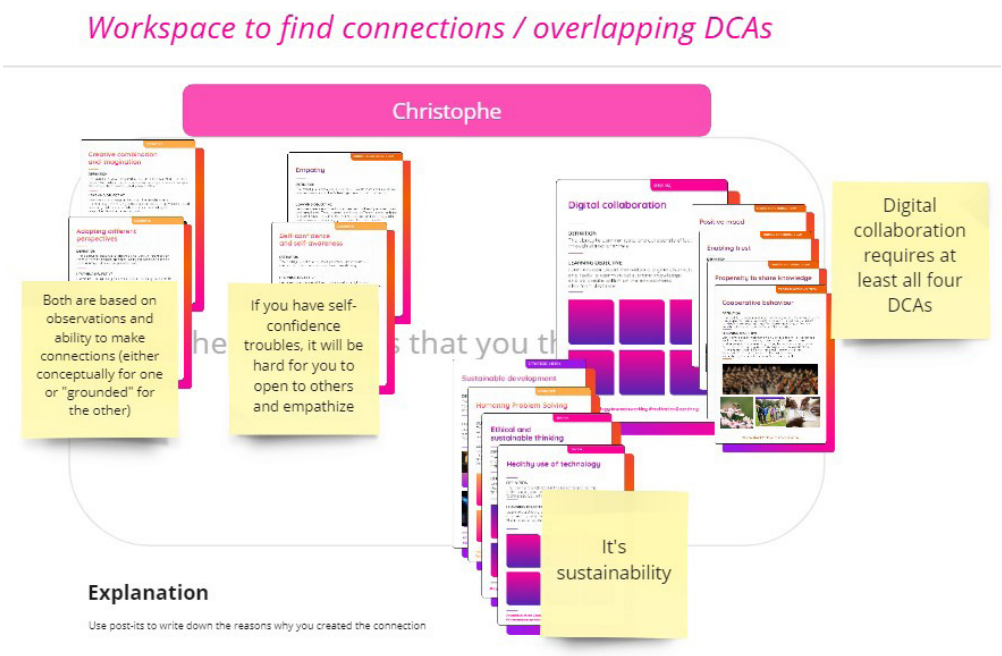


Fig. 3.11
The work of Christophe exemplifies the two methods used: some DCAs are grouped together by a common topic (sustainability), while others are identified as necessary to achieve another DCA (Digital collaboration).

From this intensive work, a list of 25 DCAs clusters emerged, as listed below.

1. DIGITAL COLLABORATION + POSITIVE MOOD + ENABLING TRUST + PROPENSITY TO SHARE KNOWLEDGE + COOPERATIVE BEHAVIOUR

Fig. 3.12
The DCAs belonging to the first cluster.

2. SELF-CONFIDENCE AND SELF-AWARENESS + ENABLING TRUST

Fig. 3.13
The DCAs belonging to the second cluster.

3. EMPATHY + SELF-CONFIDENCE AND SELF-AWARENESS

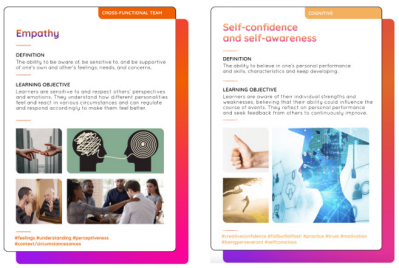


Fig. 3.14
The DCAs belonging to the third cluster.

4. CREATIVE COMBINATION AND IMAGINATION + ENVISIONING TECH OPPORTUNITIES + ADOPTING DIFFERENT PERSPECTIVES

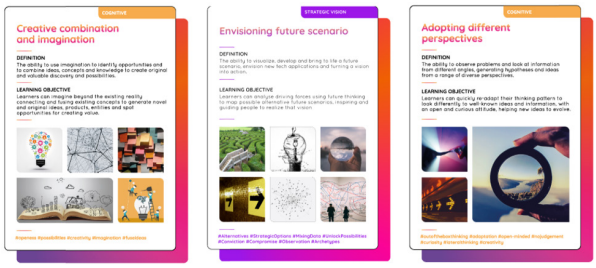


Fig. 3.15
The DCAs belonging to the fourth cluster.

5. DRIVING CHANGE AND INNOVATION + COOPERATIVE BEHAVIOR

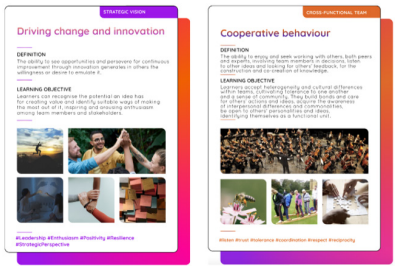


Fig. 3.16
The DCAs belonging to the fifth cluster.

6. SUSTAINABLE DEVELOPMENT + PROPENSITY TO SHARE KNOWLEDGE + COOPERATIVE BEHAVIOR + DATA LITERACY

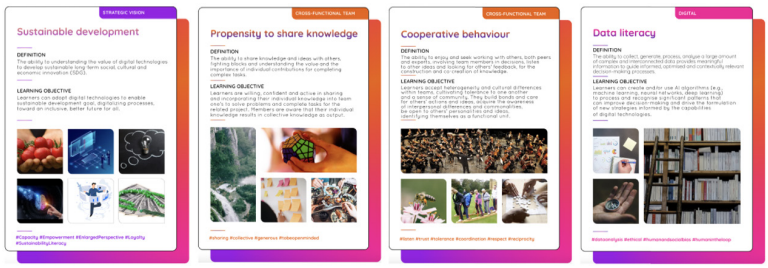


Fig. 3.17
The DCAs belonging to the sixth cluster.

7. COPING WITH UNCERTAINTY, AMBIGUITY AND RISK + SELF-CONFIDENCE AND SELF-AWARENESS

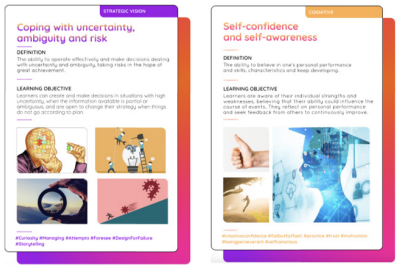


Fig. 3.18
The DCAs belonging to the seventh cluster.

8. COPING WITH UNCERTAINTY, AMBIGUITY AND RISK + ANALYTICAL AND CRITICAL THINKING

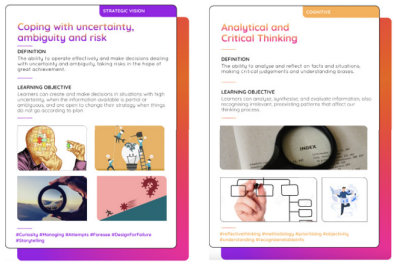


Fig. 3.19
The DCAs belonging to the eighth cluster.

9. SUSTAINABLE DEVELOPMENT + IMPACT STRATEGIC MANAGEMENT + FUTURE-ORIENTED MINDSET

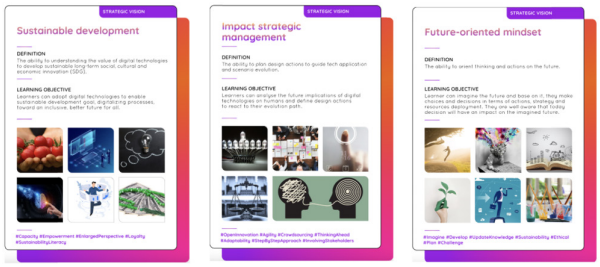


Fig. 3.20
The DCAs belonging to the nineth cluster.

10. ENVISIONING FUTURE SCENARIO + TRANSLATING KNOWLEDGE AND STORYTELLING + CREATIVE COMBINATION AND IMAGINATION

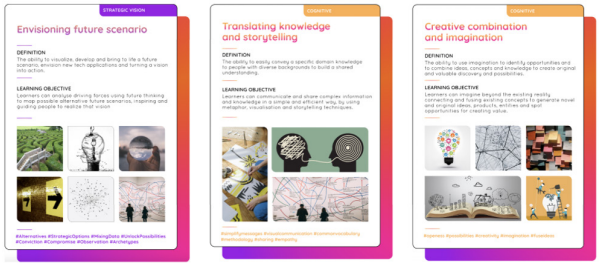


Fig. 3.21
The DCAs belonging to the tenth cluster.

11. DRIVING CHANGE AND INNOVATION + FUTURE-ORIENTED MINDSET + SELF-CONFIDENCE AND SELF-AWARENESS

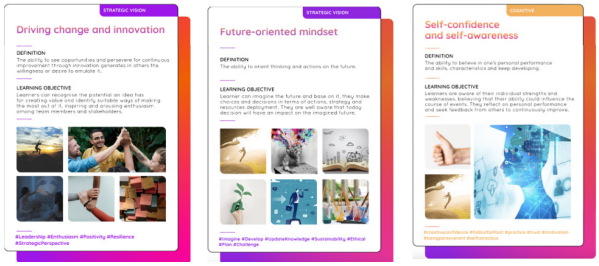


Fig. 3.22
The DCAs belonging to the eleventh cluster.

12. HUMANITY PROBLEM SOLVING + COPING WITH UNCERTAINTY, AMBIGUITY AND RISK + ENVISIONING FUTURE SCENARIO + FUTURE-ORIENTED MINDSET + ANALYTICAL AND CRITICAL THINKING

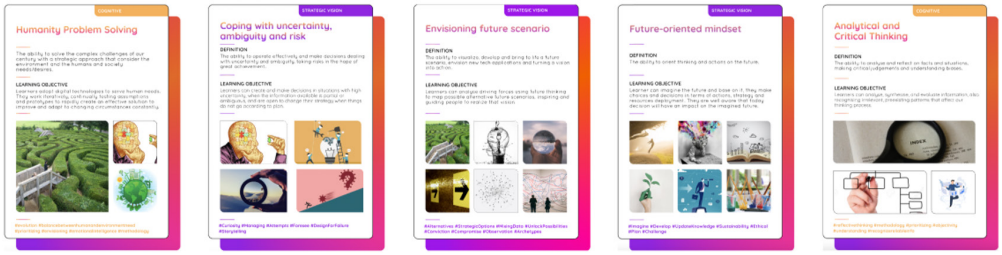


Fig. 3.23
The DCAs belonging to the twelfth cluster.

13. CREATIVE COMBINATION AND IMAGINATION + ADOPTING DIFFERENT PERSPECTIVES + POSITIVE MOOD

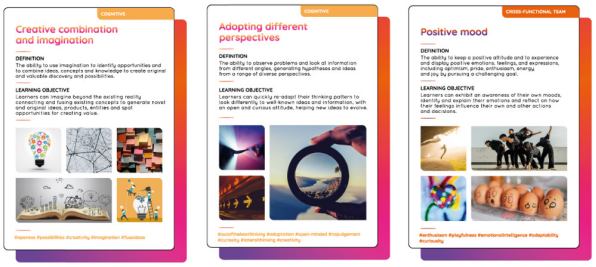


Fig. 3.24
The DCAs belonging to the thirteenth cluster.

14. HUMANITY PROBLEM SOLVING + HEALTHY USE OF TECHNOLOGY + SUSTAINABLE DEVELOPMENT + PROPENSITY TO SHARE KNOWLEDGE + ETHICAL AND SUSTAINABLE THINKING + ENVISIONING FUTURE SCENARIO + ENVISIONING TECH OPPORTUNITIES

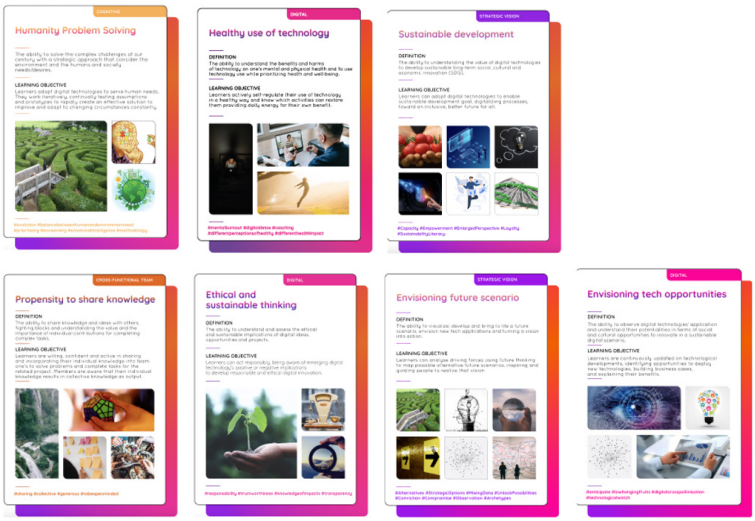


Fig. 3.25
The DCAs belonging to the fourth cluster.

15. HUMANITY PROBLEM SOLVING + SUSTAINABLE DEVELOPMENT + FUTURE-ORIENTED MINDSET

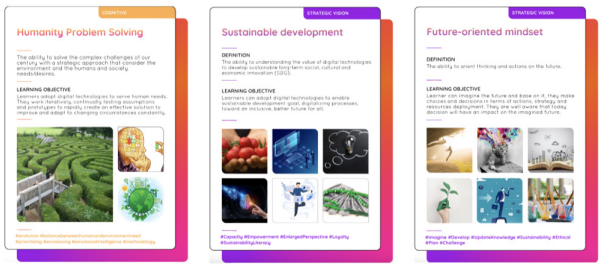


Fig. 3.26
The DCAs belonging to the fifteenth cluster.

16. TRANSLATING KNOWLEDGE AND STORYTELLING + DIGITAL COLLABORATION + COOPERATIVE BEHAVIOR

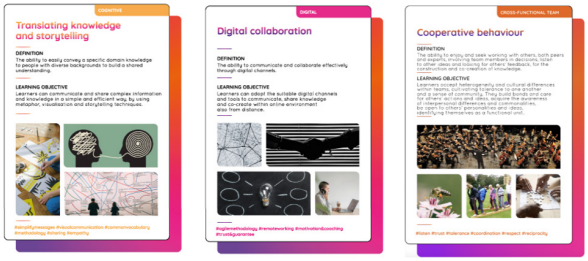


Fig. 3.27

The DCAs belonging to the sixteenth cluster.

17. POSITIVE MOOD + SELF-CONFIDENCE AND SELF-AWARENESS + HEALTHY USE OF TECHNOLOGY + FUTURE-ORIENTED MINDSET

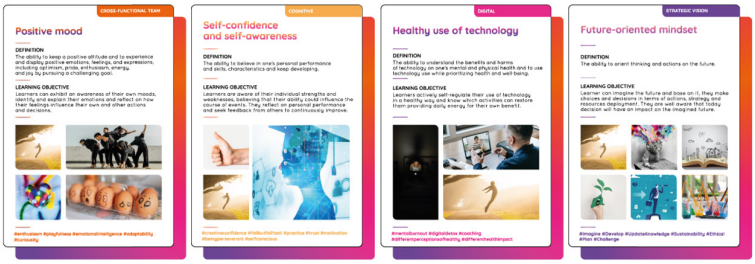


Fig. 3.28

The DCAs belonging to the seventeenth cluster.

18. ADOPTING DIFFERENT PERSPECTIVES + INFORMATION LITERACY + DATA LITERACY

Fig. 3.29

The DCAs belonging to the eighteenth cluster.

19. PROPENSITY TO SHARE KNOWLEDGE + TRANSLATING KNOWLEDGE AND STORYTELLING

Fig. 3.30

The DCAs belonging to the nineteenth cluster.

20. SELF-CONFIDENCE AND SELF-AWARENESS + CREATIVE COMBINATION AND IMAGINATION + HUMANITY PROBLEM SOLVING

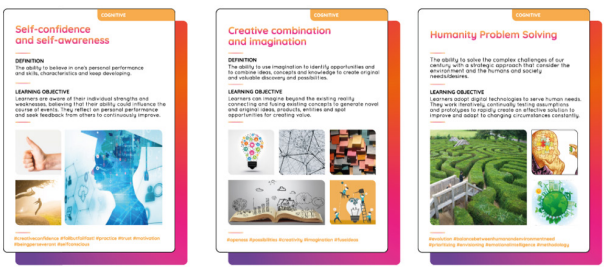


Fig. 3.31

The DCAs belonging to the twentieth cluster.

21. POSITIVE MOOD + ENVISIONING FUTURE SCENARIO + FUTURE-ORIENTED MINDSET

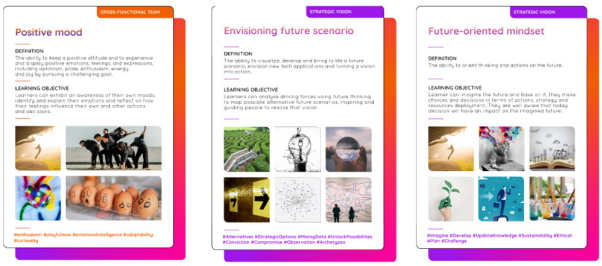


Fig. 3.32
The DCAs belonging to the twenty-first cluster.

22. RELATIONSHIP MANAGEMENT + IMPACT STRATEGIC MANAGEMENT

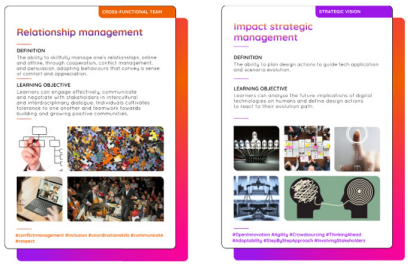


Fig. 3.33
The DCAs belonging to the twenty-second cluster.

23. COPING WITH UNCERTAINTY, AMBIGUITY AND RISK + ENVISIONING TECH OPPORTUNITIES + FUTURE-ORIENTED MINDSET + ENABLING TRUST

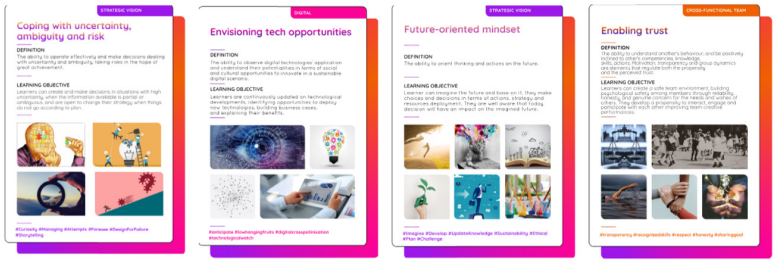


Fig. 3.34
The DCAs belonging to the twenty-third cluster.

24. DRIVING CHANGE AND INNOVATION + SELF-CONFIDENCE AND SELF-AWARENESS + TRANSLATING KNOWLEDGE AND STORYTELLING

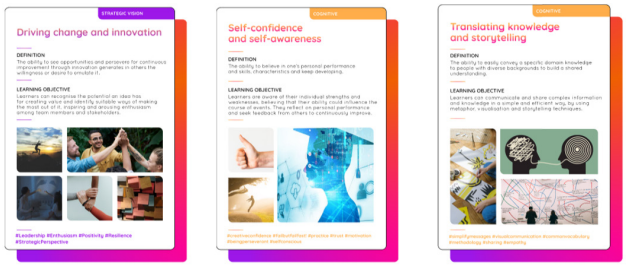


Fig. 3.35
The DCAs belonging to the twenty-fourth cluster.

25. INFORMATION LITERACY + DATA LITERACY + ANALYTICAL AND CRITICAL THINKING

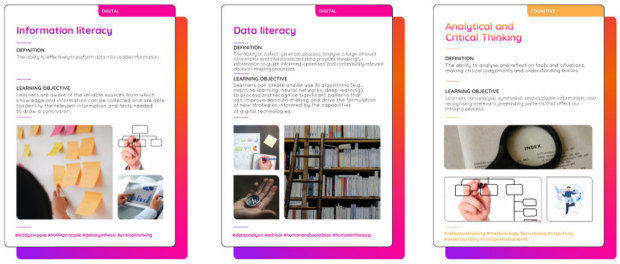


Fig. 3.36
The DCAs belonging to the twenty-fifth cluster.

This clustering exercise was very important both in terms of analysing more deeply the link established between different DCAs and because it forms the groundwork for the activities performed during the bootcamp days in September.

3.3 Bootcamp 2: towards the definition of Drivers

The second bootcamp session took place from the 14th to the 16th of September. The work carried out in these days considered the results of the July session as a starting point, in order to deepen and develop them further.

More specifically, the clusters were reviewed and the results obtained were analysed more specifically from which some observations arose. It was noted that some clusters had some common DCAs, so it was discussed whether a further step of grouping the clusters could be made, so as to obtain fewer groups. Hence, the clusters were distributed among the participants who, by directly interacting with each other, modified the combinations by joining, exchanging or removing DCAs. Moreover, while carrying out this activity, they tried to use each DCA of each thematic area. This exercise led to the definition of six different groups, each of which was represented by a specific topic. The discussion resulting from this activity led the working group to consider appropriate the classification of these new clusters, thus defining them as Drivers. This name has been conveniently chosen to highlight the importance of these skills in guiding individuals towards achieving Digital Maturity. The six topics that classify the Drivers are: Sustainability, Sense-giving, Tech foresight, Ethics, Collaboration and Complexity.

DEFINITION: Drivers

A Driver is a cluster of DCAs that enable the learner to become aware of: Sustainability; Sense-giving; Tech-foresight; Ethics; Collaboration; Complexity.

Once this result was achieved, efforts were made to understand the best way to develop the DCAs of each cluster, and thus to proficiently master each Driver. In order to facilitate this work, the tools, methods and activities provided at the beginning by the partners were analysed. Furthermore, once the effectiveness of the tool or method for the development of one or more DCAs was recognised, it was then placed on the model in order to have a visual overview of any possible gap. In fact, another objective of this work was to have some resources for the development of each Driver, and therefore of each DCA, both for the Pre-Process and Process phases of the DC4DM Model. Having these two steps of the model completely covered turned out being necessary to better support the student in the process of knowledge and skill acquisition, first from a theoretical point of view and then from a practical one.

Fig. 3.37

Image from the second bootcamp: the Drivers definition.

Fig. 3.38
Image from the second bootcamp: the partners working on the Drivers definition.

4 BOOTCAMP'S RESULTS

4.1 An overview of the six Drivers

As mentioned in the previous chapter, the bootcamp activities resulted in the definition of six specific Drivers, useful for the Digital Maturity Enabler to reach Digital Maturity. Given the importance of all the Drivers, this chapter gives an overview of each one, describing it through the learning objective and the DCAs included in it.

Sustainability

LEARNING OBJECTIVE

Learners are able to design the future through/with digital technology aiming at improving and guaranteeing the well-being of the planet and its communities, among which the human ones. Learners see and think from the perspective of other organisms (beyond human), balancing resources from environmental, economic, technological, socio-cultural and political level.

DCAs

Positive mood
Healthy use of technology
Sustainable development
Humanity Problem Solving
Impact strategic management
Ethical and sustainable thinking

Sense-giving

LEARNING OBJECTIVE

Learners are able to create or extract knowledge from an overwhelming amount of digital contents, select reliable sources, possibly from different domains, are able to process, analyse, interpret information in order to build a 360° view of the world and allow them to think outside the box to define the design objective.

DCAs

Analytical and critical thinking
Information literacy
Data literacy
Adopting different perspectives
Creative combination and imagination

Tech foresight

LEARNING OBJECTIVE

Digital Maturity Enabler should learn:
- How to be continuously updated on technological development;
- How to understand the feasible and viable opportunities from different angles that they could open in the future as well as their implications;
- How to envision new scenario of application out of them.

DCAs

Impact strategic management
Envisioning future scenario
Adopting different perspectives
Future-oriented mindset
Envisioning tech opportunities

Ethics

LEARNING OBJECTIVE

Learners are able to identify and understand ethical challenges and implications of digital innovation, to drive digital strategy, to adopt an ethical attitude/behaviour during the design and implementation process.

DCAs

Ethical and sustainable thinking
Future-oriented mindset
Healthy use of technology
Empathy
Relationship management

Collaboration

LEARNING OBJECTIVE

On an individual level, learners are able to understand the dynamics of collaboration especially in a digital context, are able to recognize their own abilities and potentials, to develop the mindset to share knowledge (= simplify language) and build trust.

DCAs

Translating knowledge and storytelling
Enabling trust
Digital collaboration
Self-confidence and self-awareness
Cooperative behaviour
Propensity to share knowledge

Complexity

LEARNING OBJECTIVE

Learners know how to cope with the complexity of digital challenges, the unexpected turn of events, the dialogue with different stakeholders, the difference between the vision and digital possibilities in reality.

DCAs

Driving change and innovation
Coping with uncertainty, ambiguity and risk
Translating knowledge and storytelling
Adopting different perspectives
Cooperative behaviour

Although the six Drivers are separate topics, yet the opposite can be stated. As one can quickly and clearly notice, some DCAs are shared between the various Drivers, but this is not the main cause. This statement can be easily verified by making a simple example with two random Drivers. Let us consider Sense-giving and Complexity: these two Drivers are strongly connected one with the other because, in order to succeed in solving complexity in the digital field, one of the most important step is to understand which parts constitute the complexity and clarify the meaning that one wants to give to the solution. This, together with the other links that are formed between the different Drivers, form a dense, intricate weave. For this reason, one can no longer speak of a Digital Maturity Enabler, and thus of Digital Maturity, without considering all the Drivers together. Therefore, the aim of the DC4DM Project is to develop an EduBox that enables learners to develop all these capabilities equally.

4.2 Further developments: tackling complexity

If the intention of the DC4DM Project is to develop the aforementioned EduBox, the objective of the work carried out by the group of thesis students is to develop the tools that will make up the final artefact, each one of focusing on one Driver. In this way, by combining the work carried out by everyone, a hypothetical complete EduBox will be obtained. The development of these tools has been structured in such a way that each student will work together with the partners of the European Project. The association between partners and Drivers was made on a voluntary basis, filtering the experiences of each reality with the objective to be pursued. The table below lists the European partner - Driver associations.

DRIVER	EUROPEAN PARTNER
Sustainability	Universidade da Madeira + Startup Madeira
Sense-giving	Télécom Saint-Etienne + Institut Mines-Télécom
Tech foresight	Institut Mines-Télécom + Politecnico di Milano
Ethics	Politecnico di Milano + Universidade da Madeira
Collaboration	Startup Madeira + Universidade da Madeira
Complexity	Politecnico di Milano + Télécom Saint-Etienne

Table 4.1
Driver - European Partner association.

This project work was carried out in cooperation with Politecnico di Milano and Télécom Saint-Etienne and operate on the Driver Complexity. The area addressed by the work has to be analysed in depth, since it is of high importance in today's world and will become increasingly crucial in the future, with the development of new technologies and systems. Therefore, the analysis of this topic is particularly useful to understand the causes that stimulate the development of complexity and the dynamics of the various systems. Being aware of these underlying structures, it will help to overcome the difficulties arising from complexity and succeed in any project. Furthermore, the study of this topic can support to discover several

possible effective methods to deal with complexity, which are useful in any context, not only from a work perspective, but also in a context of daily life. Therefore, this research is not only aimed at developing a useful resource for future students to become Digital Maturity Enablers, but it is also a source of personal growth, both on a professional and human level.

In the following chapters the individual work carried out on the issue of complexity will be described. This project unfolds with an initial research part, which explores in more detail the topic and presents some resources proposed both by partners and external sources that aim at overcoming complexity. This first section lays the foundations and represents the starting point of the design project, which aims to develop a resource to tackle complexity.

5 COMPLEXITY

5.1 Addressing complexity in digital ecosystems

5.1.1 How to better understand complexity: Complexity Theory

The continuous developments taking place in the different fields that characterise modern everyday life, such as the economy, information technology and globalisation, are shaping an increasingly complex world. Even though the world itself has always been a very complex system, it is not possible to fully understand the new complex systems that are being generated through Digital Transformation. This lack of understanding leaves us with critical issues in the ability to manage and design the systems, which, in turn, lead to the impossibility to shape solutions and outcomes of the systems.

In this scenario Complexity Theory arises, a framework whose aim is to help to understand the basic features and dynamics of complex systems (Systems Innovation, 2020). To identify this general structure, researchers have analysed models from many different fields such as mathematics, ecology, physics and computer science. From this extensive and detailed work, some common features and patterns have emerged from each area. This set of commonalities has since been addressed to as the main characteristics of complex systems, forming a generic framework that helps to analyse and study this challenging system.

DEFINITION: Complexity Theory

"Complexity Theory is a set of theoretical frameworks used for modeling and analyzing complex systems within a variety of domains." (Systems Innovation, 2020)

5.1.2 What defines a complex system? Simple vs complicated vs complex

To better address the topic of complexity, the characteristics that define a complex system should be analysed. Furthermore, since complicated and complex systems can be confused so easily, it is also worth understanding the differences between simple, complicated and complex systems. This is because the methods with which these different types of situations should be approached are different and confusing them would lead to a waste of resources and failure.

Therefore, according to several research and studies (Kurtz & Snowden, 2003; Rogers, 2008; Hummelbrunner & Jones, 2013; Sargut & McGrath, 2011), a system can be defined as:

- Simple, when the characteristics that compose the system are known to all the stakeholders and the main objective is clearly defined. Moreover, only a limited number of relationships are established and their outcome is easily predictable.

- Complicated, when the main features that constitute the system are not necessarily known to all the stakeholders and there is some disagreement about the main objective. Although the relationship that are established in this kind of systems evolve, their outcomes could be predicted by bringing in relevant expertise. This is because the interactions operate in a patterned way.

- Complex, when many features are unknown and there is disagreement about the main objective. Moreover, even though the interactions may operate in a patterned way, they are continually evolving. This makes it impossible to understand what is happening and why and also what it needs to be done to overcome this situation. For this reason, the outcomes of the interactions are impossible to predict, and depends considerably on the context. This is due to fact that complex systems are characterised by self-organising behaviour. (Systems Innovation, 2020)

A complex system depends on three main properties (Sargut & McGrath, 2011):

- Multiplicity: represents the number of the elements that can potentially interact;

- Interdependence: shows how those elements are connected;

- Diversity: refers to the degree of heterogeneity of those elements.

The greater are these three properties, the greater is the complexity in the system.

DEFINITION: Complexity

Complexity is a property of a system.
Complexity arises when the parts that compose the system come to have many interconnections between them. Likewise, interdependence between the parts is also a central characteristic of complexity. (Systems Innovation, 2020)

To better clarify this statement, it can be described an example between two realities that have different degrees of complexity. The first reality is a small country town with a population of one hundred residents. It can be said that the multiplicity and the interdependence of this system is fair, whilst the diversity is low, considering that probably all the people living in this rural town are born and raised in the same context. Therefore, it is possible to say that this system can be considered as complex, with a low degree of complexity. The second reality taken into account is a great metropolis, which is populated by people from all over the world. This system is characterised by a high level of multiplicity, since there are many people living in the city, interdependence, because different relationships

are created between different people, and diversity, since the people have different cultures and mindsets. For this reason, it can be stated that this particular kind of system is characterised by a very high degree of complexity. In order to facilitate the description and the understanding of this example, the population has been considered as the only element of the system “city”.

Therefore, after having analysed in depth the properties of each system, it is possible to say that the main feature that characterises and differentiates a complex system is the impossibility of predicting what results will be obtained, even if the initial conditions of the system are known.

5.1.3 Digital ecosystems: a new definition caused by Digital Transformation

In the current world where Digital Transformation has taken over and the relationships between different systems increase rapidly, as it was stated in the first Chapter, it is no longer possible to talk about systems only. Indeed, as this new scenario unfolds, it is clear to see that an ever-increasing number of different businesses are converging under more dynamic and broader alignments (Atluri et al., 2018). Therefore, this research has to be addressed to ecosystems that include different actors able to provide digitally accessed, multi-industry solutions. More specifically, this particular kind of ecosystem can be defined as digital ecosystems.

DEFINITION: Digital ecosystem

“A digital ecosystem is a complex network of stakeholders that connect online and interact digitally in ways that create value for all.” (Frank & Simon, 2019)

These new structures not only improve a company's performance and focus its energies on improving business value, but also assist and improve interactions between all the different stakeholders involved, allowing for fast fixes and quickly surface expectations (Brush, 2019). Three main types of digital ecosystems can be identified, according to distinctive characteristics, incremental levels of complexity and different methods of gaining revenue: the digitizer ecosystem, the platform ecosystem and the super platform ecosystem. The digitizer ecosystem aims at digitising existing products maintaining low managerial complexity. This ecosystem is best suited for businesses that lack in digital abilities and internal focus, but whose product capabilities are strong. Therefore, it can be said that it is very effective for all those businesses that want to transform their products into smart and connected solutions. The second one, the platform ecosystem, is more advanced than the digitizer ecosystem and, as a consequence, is characterised by a higher level of complexity. Its objective is to create shared platforms where users and smart devices can connect seamlessly and easily, while always guaranteeing a high quality of service. The realities that are based on this kind of ecosystem derive revenues from the users' use of these platforms. Given the increased complexity in the digital field, this model is mainly exploited by companies that have a solid digital capability and strong external expertise, such as established tech start-ups. Finally, the last and most complex type of digital ecosystem is the super platform ecosystem. This is centred on creating connections between different platforms, generating a single integrated service and collecting large amounts of user data. The companies that are most successful in navigating this context are those that already have an initial platform and possess advanced digital expertise. Furthermore, another very important feature is the willingness to cooperate with external partners.

As it can be clearly seen, digital ecosystems are not confined to one sector only, but span across several industries, which are all interlinked. Taking into account different sectors allows to have a multi-perspective view on the world and the market, which in turn helps companies to recognise the need to engage and establish relationships with an increasing number of new types of customers, competitors and partners, as the industry is rapidly shifting towards digital. Moreover, it can be easily grasped how companies

that operate in this type of context aim to add value in new ways to many more stakeholders, wisely understanding how everyone can contribute to increasing value within the ecosystem.

5.1.4 The adaptive cycle model and the panarchy: a focus on the internal dynamics of ecosystems

Having defined these complex digital ecosystems and analysed their main characteristics and objectives, it is important to understand the dynamics that develop within them. In this regard, the adaptive cycle model and its extension to panarchy (Sundstrom & Allen, 2019), or nested adaptive cycles, are applied as a metaphor and conceptual tool. Indeed, through these models, it is possible to understand more easily and clearly the dynamics of long-term change in complex adaptive ecosystems. This model, shown in Fig. 5.1 in the original version proposed by Gunderson and Holling (2002) and in the modified version by Burkhard et. al (2011), is divided into four main parts and is based on the processes of destruction and reorganisation, which are often neglected in order to favour growth and preservation. Furthermore, it describes the changes in the system through a three-dimensional space composed of potential, connectedness, and resilience. In this specific case, resilience is the competence to effectively navigate through all four phases of the model, despite turbulence and shocks caused by external changes.

The four phases that make up the model are: growth (r), equilibrium (K), collapse (Ω), and reorientation (α) (Fath et al., 2015). Each phase is connected to the next, thus creating two major phases, or transitions. The first phase, also called foreloop (r -> K), is characterised by a slow incremental process of resource accumulation and growth. The second, also known as the backloop (Ω -> α), consists of the rapid reorganisation phase leading to renewal and exploitation (Resilience Alliance, n.d.).

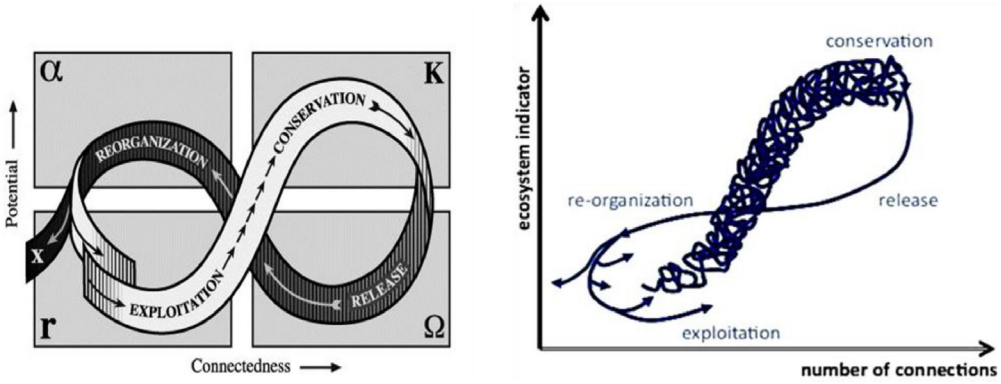


Fig. 5.1
On the left the two-dimensional representation of the adaptive cycle as originally conceived by Gunderson and Holling (2002) and, on the right, the model reviewed by Burkhard et al. (2011). The latter version has two main modifications: it is rotated 45° to avoid increase in resilience at the end of the release phase (Ω), and to capture non-monotonic growth in the exploitation (r) and conservation (K) phases.

Since changes at one level can trigger other changes at another level and given the interconnectedness between different systems as the complexity increases, it is possible that multiple models can be intertwined, thus creating a panarchy (Fig. 5.2).

As shown in the Fig. 5.2 (Sundstrom & Allen, 2019), the panarchy cycles follow a hierarchy dictated by time and space, which explains how new recombinations can be created for short periods. These new possible solutions are tested during the long periods of resource accumulation and, if they turn out to be unsuccessful, they do not create instabilities that affect the whole system. This is due to the fact that nested hierarchies are characterised by a self-stabilising nature. In fact, it can be stated that the larger and slower components of the panarchy are more solid and more resistant to change, and therefore provide a memory that enables the smaller and faster adaptive cycles to be retrieved (Resilience Alliance, n.d.).

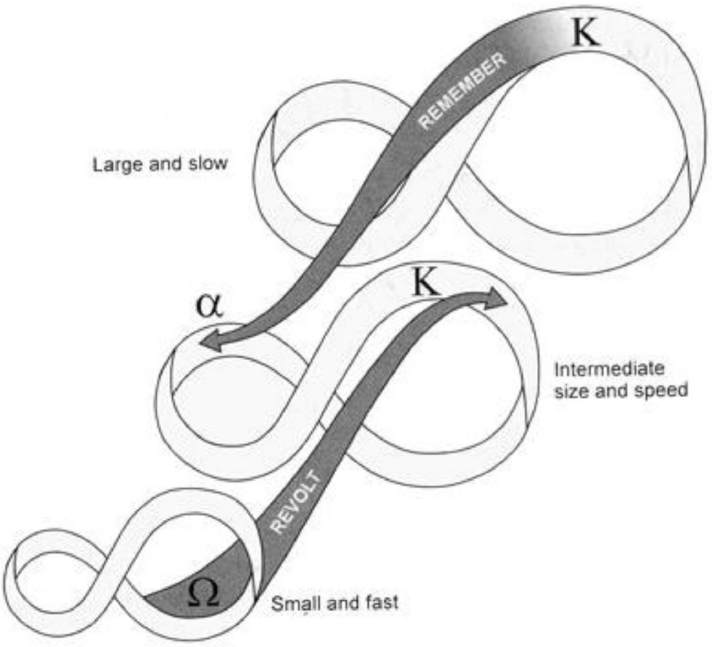


Fig. 5.2
The panarchy model, showing three nested adaptive cycles. The main characteristic of this model relies in its bi-directional cross-scale feedbacks that encompass all the spatial and temporal scales of system processes and dynamics (Gunderson and Holling, 2002).

Understanding in depth what these ecosystems are and the dynamics that arise from their complexity, is not only important to understand how to keep an ecosystem functioning through all the criticalities it may undergo. In fact, becoming fully aware of these two topics is crucial to figuring out all the skills needed to navigate these continuously changing contexts and to transform them into new and more desirable states (Krause et al., 2009).

5.2 Complexity: from the bootcamp's results to the literature review

5.2.1 What skills are needed to manage complexity? Analysis of the DCAs

The joint work carried out during the bootcamp days resulted in the definition of the Drivers, each with its own specific DCAs. This part offers an overview of the DCAs that characterise the Driver Complexity, since not all of them have been addressed in detail in the initial chapters. The Driver Complexity is composed by five different DCAs, two from the Strategic Vision area, two from the Cognitive area and one from the Cross Functional Team area. In the following section, each DCA is analysed in more detail, by presenting the area, the description and the learning objective.

Driving change and innovation

AREA: Strategic Vision

DEFINITION

The ability to see opportunities and persevere for continuous improvement through innovation generates in others the willingness or desire to emulate it.

LEARNING OBJECTIVE

Learners can recognise the potential an idea has for creating value and identify suitable ways of making the most out of it, inspiring and arousing enthusiasm among team members and stakeholders.

Fig. 5.3
Driving change and innovation card.

Coping with uncertainty, ambiguity and risk

AREA: Strategic Vision

DEFINITION

The ability to operate effectively and make decisions dealing with uncertainty and ambiguity, taking risks in the hope of great achievement.

LEARNING OBJECTIVE

Learners can create and make decisions in situations with high uncertainty, when the information available is partial or ambiguous, and are open to change their strategy when things do not go according to plan.

STRATEGIC VISION

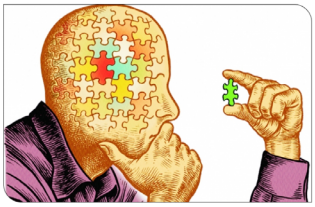
Coping with uncertainty, ambiguity and risk

DEFINITION

The ability to operate effectively and make decisions dealing with uncertainty and ambiguity, taking risks in the hope of great achievement.

LEARNING OBJECTIVE

Learners can create and make decisions in situations with high uncertainty, when the information available is partial or ambiguous, and are open to change their strategy when things do not go according to plan.




#Curiosity #Managing #Attempts #Foresee #DesignForFailure #Storytelling

Fig. 5.4
Coping with uncertainty, ambiguity and risk card.

Translating knowledge and storytelling

AREA: Cognitive

DEFINITION

The ability to easily convey a specific domain knowledge to people with diverse backgrounds to build a shared understanding.

LEARNING OBJECTIVE

Learners can communicate and share complex information and knowledge in a simple and efficient way, by using metaphor, visualisation and storytelling techniques.

COGNITIVE

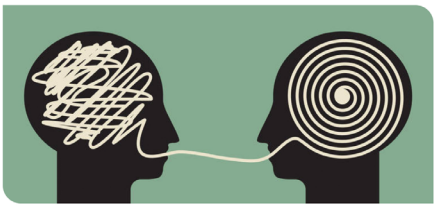
Translating knowledge and storytelling

DEFINITION

The ability to easily convey a specific domain knowledge to people with diverse backgrounds to build a shared understanding.

LEARNING OBJECTIVE

Learners can communicate and share complex information and knowledge in a simple and efficient way, by using metaphor, visualisation and storytelling techniques.



#simplifymessages #visualcommunication #commonvocabulary #methodology #sharing #empathy

Fig. 5.5
Translating knowledge and storytelling card.

Adopting different perspectives

AREA: Cognitive

DEFINITION

The ability to observe problems and look at information from different angles, generating hypotheses and ideas from a range of diverse perspectives.

LEARNING OBJECTIVE

Learners can quickly re-adapt their thinking pattern to look differently to well-known ideas and information, with an open and curious attitude, helping new ideas to evolve.

COGNITIVE

Adopting different perspectives

DEFINITION

The ability to observe problems and look at information from different angles, generating hypotheses and ideas from a range of diverse perspectives.

LEARNING OBJECTIVE

Learners can quickly re-adapt their thinking pattern to look differently to well-known ideas and information, with an open and curious attitude, helping new ideas to evolve.

#outoftheboxthinking #adaptation #open-minded #nojudgement #curiosity #lateralthinking #creativity

Fig. 5.6
Adopting different perspectives card.

Cooperative behaviour

AREA: Cross Functional Team

DEFINITION

The ability to enjoy and seek working with others, both peers and experts, involving team members in decisions, listen to other ideas and looking for others' feedback, for the construction and co-creation of knowledge.

LEARNING OBJECTIVE

Learners accept heterogeneity and cultural differences within teams, cultivating tolerance to one another and a sense of community. They build bonds and care for others' actions and ideas, acquire the awareness of interpersonal differences and commonalities, be open to others' personalities and ideas, identifying themselves as a functional unit.

CROSS-FUNCTIONAL TEAM

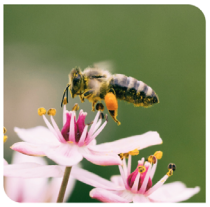
Cooperative behaviour

DEFINITION

The ability to enjoy and seek working with others, both peers and experts, involving team members in decisions, listen to other ideas and looking for others' feedback, for the construction and co-creation of knowledge.

LEARNING OBJECTIVE

Learners accept heterogeneity and cultural differences within teams, cultivating tolerance to one another and a sense of community. They build bonds and care for others' actions and ideas, acquire the awareness of interpersonal differences and commonalities, be open to others' personalities and ideas, identifying themselves as a functional unit.



#listen #trust #tolerance #coordination #respect #reciprocity

Fig. 5.7
Cooperative behaviour card.

The choice of these specific skills leads to several considerations concerning the objectives to be achieved in order to effectively manage complexity. Considering the DCAs of Strategic Vision, it is clear to understand how important is to adopt a future thinking mindset, fostering the ability to envision all the possible future scenarios. This is also highlighted by the presence of “Adopting different perspectives”, that suggests an open-minded behaviour able to cope with unplanned events. Therefore, it is possible to state that a future-oriented mindset has to be developed and a high level of flexibility has to be achieved. The remaining two DCAs are crucial to set a common ground able to understand the context and to build a common knowledge about the topic to be addressed. Indeed, one challenging issue when working in complex systems is to make it easily understandable by translating and simplifying it into a common language for everyone.

These aspects can also be found in the learning objective drafted by the partners, that addresses the Driver to achieve four main objectives:

- Cope with the complexity of digital challenges;
- Cope with the unexpected turn of events;
- Cope with the dialogue with different stakeholders;
- Cope with the difference between the vision and digital possibilities in reality.

The next section shows how even from typical desk research these key strategies and objectives can be found to break down and manage complexity.

5.2.2 The desk research to support the bootcamps’ results

Once the work carried out in the group during the bootcamps has been completed, an individual desk research was performed about the Driver’s topic. This research involved the analysis and study of various didactic and scientific documents, including articles, papers, books and also videos. The process yielded information very similar to the results of the bootcamps,

supporting and confirming the validity of the work conducted by the teams.

Starting from the description and characteristics of complex systems outlined in the previous chapters, it is possible to identify some critical aspects. From these crucial issues, it is then possible to derive the skills needed to work effectively in complex systems.

One aspect found in the literature underlines the difficulty to grasp and analyse an entire system or ecosystem in its wholeness (Sargut & McGrath, 2011). This is because these kinds of systems are characterised by many different relationships, events, actions and consequences. Due to the presence of many active actors in the system, it is very important to understand and comprehend all the relationships that are established among the different players (Sevaldson, 2013). Moreover, it is essential that everyone is aligned on the characteristics of the targeted system and the objectives to be achieved. Indeed, if everyone involved in the system is not aligned and the objectives are not fully comprehended by all the actors, it will be impossible to lead an effective transformation or develop a functional solution. Therefore, to meet these fundamental needs, it is necessary to gain very good communication, schematisation, storytelling and narrative skills.

Moreover, taking into account the managerial areas, due to high instability caused by complexity, it is possible to identify three more aspects that are affected by continuous problems and challenges: future forecasting, risk mitigating and trade-offs making (Sargut & McGrath, 2011). These assertations arise from the fact that predicting the possible outcome of an action in a complex system is quite impossible. To tackle these issues, it is fundamental to develop skills that allow to envision different future scenarios, to plan in an adaptive way and to manage continuous risks, without focusing on one prospective only.

5.2.3 Final considerations: main challenges and learning objective

The literature review points out four main challenges that characterise digital ecosystems (Sargut & McGrath, 2011; McKelvey et al., 2021; Sevaldson, 2013):

- The inability to predict outcomes;
- The fast-paced evolution process;
- A large amount of information continuously flowing;
- The presence of many stakeholders.

As it can be noticed from the previous remarks, it is clear to see that both the desk research and the bootcamp's findings meet in common results. More specifically, the abilities needed to effectively navigate in complex systems and ecosystems can be grouped in two main blocks. The first one regards the topic of future, aiming at solving and managing unexpected events. In this group there are many different abilities, everyone focused on the self. Some of the skills that make up this group are: envisioning future scenarios, adaptive planning and divergent thinking. The second block regards the topic of communication and working in group, that allows for setting a common work ground and objective. In this case some of the abilities that can be found are: storytelling, effective communication, translating knowledge and narrative skills.

This schematisation is a further attempt to simplify the learning objective defined with the partners. The learning objective outlines and defines clearly all the targets and results to be achieved to develop projects in complex systems and ecosystems. For this reason, it can be stated that the definition proposed by the partners does not need any further modification. Therefore, the learning objective is:

Learners know how to cope with the complexity of digital challenges, the unexpected turn of events, the dialogue with different stakeholders, the difference between the vision and digital possibilities in reality.

ANALYSIS OF THE RESOURCES

6 COMPLEX SYSTEM DESIGN: HOW TO MANAGE COMPLEXITY

6.1 The literature

6.1.1 Some strategies to tackle complexity

Working in systems that are different and more complex than the usual, requires a shift in the main focus of the design paradigm. This new approach is centred on the development of open systems that integrate different components through dynamic networks. Starting from this observation and the literature analysis of the main issues caused by complexity, it is possible to find different strategies that are aimed at helping in navigating these particular systems and ecosystems. This section explains six approaches that aim at managing and navigating effectively through complexity. The selection was based on the main problems that emerged from the analysis of complex systems.

Improve forecasting methods
(Sargut & McGrath, 2011)

Complex ecosystems do not have the same characteristics of any other system or ecosystem, therefore some analytical methods can no longer be used. This applies for forecasting methods that are based on average responses and medians. New approaches must be defined, capable of taking into account all the interaction happening both inside and outside the ecosystem. For this reason, it is important to simulate the behaviour of the ecosystem, to have a real understanding of how it could develop and transform.

Moreover, to help in predicting the future, it is possible to divide data in three buckets: lagging, current and leading. The first one contains data about what already happened, the second is about what is happening at the moment, and the latter holding the data about where the ecosystem is leading to and how it might respond to different opportunities. If all the data are in the "lagging bucket", it is a warning sign, because it would mean that decisions are based on already happened circumstances. In other words, it would be as betting that the future will be as the past.

Better risk mitigation
(Sargut & McGrath, 2011)

In order to minimize risk, four main approaches can be helpful. The first one is to limit and minimize the importance of predictions. This can be achieved by designing specific ecosystems that put the user in charge of the development of the output, or that are based on iterative models, whose design evolves according to the customer's inputs. Another way is to use advanced visualization techniques that allow to capture feedbacks as early as possible, in order to reduce unexpected interactions.

The second approach involves the use of decoupling and redundancy models. The first one allows both to shield from risks triggered by unexpected events, as well as to preserve parts that may be needed to mount a response. On the other hand, having a redundant structure, in which elements can substitute one another, may help the ecosystem to function, even if some parts of it are being challenged.

The third approach helps to mitigate risks by getting people used to view potentially catastrophic future events as real, even if they are unlikely to happen. This can be fostered by using some "soft" approaches such as posing counterfactuals or narrating stories about near misses. In this way people's attention is drawn to analysing the possible future scenario and trying to understand what they would do in that situation.

Eventually, the last approach consists of approaching complex ecosystems by attacking the problems from different angles. In this way it is possible to have a clearer view of the entire problem.

Smart trade-offs decisions
(Sargut & McGrath, 2011)

This strategy can be seen as another way of mitigating risks, more specifically it aims at increasing resilience by learning from early and cheap failures. The approach that can be taken is to make relatively small

investments that can allow to make further investments further on. This approach, also called “intelligent failure” by Sim Sitkin et al., does not eliminate risks, but it limits downsides while maximising the values on the upsides.

Move from static to adaptive managements
(Hummelbrunner & Jones, 2013)

Managing in the face of complexity requires different approaches that are able to follow the development of the evolving context and limit the importance of predictions. To do so, it is important to articulate a theory of change, as an expression of hypotheses and assumptions, the purpose of which is to test ideas on the best way to achieve the objective and to produce desired results. This constant experimentation regarding the best method to apply entails a continuous search for innovation, which ensures a continuous rich learning exercise.

Move from directive and centralised to collaborative and decentralised management
(Hummelbrunner & Jones, 2013)

When dealing with complex issues, collaboration should be beyond the control of individual actors. Rather, partners should collaboratively direct the trajectory through the implementation process to achieve results. Therefore, this strategy helps to overcome complexity by decentralising control and fostering a more diverse perspective on the situation. More specifically, it drives the resolution project by drawing on the knowledge and skills of all people and encouraging group commitment to common goals. Decentralised management should be conceived as a set of nested subsystems, with each level acting in a context defined by the others.
In order to make this particular type of embedded structure work, it is necessary to clearly separate the responsibilities of each individual, but without defining how the agreement is to be achieved.

However, it is also true that the decentralised approach does not fit every situation. Indeed, when fast decisions are needed, a more democratic decentralised approach is too long taking and bulky, whilst a more authoritarian centralised style could solve the situation more quickly. Therefore, it can be said that a centralised organization design creates a focal point for coordination, so it is more efficient, while the decentralised one is more effective (Bridgeway Partners Blog, 2019).

Holding firm to a limited number of priorities
(Bridgeway Partners Blog, 2019)

In order to reduce the level of complexity, it is crucial to maintain a limited number of priorities. In fact, as the number of priorities increases, so does complexity, and vice versa. When a certain level of complexity is reached, it is impossible to successfully manage all the priorities arising from the context, due to human cognitive limits.

6.1.2 Systems Oriented Design

Systems Oriented Design (SOD) is an approach developed by Birger Sevaldson, a researcher and lecturer from the Oslo School of Architecture and Design. The main objective of this new method is to help designers when dealing with complex problems , by looking at modern systems thinking in a more pragmatic way (Sevaldson, 2009). In this way, it is possible to re-interpret perspectives and theories coming from different and external fields and adapt them in the context of design (Sevaldson, 2013).

Systems Oriented Design shifts the main objective from the result of the intervention to the interrelations of the systems. The designer who applies this methodology is interested in looking at interactions and relations emerging from the context, rather than focusing on hierarchical orders and boundaries of systems. In this way it is possible to obtain a holistic approach, monitoring both small details and broad networks. Moreover, by achieving this wide perspective the designer can oversee the consequences

of particular relations and find intelligent design outputs (Sevaldson, 2013).

Systems Oriented Design is considered as a real creative tool in design, based on approaches and theories drawn from the modern system thinking and the critical system thinking. On top of that, SOD introduces a number of new concepts, methods and techniques specifically developed for this context. For instance, tools and practices such as GIGA mapping, ZIP analysis and impact and threshold analysis are featured in this new approach. These three methods are aimed at dealing with one specific issue, respectively, the visualisation of the system, the analysis of the context and the evaluation of the outcomes. However, the entire process is based on the importance of GIGA mapping, since it is a representation of the entire system and all its relationships.

GIGA mapping

GIGA mapping is a method that supports the design process and is used to visualise all the information, actors and relations of a complex system. Although it may be intuitive to think that this framework is employed to simplify and communicate more easily the information of the complex system, this is not the case. The main purpose of it is to explode the system to spot hidden relations and connections, tracking all the systemic relations and internalising as much information as possible. Only when it known enough about the whole, then it is possible to simplify and start drawing a system boundary (Sevaldson, 2013).

The GIGA map framework is not a strict and pre-established tool has to be filled in, instead is just an approach guides the designer, or the working group, to come to a desired outcome. This is because every complex system is different from the other. This is also the reason why it is impossible to find identical GIGA maps. The process is based on sketching, co-creation, analysis of the relations, redesign and iteration.

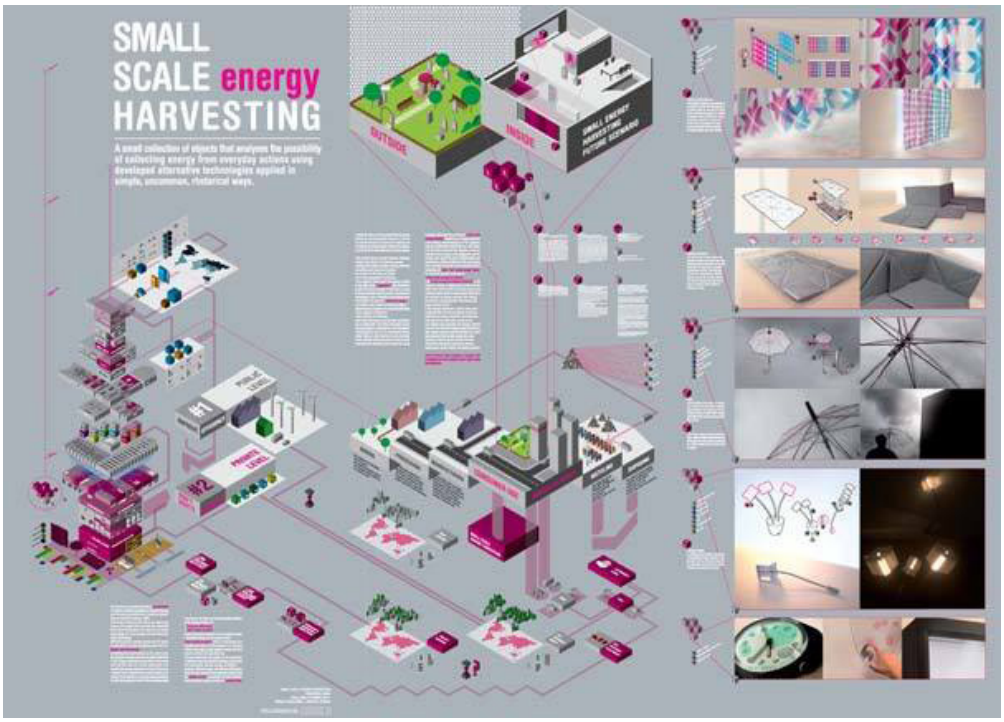


Fig. 6.1
An example of GIGA map, The Small Scale Energy Harvesting project (Sevaldson, 2013).

ZIP analysis

ZIP analysis is a method that helps in developing GIGA maps while highlighting potential areas for interventions and innovations (Sevaldson, 2013). ZIP is an acronym that stands for Zoom, Innovation and Potential.

The ZIP analysis is applied to underline some points or parts of the GIGA map, finding zoom areas, problems, potentials or ideas. These are called ZIP points. This process can be done while developing the map or in a second moment during an analysis session (Sevaldson, 2012; Sevaldson, 2013).

Z: Zoom is used to highlight areas or points on the map that need further research.

P: Potential is used to spot both obvious problems, that offer the potential of improvement, and something that works exceptionally fine, which offers the potential to learn from it.

I: Innovation/intervention is used to mark new possibilities such as something new that it is possible to do, solutions to a problem or new links between different actors that create new relations.

The ultimate aim of this activity is to start a generative process and to find innovation in the map. Because these processes start from analysis points found within the GIGA map, it is possible to say that all the outcomes that will emerge are rooted in the system.

Impact and threshold analysis

The Systems Oriented Design approach proposes a range of evaluation tools to work and develop ideas arising from the GIGA map and the ZIP analysis. The tools are grouped in five different evaluating criteria, that have to be addressed to all the I points, the Innovation/intervention points, emerging from the ZIP analysis. The list below shows the five criteria and the related tools, developed especially for SOD by the SOD team (Sevaldson, 2016).

1. Systemic impact (leverage)
    - Radius of ripple effects
    - Short term
    - Long term
    - Platform effect (to what degree the intervention is creating conditions for further interventions)
2. Treshold
    - Economic
    - Technological
    - Cultural

- Organisational
- Pestel

3. Synergies
    - Synergies between intervention and the existing system
    - Synergies between interventions
    - Orchestration effects (combined effects, high-level synergies)
    - Orchestration thresholds (how easy is it to orchestrate the implementation?)
4. Counter (-intuitive) effects (unwanted and counter-intuitive effects)
    - Short term
    - Long term
    - Counter effects between the intervention and existing system
    - Counter effects between interventions
5. Resilience
    - Resilience toward micro-fluctuations
    - Resilience toward macro-fluctuations
    - Resilience toward extreme scenarios
    - Black swans

These tools are applied at the end of the process, to evaluate systematically the efficiency and effectiveness of the implementation propose. Therefore, they are based on a score method.

6.1.3 Toolkits: Systems Innovation and Systemic Design Toolkit

Systems Innovation

Systems Innovation is an e-Learning and collaborative platform for systems innovators aimed at building better systems by co-creating system change. This platform offers different services, some of which are accessible for free, while others need a subscription to a plan. The website is composed of three main sections: one with courses about systems thinking, complexity and innovation, one that allows to download guides, toolkits and tools to support the design of complex systems methodology, and the last one that gathers many system innovators in an online community.

The courses offered by Systems Innovation range from Systems Theory to Game Theory, proposing both wider subjects as well as more specific topics. Each course presents some lectures and videos that are aimed at analysing and explaining one specific part of the topic of interest. The course regarding Complex Systems Design is structured in five main sections, listed below (Systems Design, n.d.).

Part 1 – A New Design Paradigm
The first part of the course explores some of the major themes that are shaping the design and engineering of systems in the 21st century. Moreover, it offers an overview of complexity theory and complex systems design. Finally, the basic concepts that will be used throughout the course are explained.

Part 2 – Key Concepts
The second part of the course is focused on one specific key takeaway of the entire course: the idea of abstraction as a powerful tool for solving complexity.

Part 3 – Design Principles
In the third part of the course the primary principles to design complex systems are discussed. Those involve networks, adaptive systems, the key mechanisms of evolution and their effect on the life cycle of the systems).

Part 4 – Systems Architecture
In the fourth part of the course the platform technologies and their internal workings are discussed. Moreover, modular systems design and event driven architecture are analysed.

Part 5 – Design Methods
The fifth and last part of the course introduces some design methods and processes best suited to the activity of complex systems design.

On the other hand, the Systems Innovation Toolkit is designed as an open

source set of modules that can be combined to support a system change initiative (Systems Innovation, 2021). The building blocks of the toolkit are the canvases, each one dealing with one key aspect of the process of system innovation. The toolkit is divided in four different sections, that compose a particular approach to the Complex System Design. The list below offers an overview of the four sections with the related tools proposed by the Systems Innovation team (Systems Innovation, 2021).

Ideating

This section includes all the canvases that help to change the way of thinking and looking at the system, in order to start to see new possibilities.
The canvases included in this section are:
- Systems Thinking
- Reflexive Thinking
- Iceberg Model
- Ecosystem Thinking
- Emergence Thinking

Mapping

This section includes all the canvases that help to understand in depth the current state of the system and make holistic inquiries by mapping the actors, structure and dynamics of the system.
The canvases included in this section are:
- GIGA Map
- Actor Map
- Dynamics
- Networks

Changing

This section includes all the canvases that support the work of transition process, finding points to intervene in the network. In this way and through the tools proposed, the bases of an effective system change are laid.
The canvases included in this section are:
- Systems Change

- Multi-Level
- Horizon Scanning
- Systems Gardening
-Two Loops

Building

This section includes all the canvases that are aimed at developing new ecosystems, connecting people and resources in new ways and scaling change.
The canvases included in this section are:
- Ecosystem
- Roles
- Activities
- Value
- Identity

The list offers only a general and superficial overview of the canvases proposed in this toolkit, since they will be analysed in more detail in the following chapter.

Systemic Design Toolkit

The Systemic Design Toolkit is an online platform that is aimed at helping to co-create interventions to tackle organisational and societal complexity. On the website it is possible to find a methodology that has been developed by the team to understand and to work in complex systems. This process is supported by a specific toolkit, which was also implemented by the Systemic Design team and is available online. Moreover, it is possible to contact the team to ask for support or to apply for training courses.

The process proposed by the Systemic Design team is based on seven steps. For each step one specific tool has been identified and implemented. The following list is an overview of the steps and the tools (systemic Design Toolkit, n.d.).

Framing the system
This section helps to set the boundaries of the system in space and time and to identify the hypothetical parts and relationships of it.
The canvas included in this section is:
- Rich Context

Listening to the system
This section focuses the attention to the experience of the people and allows to discover how the different interactions lead to the system's behaviour. Moreover, this section helps to verify the initial hypotheses.
The canvas included in this section is:
- Actants

Understanding the system
This section helps in finding and analysing the variables and interactions and how they influence the dynamics and emergent behaviours. Moreover, through this section it is possible to identify the leverage points to work with.
The canvas included in this section is:
- System Map

Defining the desired future
This section helps the stakeholders to articulate the common desired future and to create the intended value.
The canvas included in this section is:
- Value Proposition

Exploring the possibility space
This section explores possible ideas for intervening on the leverage points and allows to empower the ideas by working with the paradoxes found in the system.
The canvas included in this section is:
- Intervention Strategy

Designing the intervention model
This section helps to define the engine for change and its variations. Also, it iterates the implementation in different context by envisioning methods.
The canvas included in this section is:
- Intervention Model (Connector)

Fostering the transition
This section defines how the interventions will mature, grow and finally be adopted in the system.
The canvas included in this section is:
- Roadmap for Transition

Also in this case the list is intended to give just an overview of the different sections, highlighting the purpose of each of them. Each canvas will be further analysed in the following chapters.

6.2 The bootcamp

6.2.1 The resources proposed by the partners

Before starting the bootcamps, each partner of the project was asked to bring and present some resources that they apply in their teaching and designing method. They were retrieved in the last activity of the last day of bootcamp in September. In fact, this last step was aimed at finding all the possible tools and methods that could assist and facilitate the learning of the DCAs of each Driver. Moreover, another intention that had been conceived for this activity was to find the resources to support the design method of DC4DM. To better address this last purpose, all the resources were place on the model, in order to determine at what point in the process they could be employed.

Regarding the Driver Complexity, five resources were selected and were divided as shown in Table 6.1.

PRE-PROCESS	PROCESS
Pitch as a method	Building: - Pitch applied to project - Brief Generation Canvas Ideating: - Pitch applied to project - Brief Generation Canvas - Pizza slices - Idea clustering - Unpack Creativity Canvas

Table 6.1
The resources identified for the Driver Complexity.

6.3 Analysis of the tools

6.3.1 System Innovation Toolkit

Systems Thinking Canvas

i ABOUT

This canvas is designed to help members to try and to change their way of thinking and their way of looking at the world towards a more holistic paradigm that is characteristic of systems thinking.
The exercises proposed in the canvas will walk participants through a set of questions that will make them think about how they currently look at the world and how that may change.
The canvas is divided in four different steps:

1. Analysis of the systems from a “piecemeal thinking” to an “holistic thinking”
Piecemeal thinking: What does it mean to look at the system of interest in a piecemeal way, seeing only the parts?
Holistic thinking: Try to look at the whole system, what does this look like?

2. Analysis of the systems from a “reductionism thinking” to an “emergent thinking”
Reductionism thinking: In what way do we work to break the system down into parts within hierarchical structures?
Emergent thinking: How do small parts come together in a bottom-up way to form new emergent patterns?

3. Analysis of the systems from a “linear thinking” to a “nonlinear thinking”
Linear thinking: In what way are we looking at events as the result of simple linear interactions?
Nonlinear thinking: Start to think about the feedback loops in the

system and cyclical causation.

4. Analysis of the systems from a “disconnected thinking” to a “connected thinking”
Disconnected thinking: In what way do we take an isolated or disconnected view of the system?
Connected thinking: How might we start to look at the system through a lens of interconnectivity and networks?

IN THE DC4DM MODEL

The Systems Thinking Canvas is a comprehensive tool that could be applied in the Pre-Process part of the DC4DM model. This canvas is helpful to comprehend the main features of complex systems and what it means to work within complexity. This canvas is design to fit each complex systems, therefore it can be also applied for digital complex system.

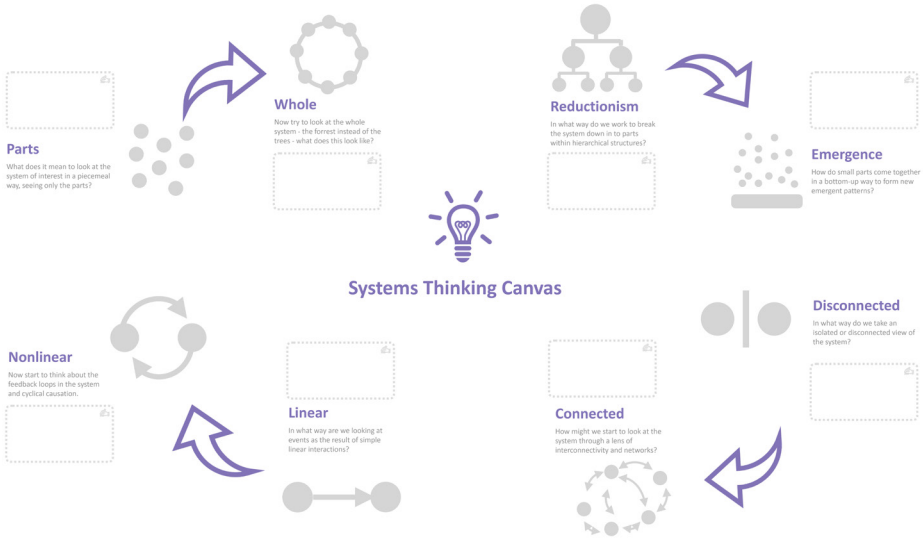


Fig. 6.2
Systems Thinking Canvas (System Innovation Toolkit, 2021).

Reflexive Thinking Canvas

ABOUT

Through this canvas it is possible to become aware of how personal thinking shapes what we see, do and the world we create. This, in turn, feeds back to shape our thinking forming an ongoing feedback loop.

The canvas is divided in four main parts, each one representing a different aspect of the dynamic described before. In this way it is possible to become better aware of them and the overall process.

The four parts are:

1. Conceptual Models: Our paradigm forms our conceptual models & categories – How are we thinking?

2. What We See: Our conceptual models shape everything that we see – What do we see?

3. What We Do: How we see the world determines how we act in it – How are we acting?

4. The World We Create: Our actions create the world we live in which feeds back to shape our thinking again – What are the outcomes?

IN THE DC4DM MODEL

The Reflexive Thinking Canvas helps in focusing on the personal mindset and it highlights how the personal point of view shapes our choices and our future. This canvas could be applied in the Pre-Process, to develop personal skills. However, because of its aim and features, it does not fit within the Driver Complexity.

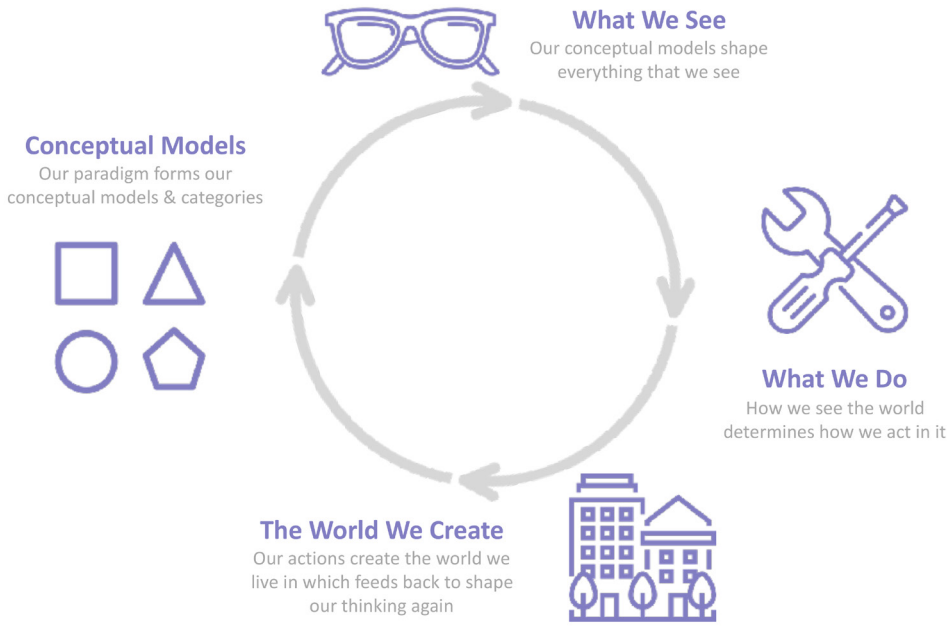


Fig. 6.3
Reflexive Thinking Canvas (System Innovation Toolkit, 2021).

Iceberg Model Canvas

ABOUT

The Iceberg Model Canvas is used in systems change to analyse the different levels of abstraction of an event or organization. This canvas helps to think about and map all these levels, from observable events to underlying patterns, the supporting structures and the mental models of the actors.

The canvas is structured in four main parts, each one representing one level of abstraction, and is divided in two main steps: the first is focused on the current system, while the second looks at the emerging one.

The four levels analysed are:

1. Events: the observable actions and phenomena;

2. Patterns: the changes in variables that occur over a period of time;

3. Structures: the rules, norms, policies, … that characterise the current system;

4. Models: mental models that support everything else in the system.

This model is based on a cause-effect property: each level is caused by an underlying level, that is the effect of another level, and so on. At the start of this chain there are the mental models. The user starts by analysing the events of the current system, and proceeds to go more in depth, until the mental models. By understanding them and defining which are needed to shift the current paradigm, it is possible to predict and envision the emerging system.

IN THE DC4DM MODEL

The Iceberg Model Canvas could fit in the Process part of the DC4DM model, more specifically in the Horizon Scanning step: it is a canvas that helps in looking at a present system and to understand all the possible turns it can take in the future. The Iceberg Model Canvas is a generic tool, therefore it can be applied for each kind of complex system, including digital ones.

Fig. 6.4
Iceberg Model Canvas (System Innovation Toolkit, 2021).

Ecosystem Thinking Canvas

ABOUT

The Ecosystem Thinking Canvas is designed as a template to help to shift people's thinking from "ego-system" to "eco-system". The first one is related to a self-centred view of the system, while in the second people are aware that they are a part of a more complex system.

The canvas' activities start by analysing the users' underlying paradigms and mental models, focusing on the "ego-system" thinking approach. By having a clear understanding of this, it is possible to form the basis that allow to shift from the "ego-system" to the "eco-system" approach.

IN THE DC4DM MODEL

The Ecosystem Thinking Canvas does not fit within the Driver Complexity, nor the DC4DM model. Indeed, it is helpful to understand the centrality of the relationships in complex systems, but this does not bring any other personal or skill profit.

Fig. 6.5
Ecosystem Thinking Canvas (System Innovation Toolkit, 2021).

Emergence Thinking Canvas

ABOUT

The Emergence Thinking Canvas is aimed at helping to think about emergences in the context of interest. Emergence describes a process whereby novel patterns emerge when elementary parts are put together as they interact and self-organize to create new levels of organization. Through this canvas it is possible to see the overall state of the system as an emergent phenomenon and how the interactions between the different parts create new patterns in the system.

The canvas is focused on two main elements: parts and interaction.

1. Parts: What the small parts to the system? What are the simple rules under which they operate?

2. Interaction: What are the interactions between the parts?

After these are defined, it is possible to understand what overall pattern characterises the system. At the end of this process of analysis, the attention is brought to the “emergent thinking” approach. A new question arises: How do small parts come together in a bottom-up way to form new emergent patterns?

IN THE DC4DM MODEL

The Emergence Thinking Canvas is helpful to understand what are the possible outcomes of different relationships in the system. This tool and the matter covered by it are of crucial importance in supporting the design process of the DC4DM model. However, as it can be seen in the following pages, they are already treated and covered in the GIGA Map.

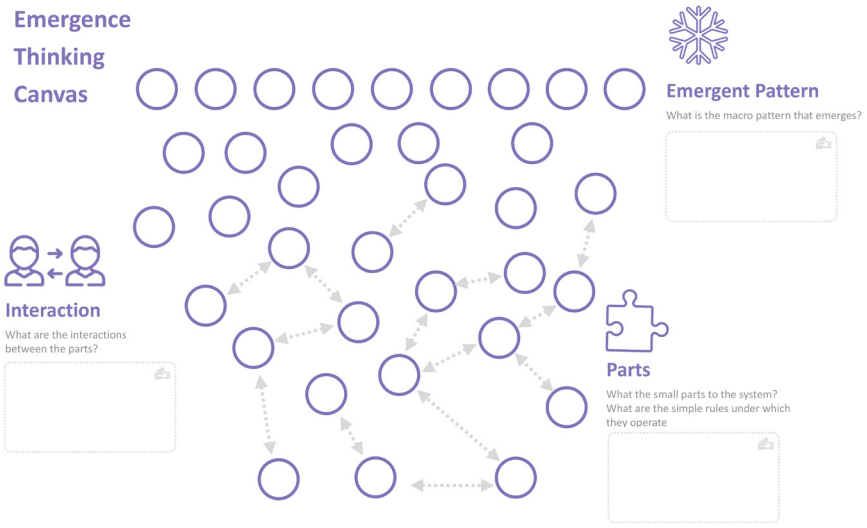


Fig. 6.6
Ecosystem Thinking Canvas (System Innovation Toolkit, 2021).

GIGA Mapping - Systems Mapping

ABOUT

The canvas is designed to support the development process of System Mapping design. The aim of System Mapping is to get a visual overview of the entire system, the different component and how they are interrelated.

This canvas leads the designer through the two crucial elements of GIGA Mapping, that are nodes and links.

1. Defining Nodes
There are four main nodes pointed out by this canvas:
- Technological
- Social
- Environmental
- Economic

Once each node is addressed, it is further analysed by understanding the elements that compose it (i.e., Social elements: culture, education, governance, health)

2. Defining Links
This step asks to identify all the relationships between the different elements that compose the system and their nature. Those could be an exchange of ideas, of information, of finance, of energy or of materials. For each kind of link, it is asked to find a way to represent it, so that the visualisation is clear.

IN THE DC4DM MODEL

The GIGA Map is a comprehensive tool and it is of fundamental importance in the definition of complex systems. Since understanding the context and the system is one of the key aspects to better address complexity, this tool has to be taken into account for the DC4DM Project.

More specifically, it fits in the Scenario building step of the Process phase of the model. Moreover, this tool gathers all the information that can be found in other canvas, for instance the “Emergence Thinking Canvas” and the “Actor Map”.

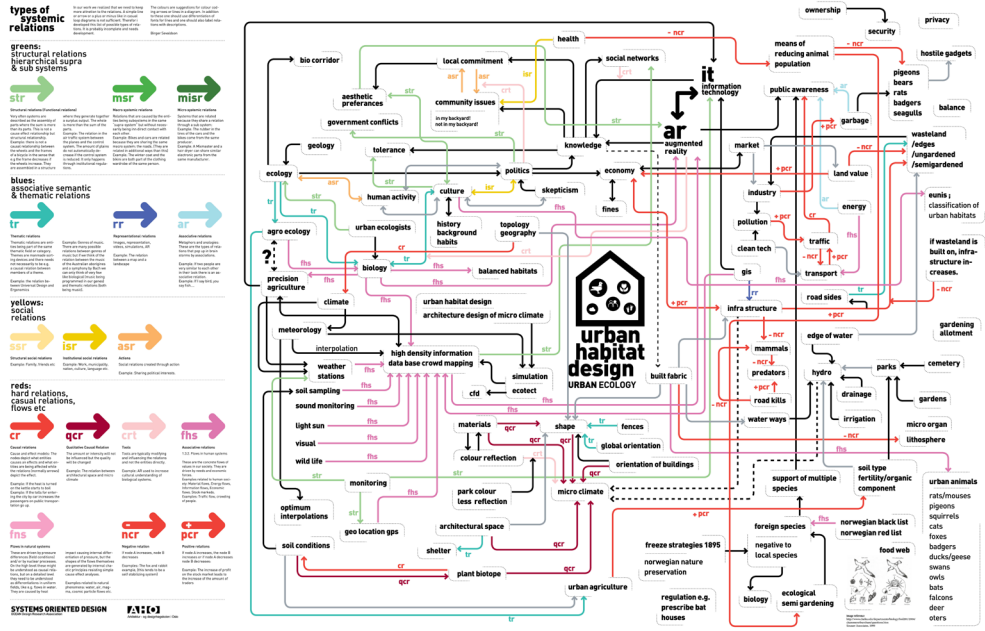


Fig. 6.7

An example of GIGA Map (Systems Oriented Design, n.d.).

Actor Mapping - Stakeholder Map

ABOUT

Actor Mapping is designed to reveal the network of people and organizations within a given system and how they are interrelated. The aim is to gain a deeper understanding of the stakeholder's values, models, incentives and the power dynamics in the system. This is done by splitting the process in two main parts: one that is focused on each actor, and one that analyses their position and relationships in the overall context. With Actor Mapping, it is possible to identify the individuals or organizations that have an influence in determining the pattern and outcomes of the system and who are influenced by it. To be responsible in systems change initiatives, it is crucial to be aware of these actors, their perspectives and interests, since they are interested in shaping events according to their stake.

The process is divided in two parts:

1. Stakeholders Analysis:
   - Identify all the stakeholders;
   - Define stakeholders' personas: understand values, mental models, incentives and power;
   - Define relevance and influence: define the level of engagement with the issue and those who are more influential/important
   - Define the alignment of interest: are the actors opposing or supporting the change proposed?

2. Mapping: Place the stakeholders on the map, scaling them according to their level of importance.

IN THE DC4DM MODEL

The Actor Mapping Canvas is important because it gives an

overall view of the main actors in the field. However, its main objective is already dealt thoroughly in the GIGA Map.

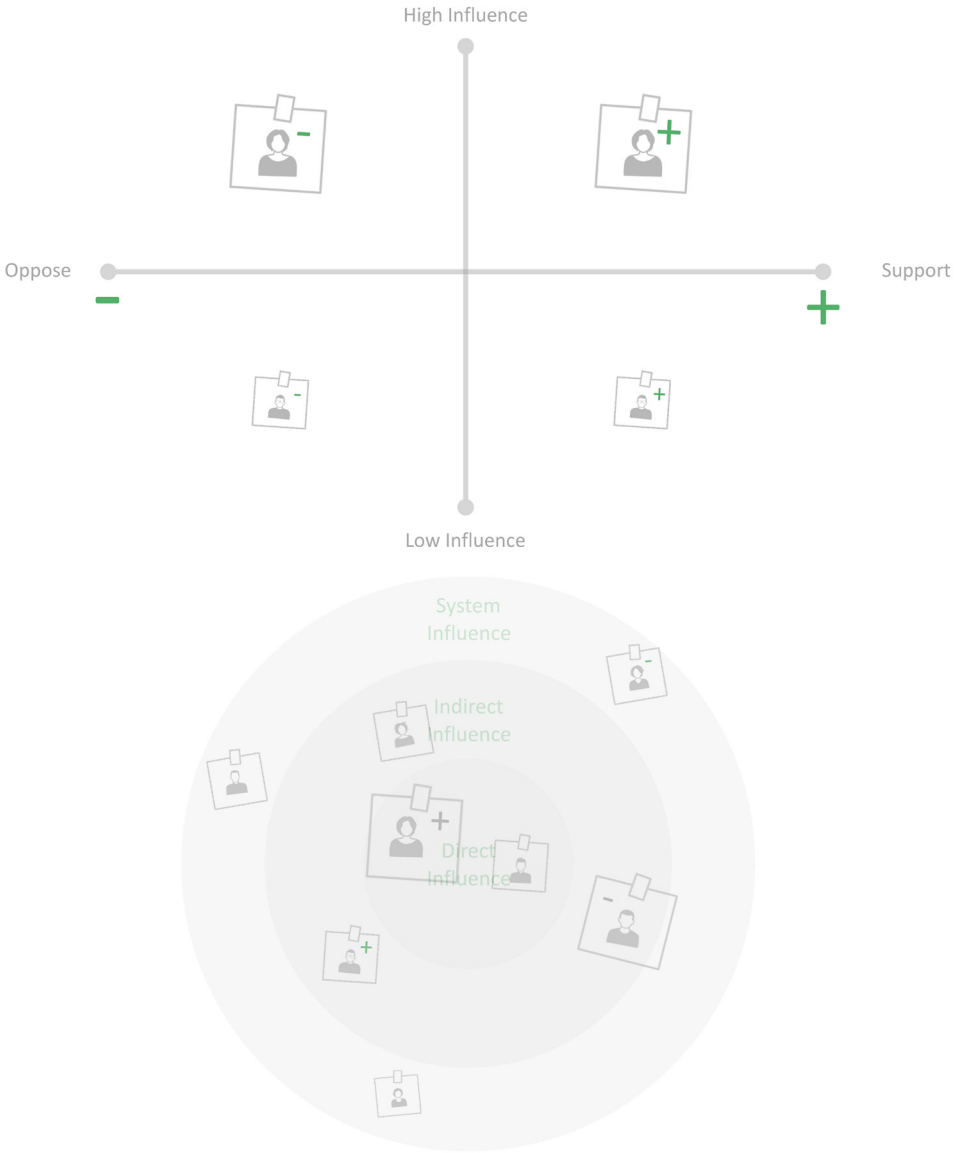


Fig. 6.8
Actor Mapping Canvas (System Innovation Toolkit, 2021).

Dynamics Mapping - Stock and Flow Canvas

ABOUT

The Stock and Flow Canvas is designed to help mapping out all the dynamics that regulate the system. This canvas is specifically focused on the stocks and flows, that, for example, are the stocks and flows of money within a financial system or the material flows within a supply chain.

This canvas is applied to understand how resources (stocks) are flowing through the network, what are the channels, the stocks, the blockages and scarcities or accumulations of stock. The canvas analyses also the regulators of the flow, that are the elements or actors that have power on the flow of stock and can manage it.

IN THE DC4DM MODEL

The Stocks and Flow Canvas highlights the links between the actors and the relationships between them, focusing on the stock management aspect. Due to its importance in the understanding of complex systems, this tool has to be considered in the DC4DM Model. However, also in this case, the objective of it is already covered with the GIGA Map.

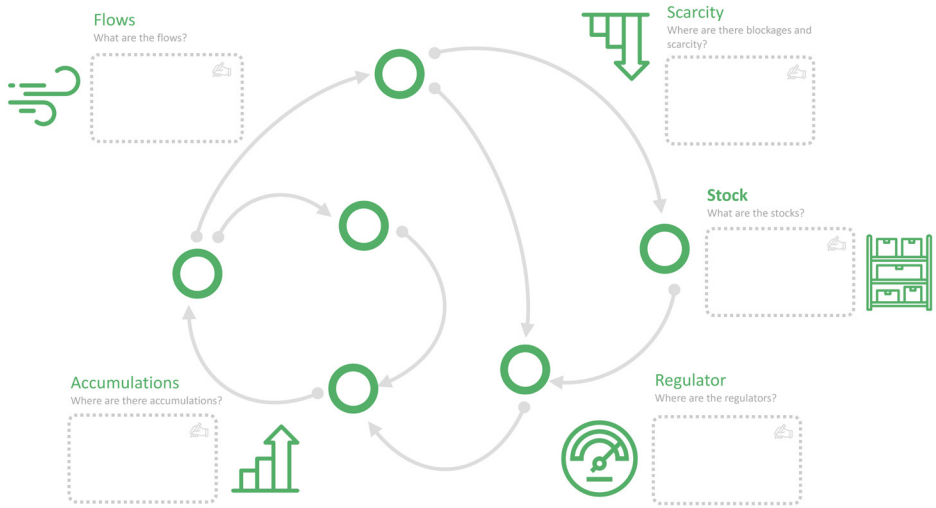


Fig. 6.9
Stock and Flow Canvas (System Innovation Toolkit, 2021).

Network Analysis Canvas

ABOUT

The Network Analysis Canvas is designed to support the analysis and understanding of a social network. The spotlight of this canvas is on six core aspects:

1. Node Centrality: how influential or significant a given node is within the overall network?
Four metrics to address Node Centrality:
- Degree of Connectivity: the measure of the direct number of connections the node has;
- Closeness Centrality: how close the node is to any other node;
- Betweenness Centrality: the node's role as a connector or bridge between other groups of nodes;
- Prestige Metrics: how significant a node is based upon how significant the nodes it is connected to are;
- Centralization: how the connectivity is distributed out among the members? Is the system a centralized network or is it a decentralized network?

2. Network Dynamics: what are the rules under which the network was created? How did this network form? How is it currently developing?

3. Network Diffusion: how would some new phenomenon spread across the network and what would enable the spreading? What would resist it?

4. Network Resilience: how resilient is the network? What will happen to the network's overall connectivity and integration if we remove some components or connections?

IN THE DC4DM MODEL

The Network Analysis Canvas is an important tool to understand the different relationships and the layout of the system. However, also in this case, the main issue addressed by this tool is covered in the GIGA Map too.

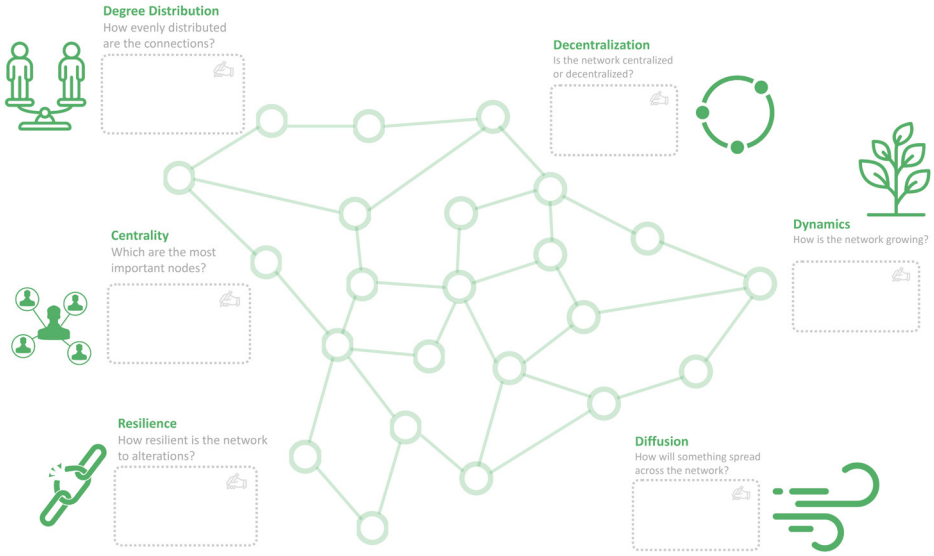


Fig. 6.10
Network Analysis Canvas (System Innovation Toolkit, 2021).

Systems Change Canvas

ABOUT

The Systems Change Canvas is a comprehensive tool that helps to think about the different aspects involved in a systems change process. This canvas integrates the other models selected by Systems Innovations for the “Changing” section. Therefore, it is based on the Multi-level perspective, Two Loops, Horizon Scanning and System Gardening.

This canvas helps in addressing all the different key aspects that need to be tackled in the three levels of systems:

- Macro level: represents the major environmental changes;

- Miso level: represents the existing incumbent configurations in the systems and the transition process they will go through to give rise to the new system;

- Micro level: represents the new innovations.

IN THE DC4DM MODEL

The Systems Change Canvas is an extensive tool that can support in the Process phase of the DC4DM model. However, not all its sections are relevant to the DC4DM methodology: each tool included in this canvas is analysed and addressed in the following pages.

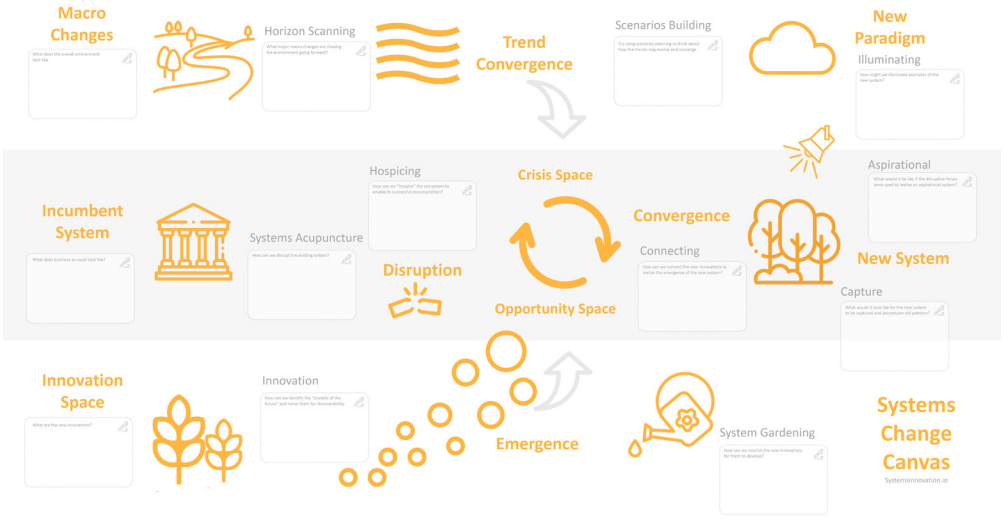


Fig. 6.11
Systems Change Canvas (System Innovation Toolkit, 2021).

Multi-level Canvas

ABOUT

The Multi-level perspective (MLP) Canvas is a framework that support the definition and description of the transition process in complex system, highlighting what happens at each level. This canvas has been designed to help to analyse and to better understand the “long term, multi-dimensional and fundamental transformation processes through which established socio-technical systems shift to more sustainable modes of productions and consumptions”.

The canvas is structured to help thinking about change at three different levels:

- Landscape
The landscape level represents the overall environment within which the system exists.

- Meso level
The meso level is the locus of the “regimes”, which are persistent configurations of markets, infrastructures, technology, policy, … that have settled into stable configurations.
Destabilizations of regime create “windows of opportunity” for niche innovations to break through.

- Micro level
The micro level is the setting of “niche” innovations: new models, communities, or local networks on the micro-level.
Niche innovations build up momentum through support, learning and improved efficiencies over time.

IN THE DC4DM MODEL

The Multi-level Canvas fits in the Process phase of the DC4DM

Model by supporting the understanding of how each level of the system can develop according to different innovations. Due to its generic framework, this canvas can be easily applied in the more specific digital context with little or no modifications.

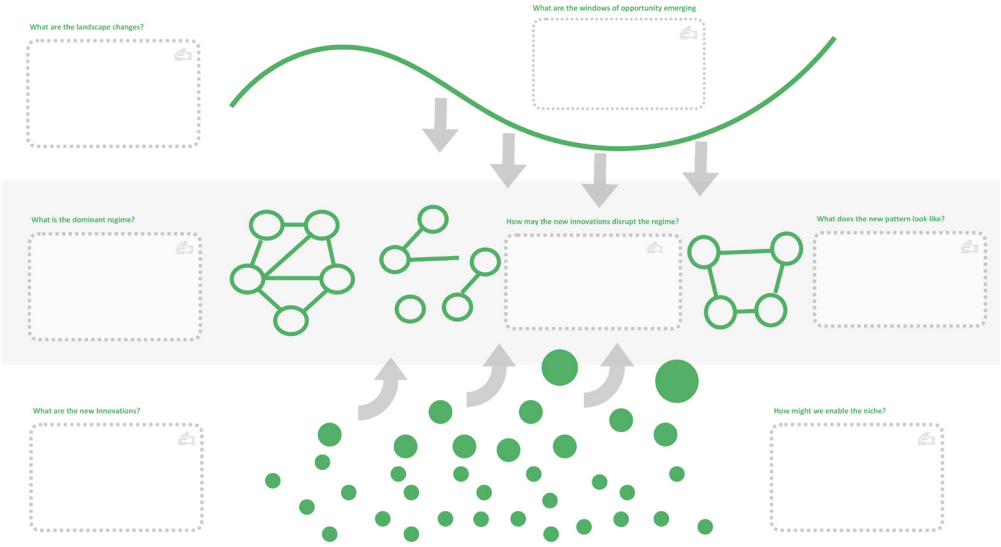


Fig. 6.12
Multi-level Canvas (System Innovation Toolkit, 2021).

Three Horizons Canvas - Horizon Scanning

i ABOUT

The Three Horizon Canvas is aimed at supporting the process of thinking about how transition evolves by looking at the driving forces of innovation, the decline of incumbent systems, and the emergence of new patterns of organization. This canvas is designed to help to think through these three horizons in the context of a systems change initiative.

The canvas is a diagram that keeps track of existing pattern and their evolution over time. They can evolve according to three different perspectives, that will define the three possible horizons:

1. Business as Usual: the dominant system at present;

2. Aspirational: the desired future;

3. Disruptive Innovations: current innovations that are driving change.

By having this clear picture, it is possible to analyse how different trends may play out and interact over time. There are two possibilities:

1. The trends extend into the “Business as Usual” world: the new innovations are applied in the consolidated system and are exploited to make more efficient or faster the existing pattern.

2. The trends extend into the “Aspirational” world: the new innovations help in building the infrastructures for the emergence of new kinds of organizations.

IN THE DC4DM MODEL

The Three Horizons Canvas is a support tool that can be used in the Horizon Scanning step of the Process phase of DC4DM model. This canvas is an extensive tool that allows to identify possible different future scenarios in every context.

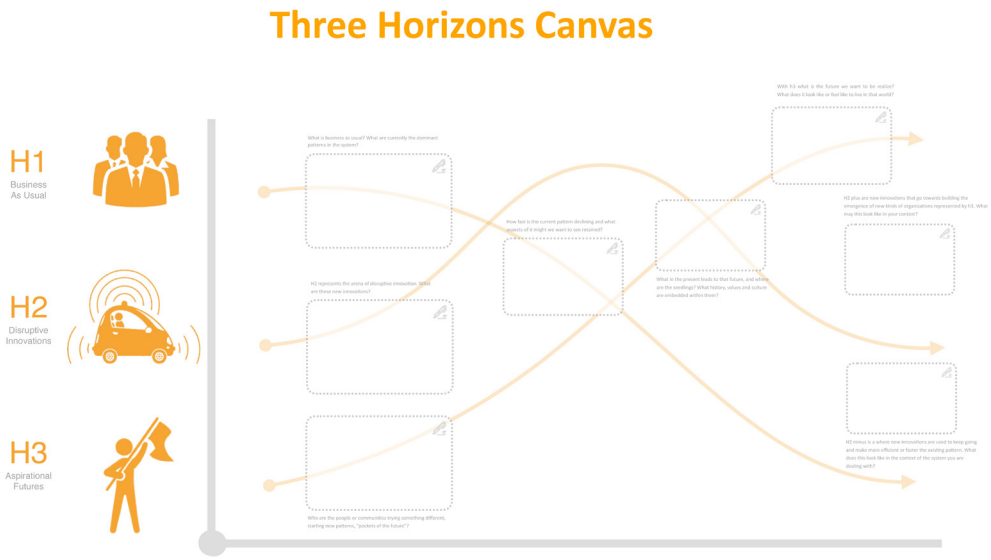


Fig. 6.13
Three Horizons Canvas (System Innovation Toolkit, 2021).

Systems Gardening Canvas

ABOUT

Systems Gardening is an approach that is aimed at influencing the development of a complex adaptive system and realising systems change by working with the context. This can be translated in creating and developing a context that allows for the emergence of beneficial outcomes. This is supported by the use of probing experiments that test where there is the potential for the development of beneficial attractors.

The whole method is structured in four steps:

1. Identity Landscape: identify the context within which the system exists.

2. Pockets of the future: find “pockets of the future”, the beneficial attractors towards which the system should develop. It is also important to identify those patterns that are detrimental to the system’s development.

3. Probing Experiments: experiment by creating probes where there could be the potential for beneficial outcomes. This allows to test the fertile soil and to understand if it is possible to create an attractor. By these tests and probes, new patterns of behaviour are stimulated in the system.

4. Dampen & Amplify: if the results of the probes are working, they have to be amplified if beneficial, while dampened if detrimental.

Once working and beneficial attractors are found, they can be connected into new ecologies and achieve system change.

IN THE DC4DM MODEL

The Systems Gardening Canvas can a functional tool to support the prototyping and testing process in the Generate step of the Process. However, this tool has to be implemented to be more focused on the prototyping part and on the digital context.

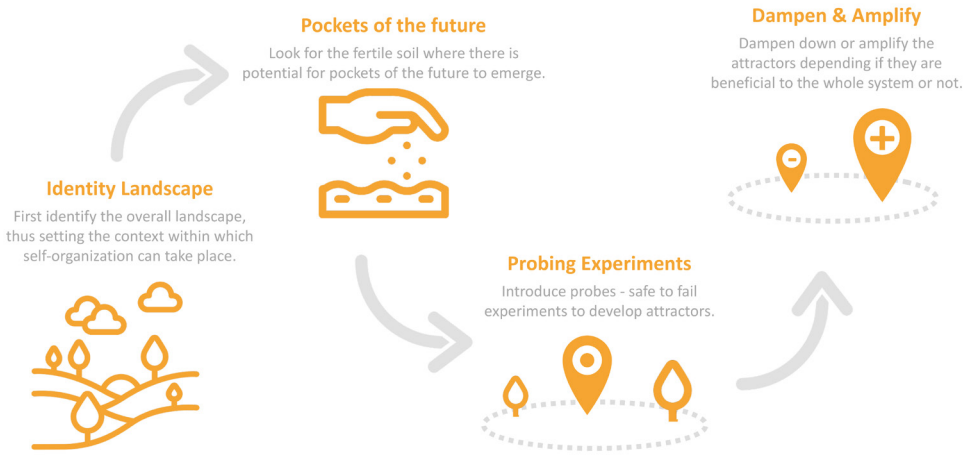


Fig. 6.14
Systems Gardening Canvas (System Innovation Toolkit, 2021).

Two Loops Canvas

ABOUT

The Two Loops Canvas is designed to help to identify and to think about people's position in a system during a transition process and to recognise their interdependence with other actors. This canvas describes two loops: the first one represents the growth and subsequent decline of the existing incumbent system; the second represents the new emerging next generation of the same system.

This approach is divided in two main parts: the first one defines the new emerging system, starting from the old incumbent one; the second part is focused on the roles and positions of each actor of the system.
Three main domains of work can be identified:

1. Stabilizing: stabilizing the old while letting go of what needs to go.

2. Innovators: people creating the new possibilities.

3. Bridging: people building bridges between the two loops and demonstrating that the new alternatives already exist and it is time to move forward an make the transition.

The last step is to understand how to link all the people and the nature of the relationships needed between the actors in order to achieve the transition.

IN THE DC4DM MODEL

The Two Loops Canvas is a framework that is not relevant for the DC4DM Methodology. This is due to the fact that some parts are already dealt in other canvas, or they do not focus on relevant

issues for the model.

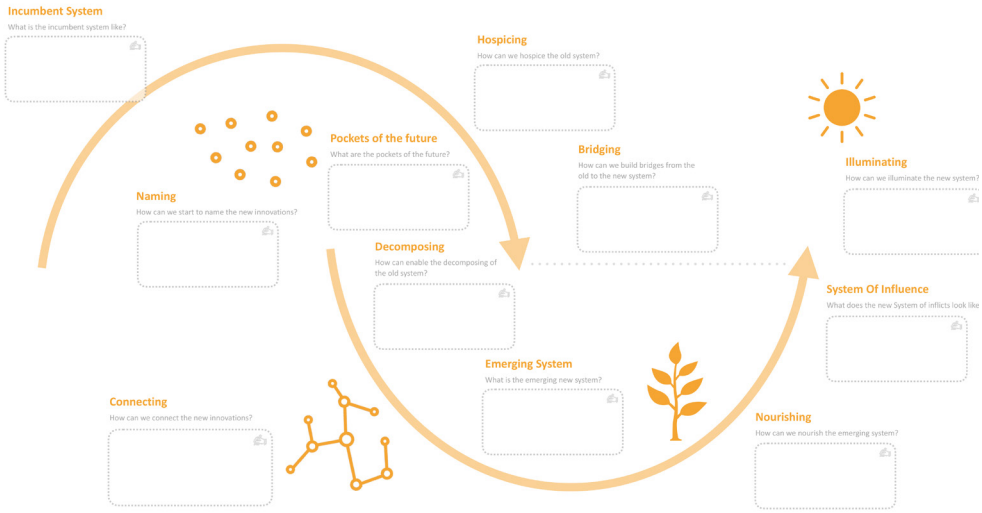


Fig. 6.15
Two Loops Canvas (System Innovation Toolkit, 2021).

Innovation Ecosystems Canvas

ABOUT

An Innovation Ecosystem is a network through which a set of diverse actors interact to enable constant innovation outcomes in a given region or domain. The Innovation Ecosystem Canvas is a comprehensive framework that allows to explore and to analyse all the components of the Innovation Ecosystem.
There are four key elements that are addressed with this canvas:

1. Actors
Who are the actors in the ecosystem? What roles do they play?

2. Exchanges
How does information and resources flow between the actors? How could it be facilitated?

3. Function
What is the overall function that you wish to see emerge? How will we assess for the impact?

4. Dynamics
How will the ecosystem grow, learn and evolve over time?

In addition, there are other elements that are analysed:

- System
What is the system? What is the common infrastructure, the set of resources and services that could enable the community to function better as a whole?

- Roles
What are the different functional roles in the ecosystem?

- Synergies: Positive and Negative

Where can the positive/negative synergies be found in the network?

- Cooperation
How can we turn the negative synergies in to positive synergies to get cooperation in the system?

- Ranking
What is the peer feedback ranking system that will enable productive behaviour to be valued?

- Function
What is the overall function of the ecosystem?

- Impact assessment
How can we assess for the impact of the ecosystem?

- Scaling
What is the feedback scaling engine that will drive the ecosystem development over time?

- Learning
What is the learning engine that will enable the community to learn collectively, develop and share new knowledge?

- Investment
How will we define the portfolio of new initiatives that we want to invest in?

IN THE DC4DM MODEL

The Innovation Ecosystem Canvas is a comprehensive framework that helps to define the system and address which direction it can develop, based on the emergences. Therefore, this canvas is an analytical tool to be applied once the scenario is already defined. For this reason, it is difficult to place this

canvas in the DC4DM Model, since there is not a specific step addressed to this aim. Therefore, the Innovation Ecosystem Canvas may not be considered for this project.

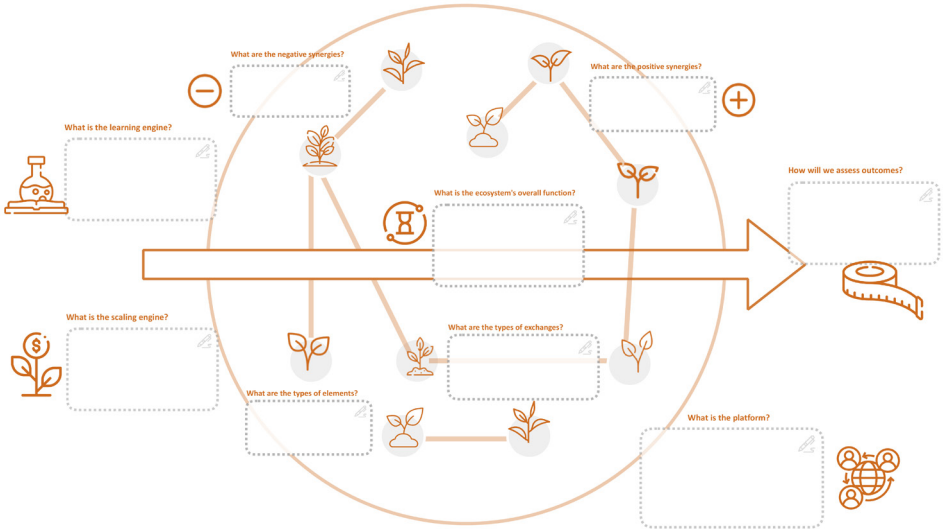


Fig. 6.16
Innovation Ecosystems Canvas (System Innovation Toolkit, 2021).

Identity Creation Canvas

ABOUT

The Identity Creation Canvas is a template to support in the definition of the overall description of the organisation, thus its identity. This framework highlights all the key aspects that are needed to achieve the Identity Creation. These can be summed up into four main questions:

- Why does the organisation exist?
- What does the organisation do?
- How does the organisation do it?
- Who does the organisation do it for?

IN THE DC4DM MODEL

The Identity Creation Canvas is a managerial tool that helps in defining the objectives and the backbone of a company. For this reason, it can be discarded, or, if necessary, some parts can be integrated into other more relevant resources.

Fig. 6.17
Identity Creation Canvas (System Innovation Toolkit, 2021).

6.3.2 Systemic Design Toolkit

Rich Context Canvas

ABOUT

The Rich Context Canvas is a framework that helps in understanding the context, by mapping current practices, trends and innovative initiatives in the system. This canvas is used to generate shared understanding about the current situation and to identify the key actors to interview in the field studies.

This canvas is focused on mapping three main elements:

1. Long term trends: find the trends affecting the issue (i.e., climate change, population growth, …)

2. Current systems: map the established methods, norms, practices, ...
Answer the question: how is society currently dealing with the issue?

3. Emerging niches initiatives: map the alternative ways of doing.
Answer the question: what are the new, innovative ways of dealing with the issue?

IN THE DC4DM MODEL

The Rich Context Canvas helps in analysing the context and the system. This objective is well fulfilled by other resources proposed. For this reason, it is not relevant for the DC4DM Project.

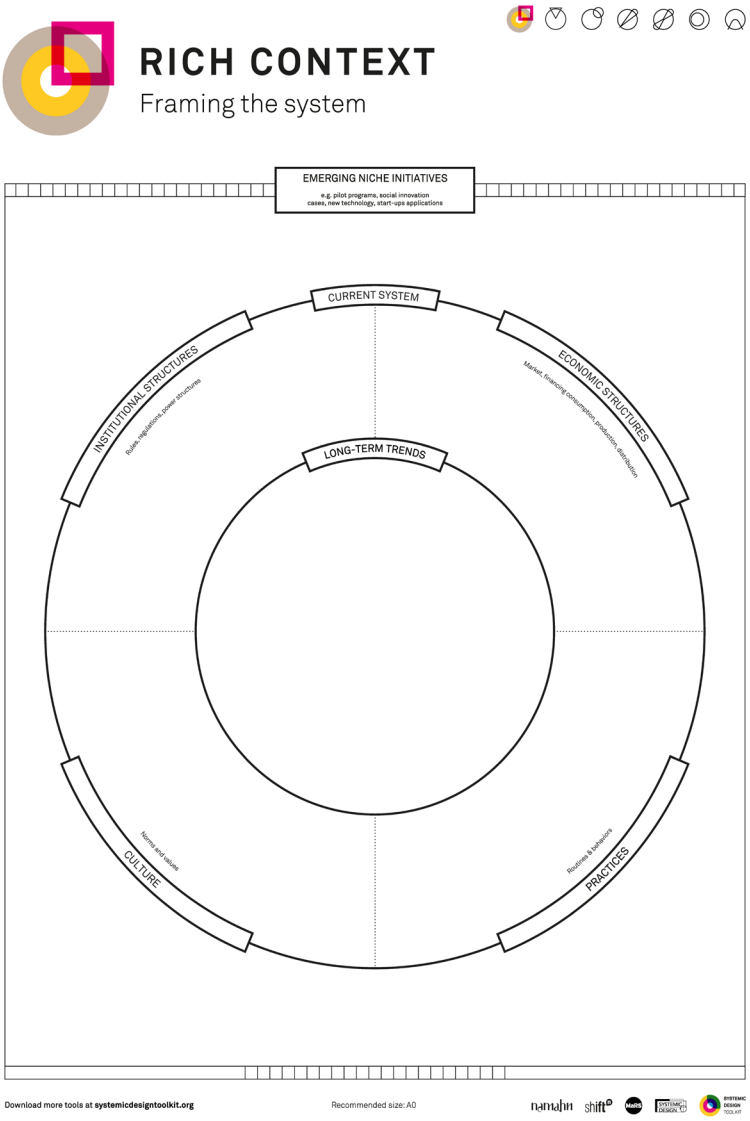


Fig. 6.18
Rich Context Canvas (Systemic Design Toolkit, 2018).

Actants Canvas

ABOUT

The Actants Canvas is a framework that helps in describing archetypical relationships. It is a way to model, summarise and communicate systemic field research. The aim of this tool is to offer a base to better understand and to map the system: it is useful to extract influencing variables from the field studies.

This canvas focuses on the interaction between two actors at a time. The process is structured in four main steps:

1. Focus on a relationship between two roles, analyse their perspective about the issue and sum it in an effective and concise quote.

2. For each actant, draw the archetypical experience over time with a curved line. The analysis of this curve allows to annotate key moments and all the different emotions felt by each actant.

3. Analyse the curves separately and try to define, from the interviews, the qualitative and quantitative factors or variables that influence the changes in the experience.

4. Observe the curves together and focus on the differences. Try to understand what are the reasons for which the experiences are different.

IN THE DC4DM MODEL

The Actants Canvas is a tool that focuses on the relationships of two actors and what it could emerge from it. These key aspects are already analysed by other resources and they are integrated in more complete canvas. For this reason, the Actants Canvas is not relevant for the DC4DM Project.

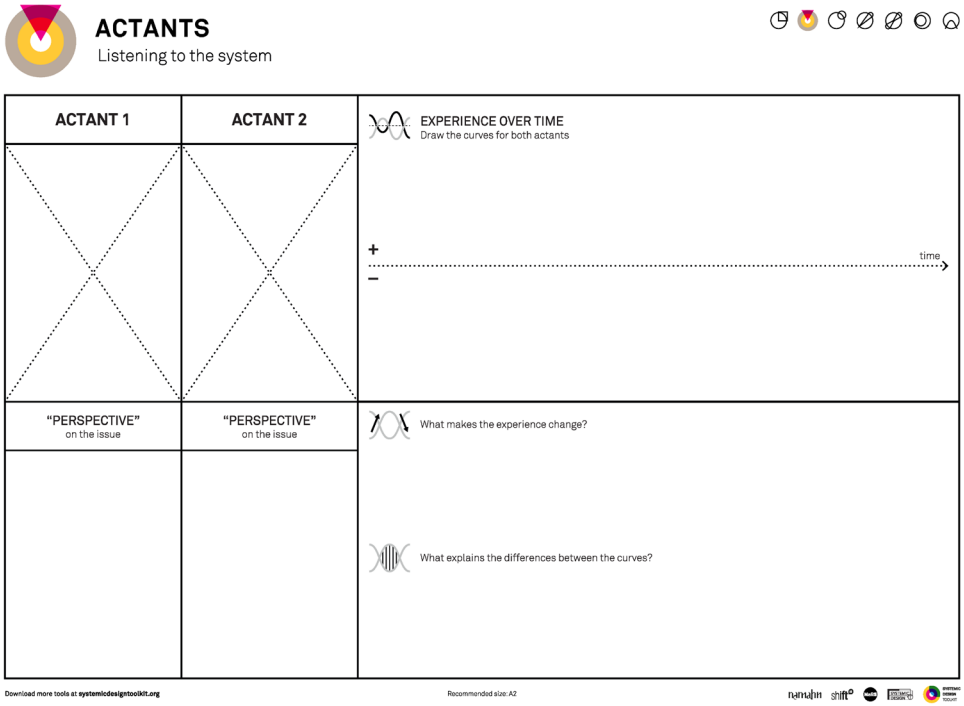


Fig. 6.19
Actants Canvas (Systemic Design Toolkit, 2018).

System Map Canvas

ABOUT

The System Map Canvas is a tool that supports in visualising the system, its structure and the interrelations between its elements. It has two main aims:

1. Develop shared understanding between the stakeholders about the system's complexity and interdependencies;

2. Discover leverage points in the systems.

This canvas is structured in four steps:

1. Ideal relationships: identify the ideal relationship between the actants;

2. Influencers: identify casual loops arising from the interviews and draw around them the "ideal future";

3. Discover leverage points in the systems: connect the variables in the loops to the core exchanges. Follow the logic of growth and balance of the feedback loop diagrams;

4. Look at the connections: which variables are the most influencing for the core relationship? Note them down, as they are the leverage points.

IN THE DC4DM MODEL

The Systems Map Canvas proposed by Systems Design Toolkit is not as comprehensive as the one analysed before. For this reason and because its aim is already fulfilled by other canvas, it can be discarded.

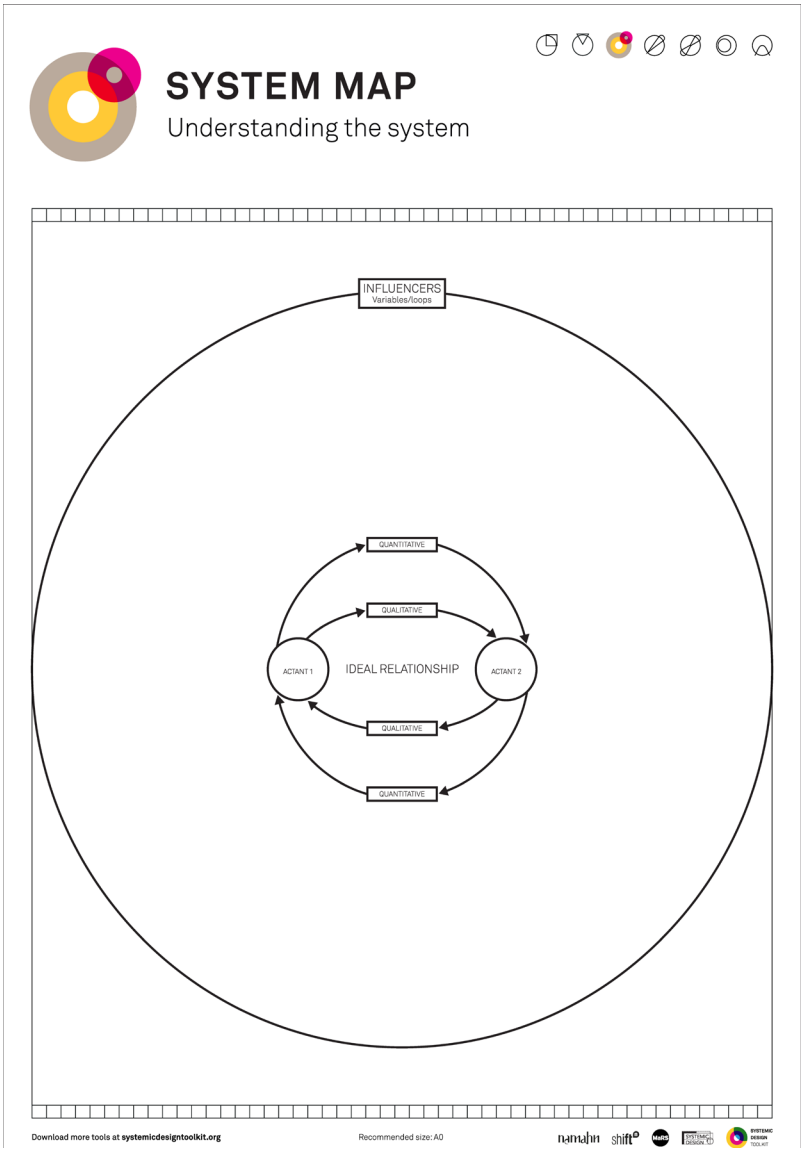


Fig. 6.20
System Map Canvas (Systemic Design Toolkit, 2018).

Value Proposition Canvas

ABOUT

The Value Proposition Canvas is a tool that helps in making the ideal future explicit by listing the benefits that the interventions will bring to the future individuals, organisations and society. The aim of this canvas is to stretch the ambition of the group and align the stakeholders on the intended outcomes.

The methodology defined by this canvas focus the attention on the leverage points that are needed to be tackled. Moreover, one other aspect that highlights is the desired future situation and how it can be achieved by intervening in the system. The canvas proposes some aspects to focus on, such as ecological and economic benefits, social values, …

The canvas is structured on three main levels:

1. Individual level: identify the benefits that will be provided to single individuals;

2. Organisational / Ecosystem level: identify the benefits that the organisation or the ecosystem will get;

3. Societal level: identify the benefits that will be provided on a societal level.

IN THE DC4DM MODEL

The Value Proposition Canvas is a useful tool that helps to align every stakeholder on the direction to take and on the goal to be achieved. Some parts of this canvas can be implemented in other resources to complete and to widen the definition of the innovation proposed. For this reason, it can be placed in the Process phase of the DC4DM Model, more specifically during the Ideation step.

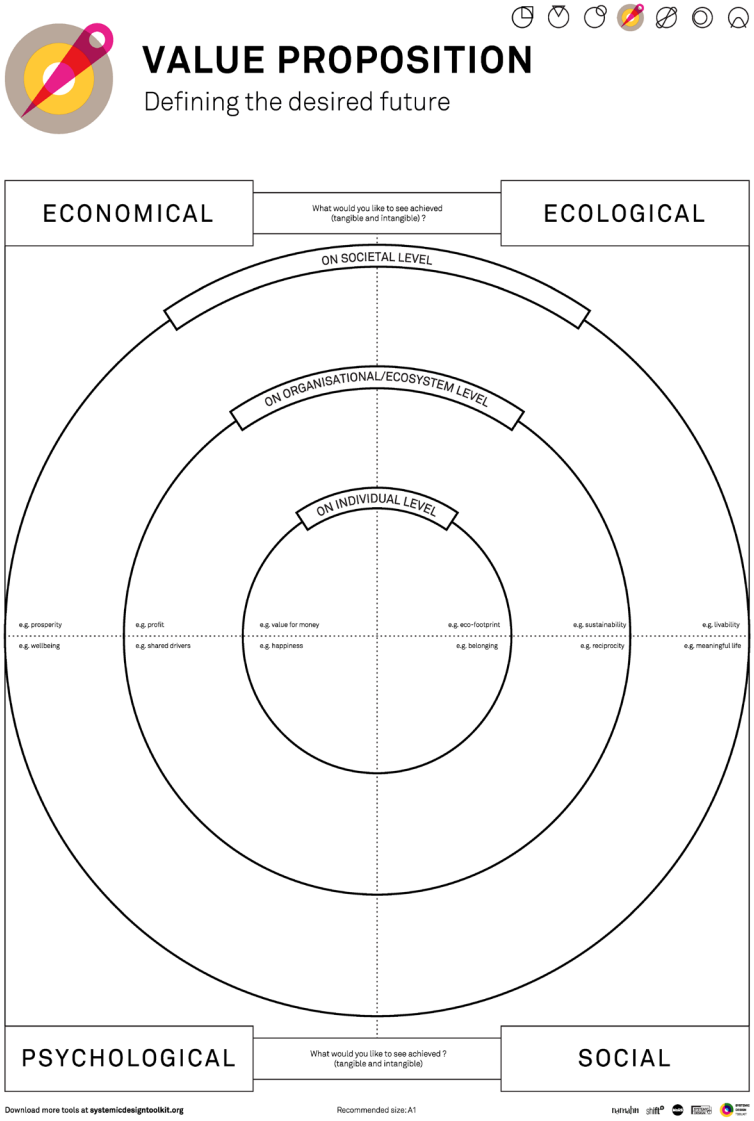


Fig. 6.21
Value Proposition Canvas (Systemic Design Toolkit, 2018).

Intervention Strategy Canvas

ABOUT

The Intervention Strategy Canvas is a brainstorming tool that helps to understand and to explore on which levels and how to intervene in the system. This tool ensures that future combination of interventions will cover the big picture. This is because it explores all the different possible typologies of interventions.

The working method of this tool is based on the leverage points identified in the system map: these represent the challenges that have to be tackled to achieve the desired future.

While using this tool, two questions should be borne in mind:

- On which levels do you need to intervene to tackle your challenges?
- What interventions are needed?

By doing so, all the possible interventions can be identified and marked under a specific level.

IN THE DC4DM MODEL

The Intervention Strategy Canvas supports the definition of the features of the solution and how it fits in the system. For this reason, it can be applied during the Ideating step of the Generate part of the DC4DM Model. However, this canvas has to be modified and implemented to gain a better understanding of it. This can be done by adding some parts of other resources analysed in this work.

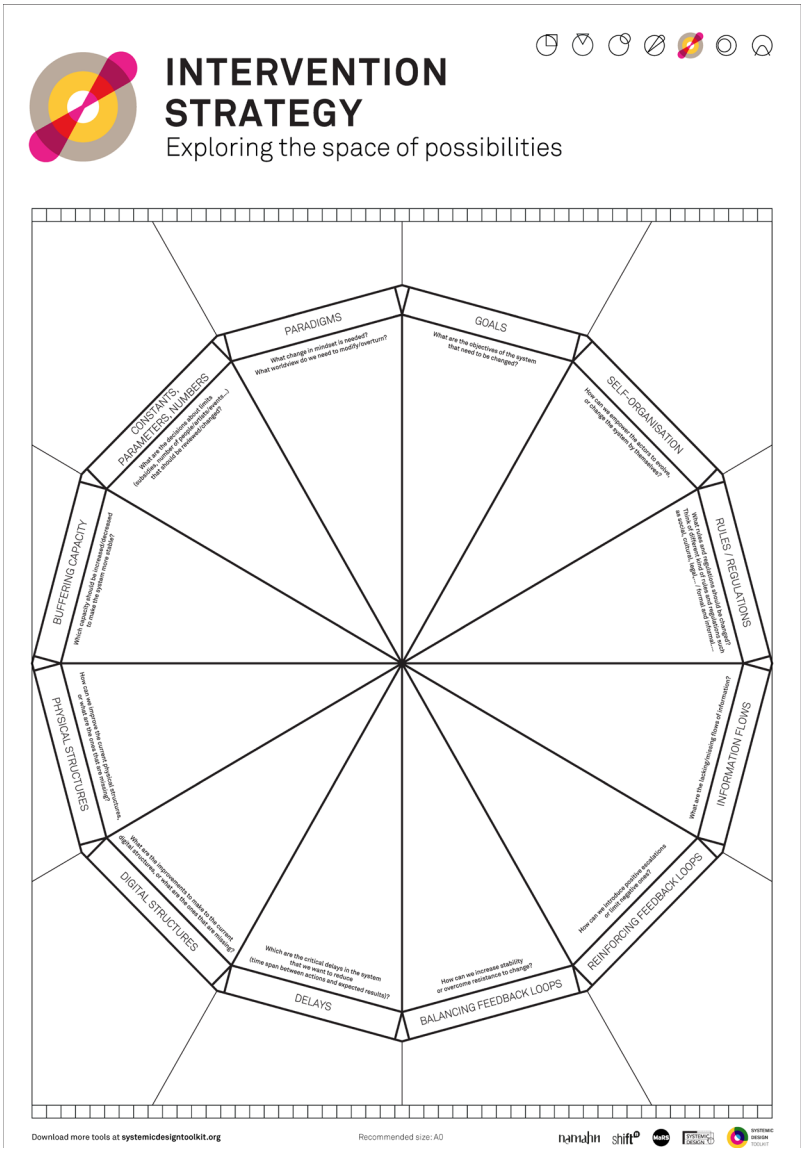


Fig. 6.22
Intervention Strategy Canvas (Systemic Design Toolkit, 2018).

Intervention Model (Connector)

ABOUT

The Intervention Model describes the DNA of change within a system. This model is formed by looking at how different interventions connect and reinforce each other. This allows to envision an effective strategy for change.

The steps to define the Intervention Model are three:

1. Review the ideas included in the Intervention Strategy Canvas: which of those can reinforce or enable each other?

2. Transcribe the ideas on sticky notes.

3. Stick the post-its on the provided props. Use them to connect your ideas. Build your model of interconnected interventions.

IN THE DC4DM MODEL

The Intervention Model and Connector can fit in the definition process of a complex design method. In the DC4DM Model they can be applied during the Ideating phase. However, other resources proposed are aimed at the same issue and manage to achieve the goal by being more comprehensive.

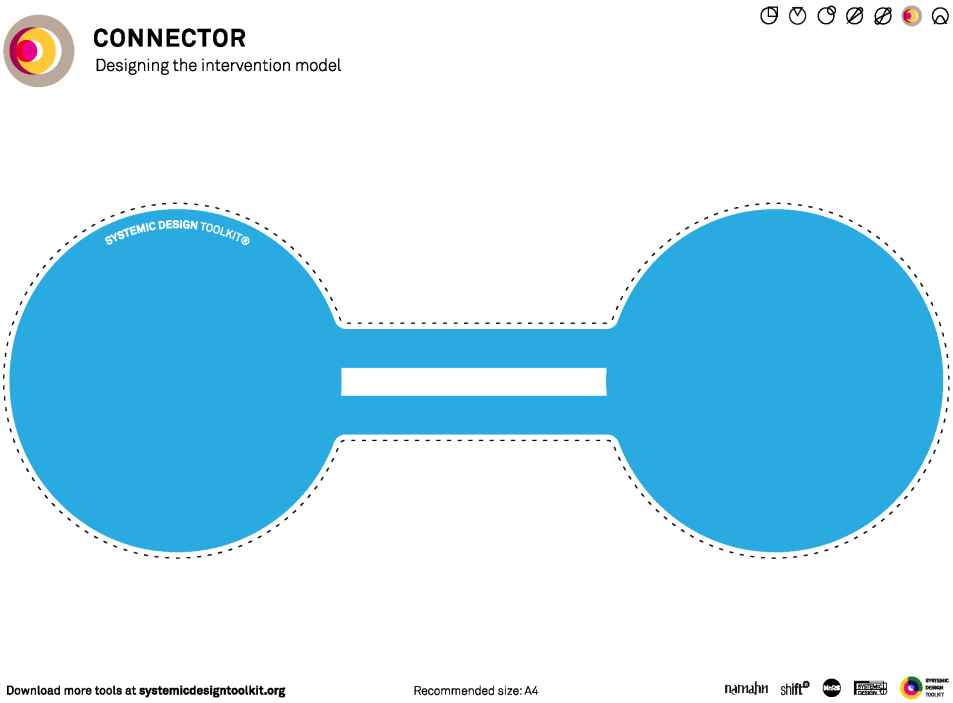


Fig. 6.23
Connector: props used to connect ideas and to define the Intervention Model (Systemic Design Toolkit, 2018).

Roadmap for Transition Canvas

ABOUT

The Roadmap for Transition Canvas is a tool that supports in planning the implementation of the interventions in a way that change occurs by design. The aim of this canvas is to map the transition towards the desired goal by planning and growing the Intervention Model in time and space.

The Roadmap for Transition Canvas is structured on three circles:

1. First circle: what is the minimal version of the intervention model that you can implement in a first stage? Describe the minimal version of the activities you plan to implement, along with the actors involved.

2. Second circle: once the first activities are accomplished, how can you connect them to likeminded people/organisations? Identify such actors and the activities you need in order to create learning networks.

3. Third circle: how can you make sure your interventions become an established practice in the current system and reach the large public?

IN THE DC4DM MODEL

The Roadmap for Transition Canvas is an interesting tool for the implementation phase of the design process. However, it is not as comprehensive as other tools analysed in the previous steps, and so it may not be considered for this project.

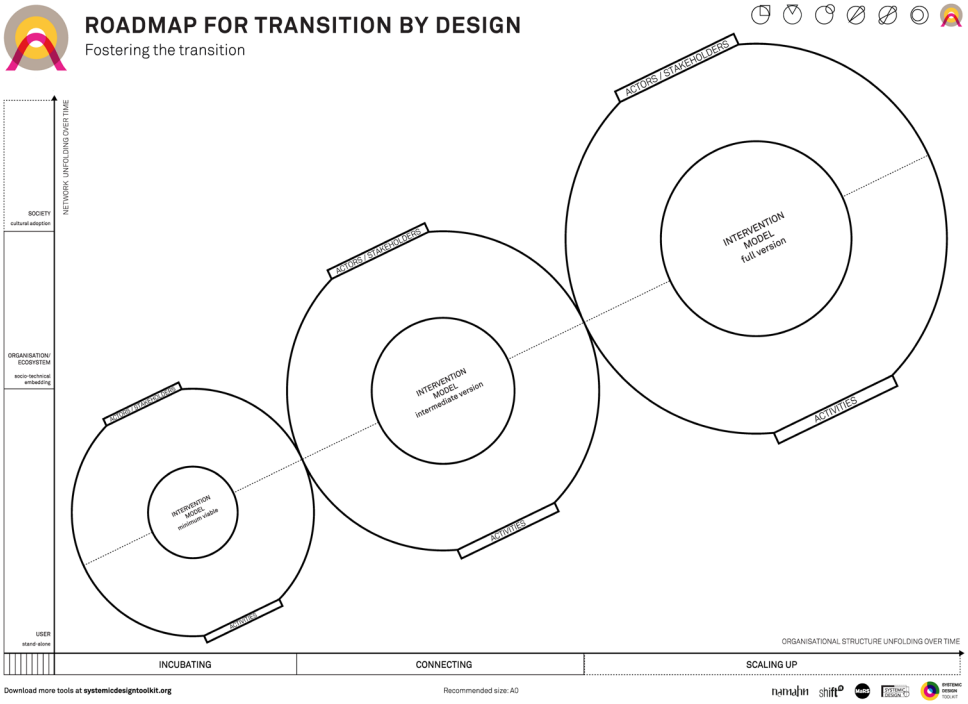


Fig. 6.24
Roadmap for Transition Canvas (Systemic Design Toolkit, 2018).

6.3.3 Partners' resources

Pitch

ABOUT

Pitch is a method that is intended to present new business models or ideas. Throughout all the resources provided by the partners, many different declinations of this approach were found.

Pitch cooking system - *by Politecnico di Milano*

ABOUT

The Pitch cooking system provides a set of ingredients to be applied while presenting the business idea in a pitch. It uses the metaphor of the "cake creation", listing the different ingredients needed for the recipe. It contains sections to display in order to communicate all the fundamental aspects of the idea. The main purpose of this tool is to help in the presentation of Human Centred Design projects, by drafting a list of priorities to be necessarily discussed.

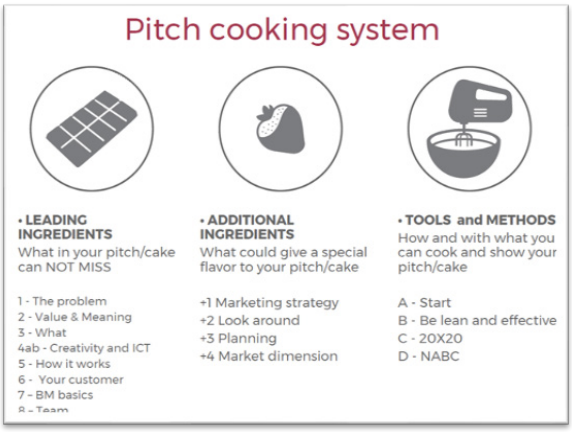


Fig. 6.25
Pitch cooking system (CILAB, 2016).

One view presentations - *by Institut Mines -Télécom*

ABOUT

Each participant presents their own point of view about a specific topic, bringing something they have previously desk researched.

The One view presentations approach has two main rules:

1. Each participant has 1 slide x 1 minute;

2. Participants present their slides in random order; each one stands up and talks when they see their slide on the screen.

The purpose of this activity is to have self-introductions of each participant and to understand their matter of interest.

Starter pitching and starter killing - *by Institut Mines -Télécom*

ABOUT

Each team has 10 minutes to present two project concepts they have previously drafted. Everyone in the room gets to vote for their preferred idea, between the two proposals of each team. The concept that gets the most votes becomes the idea that the team will use as a starting point to develop the project. Every person in the room can also put a post-it up containing ideas to improve the concept. The purpose of this activity is to get participants used to sell every idea they develop to the public.

Solution pitching - *by Institut Mines -Télécom*

ABOUT

This approach is the most common one: teams carry out final presentations of their solutions, as real-life idea pitching. Also in this case, the purpose of the activity is to convince the audience of the potential of the presented solution.

IN THE DC4DM MODEL

Pitch is a method that, if mastered, can support and help in achieving an effective communication with other people and the capacity of translating ideas and knowledge. For these reasons it is important to teach and to learn this resource in the Pre-Process phase of the DC4DM Model. Throughout the different methods analysed previously, two are considered more relevant: Pitch cooking system, because it helps in the organisation of the resources and of the thoughts, and Solution pitching, because it is the basic method.

Brief Generation Canvas - *by Politecnico di Milano*

ABOUT

The Brief Generation Canvas is a tool that allows companies to consolidate a brief. Once this activity has been carried out within the company, this tool is used to engage people that will solve the challenge. Practically speaking, the model describes clearly the different parts to address in order to solve the challenge and the types of output required from the company.

The Brief Generation Canvas is divided in seven main parts:

1. Why: What is the main purpose of the intervention?

2. What: What is the opportunity or leverage point around which the intervention is built?

3. Who: Who is the new solution intended for?

4. When: When is the new solution launched in the market?

5. Where: What is the market destination of the solution? Where is it available to buy or use?

6. How: What are the main actions to be taken to achieve the new solution?

7. How might we: What is the brief?

IN THE DC4DM MODEL

The Brief Generation Canvas supports the design phase of Ideating of the DC4DM Model. It can be integrated in some parts with other resources to become more comprehensive and to be more specific regarding the topic of digital.

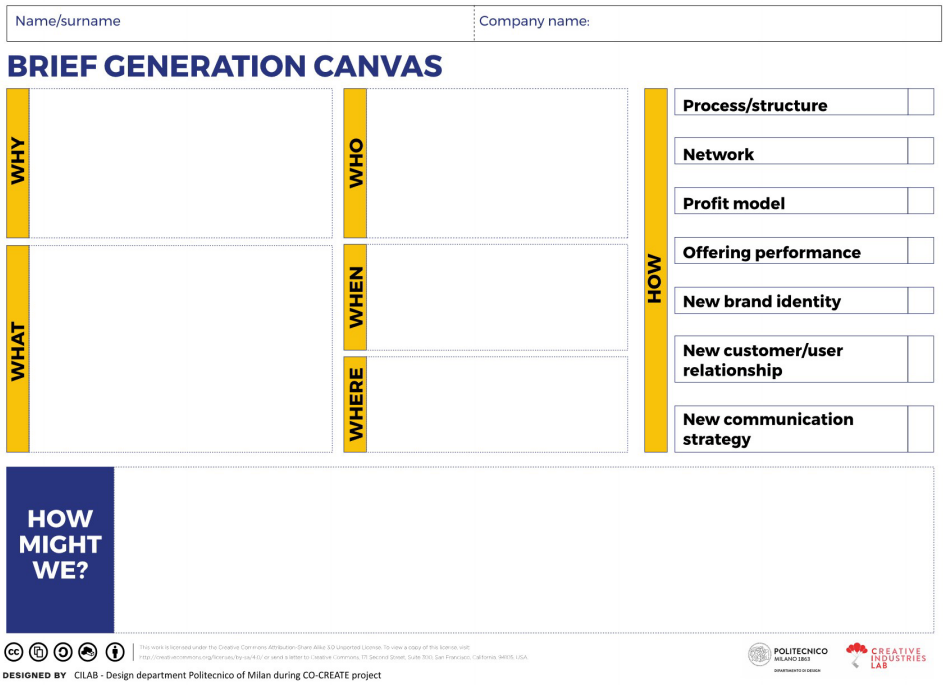


Fig. 6.26
Brief Generation Canvas (CILAB, 2018).

Pizza slices - *by Institut Mines -Télécom*

ABOUT

Pizza slices is a tool that is intended to provide the teams with a framework for developing their final projects. Teams are asked to consider and focus on the following areas:

- User: who is the idea aimed at, who will use it;

- Context: trends and insights arising from the observation of the challenge topic;

- Scenario: the storytelling that explains how the idea works;

- Technology: show the feasibility of the solution proposed;

- Business model: a list of the stakeholders, investors and actors involved in the project.

IN THE DC4DM MODEL

The Pizza slices is a tool that supports the designer during the Ideating step of the Process part of DC4DM Model. However, it covers areas that are already addressed by other resources with more detail. For this reason it can be not considered for the project.

Idea clustering - *by Institut Mines -Télécom*

ABOUT

The objective of this method is to analyse and gather in a more precise way all the ideas generated in the brainstorming phase. All the ideas are divided in different groups, each of which is characterised by a topic and can be broader or more focused.

IN THE DC4DM MODEL

The Idea clustering is a method that can support the student in the Analytical and Critical Thinking DCA, and so it can be applied during the Pre-Process. However, this tool has some similarities with other resources already analysed and considered for this project. For this reason, this method is not taken into consideration for the development of this work.

Unpack Creativity Canvas - *by Politecnico di Milano*

ABOUT

The Unpack Creativity Canvas is a business model for knowledge and idea management. This model is strictly connected to some section of the Business Model Canvas, to also facilitate the consolidation of the idea. The purpose of this tool is to allow a clear identification of the needs to answer, the context in which operate and facilitate the elaboration of different alternatives. Finally, it supports in developing a clear explanation of the different factors to be considered to implement the concept.

The Unpack Creativity Canvas is divided in two sections: Design thinking and Design making, each of which is divided in turn.

The Design thinking section is composed of:

- Scenario: describe the context of the problem or need;

- Problem need: describe the problem or need the solution is aimed at solving;

- Value and meaning: synthesize the value and meaning the idea has to respect.

The Design making section is composed of:

- Possible and disruptive solutions: think about the possible and disruptive solutions that can fit with the value and meaning;

- Best solution set: identify the best idea or cluster of ideas with common features and identify the product service system elements (product, service and communication);

- Involve the target: express how the users, customers and clients will be involved in the implementation phases;

- I have: identify the resources already possessed to implement the product service system;

- I need to develop: identify the resources to be found, bought or negotiated to implement the product service system.

IN THE DC4DM MODEL

The Unpack Creativity Canvas is a helpful resource that covers two steps of the Process phase of the DC4DM Model: Scenario Building and Ideating. This resource is very general and can fit in the digital domain. However, some parts could be modified and implemented to cover better and more specifically the issue of the digital world.

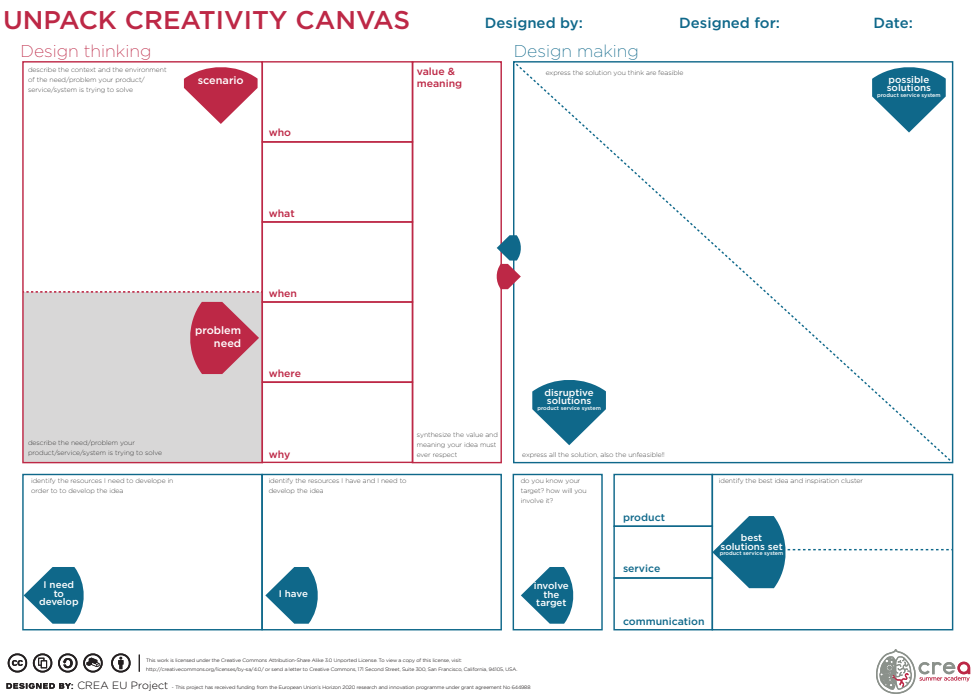


Fig. 6.27
Unpack Creativity Canvas (CREA EU Project, 2016).

6.4 Overview of the resources selected and their application in the DC4DM Model

The following table lists all the resources selected from the pool proposed by the various authors. Moreover, the resources are divided them based on when they can be applied during the DC4DM Model.

PRE-PROCESS		- Systems Thinking Canvas - Pitch
PROCESS	**Horizon scanning**	- Iceberg Model Canvas - Multi-level Canvas - Horizon Scanning
	Scenario building	- GIGA Map - Unpack Creativity Canvas
	Ideating	- Intervention Strategy - Brief Generation Canvas - Value Proposition Canvas - Unpack Creativity Canvas
	Prototyping	- Systems Gardening Canvas
PRE-PROCESS		*None*

Table 6.2

Resources selected and divided based on their application moment.

Taking this as a starting point, it is necessary to understand if it is possible to join some resources to achieve a more complete tool and how to do so. This step is necessary to reduce the number of resources to use in case of necessity during the development of the project, since the tools regarding the Complexity Driver will join the others found for each Driver.

7 LIMITS AND SHORTCOMINGS OF THE TOOLS ANALYSED: A NEW DESIGN OPPORTUNITY

The analysis conducted on the tools and methods for coping with complexity leads to several conclusions.

Firstly, it can be noted that the quantity of elements proposed is excessively dispersed. This may cause further confusion and thus not support the intended objective. For this reason, it is important not to develop different tools. Instead, it would be appropriate to design less tools that can embrace different aspects.

A second aspect to be considered is the fact that many of the tools and strategies analysed are more aimed at a managerial field, rather than an educational one.

A final conclusion that can be drawn from the analysis is that none of the tools start from the analysis of the definition of complexity. This implies that the tools are not focused on the three main properties that characterise complex systems. This makes the tools dispersive and not focused on the main topic to be analysed: complexity.

THE PROJECT

8 DESIGN CHALLENGE

Starting from the assessments from the previous chapter, it is possible to identify the main objective towards which this work is directed.

The project is aimed at developing as few resources as possible, but as much comprehensive and wide as possible. The resource proposed has to start from the definition of complexity, in order to be focused on its properties, and targeted to the educational context.

Following these guidelines, the resulting resource will be focused on the designated task of managing complexity of systems. This will be achieved by teaching specific skills to learners and shaping their mindsets, while supporting them in the design in the digital domain.

9 A GUIDE FOR THE ANALYSIS OF COMPLEX SYSTEMS

9.1 How to manage complex systems: the purpose

The project is based on the analysis of the definition of complexity, according to which this property is characterised by the three features: multiplicity, diversity and interdependence. Starting from this point, the issue was posed on how to teach the skills needed to manage complexity and support the design process in complex ecosystems. To this end, a method for analysing ecosystems and a guide to support the learner were developed. These resources were designed to be exploited at two precise moments in the DC4DM Process: Pre-Process and Process.

During the Pre-Processing phase, the resource proposed aims to teach new skills and competences needed to navigate complex ecosystems of all kinds. This is accomplished by applying the methodology provided on existing case studies. By analysing and dealing with case studies by using the resource, the learner will be able to apply it later in a real project case.

Indeed, this new application will take place in the Process phase, when the team is faced with the design of new products or services and finds itself working in a complex ecosystem. Therefore, this resource has been designed both as a support guide and as a framework to be applied in different cases. These are intended to guide project teams in harsh and challenging systems, supporting them to consider all possible contingencies.

The next paragraphs show in more detail the two main features that constitute the resource designed. The first chapter deals with the method and analyses its structure and its objectives, providing also a case study. The second chapter is aimed at presenting the guide designed to support the learner in both its versions: a printable brochure and a video.

9.2 The method

9.2.1 The structure

The method is structured in three main steps:

1. the first step aims to identify and analyse all the elements of the system;

2. the second aims at analysing the relationships between the elements of the system;

3. the third is aimed at making ethical and sustainable considerations about the project.

The next section explains in more detail the objectives and supporting materials used for each step.

First step

The first step focuses on the analysis of two properties of complexity: diversity and multiplicity. To address these properties, it is necessary to identify all the elements that compose the system taken into consideration.

To support this analysis, a set of cards have been developed. These have been divided into five different categories that group together the various elements that can characterise a possible ecosystem. Moreover, some questions have also been elaborated for each category to support the identification of each element. These were selected from the tools analysed during the initial research phase and were also developed during the case study analysis.

The five identified categories and the related cards are listed in the following pages.

Touchpoint

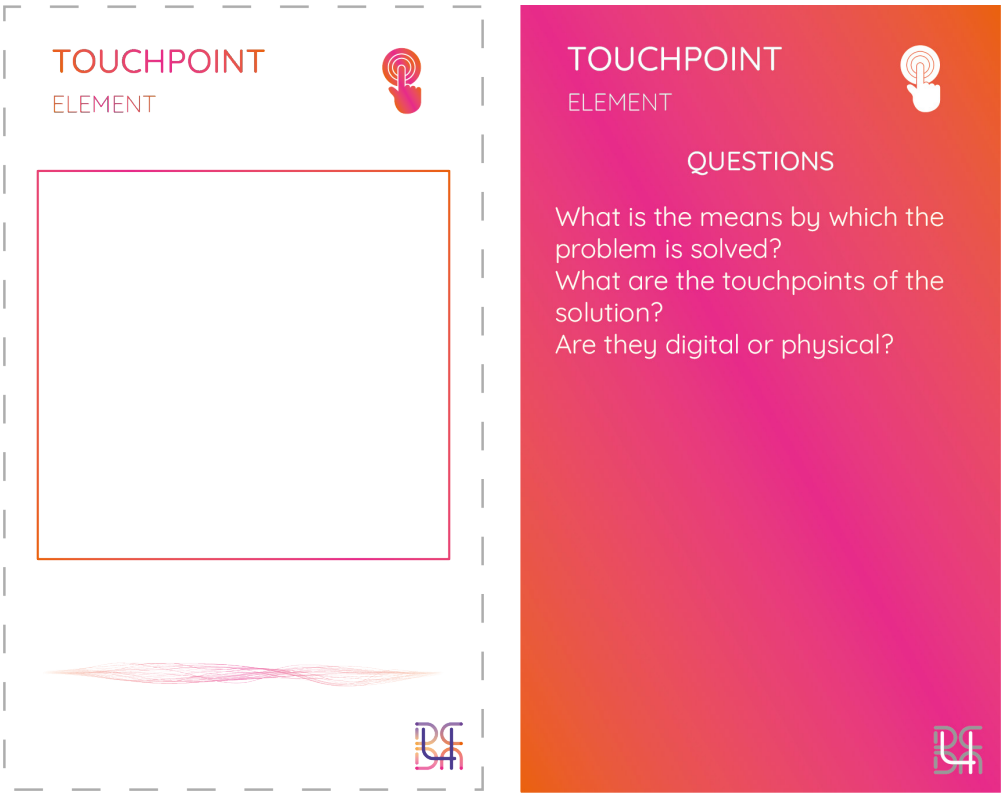


Fig. 9.1
Touchpoint card, front and back.

Stakeholder

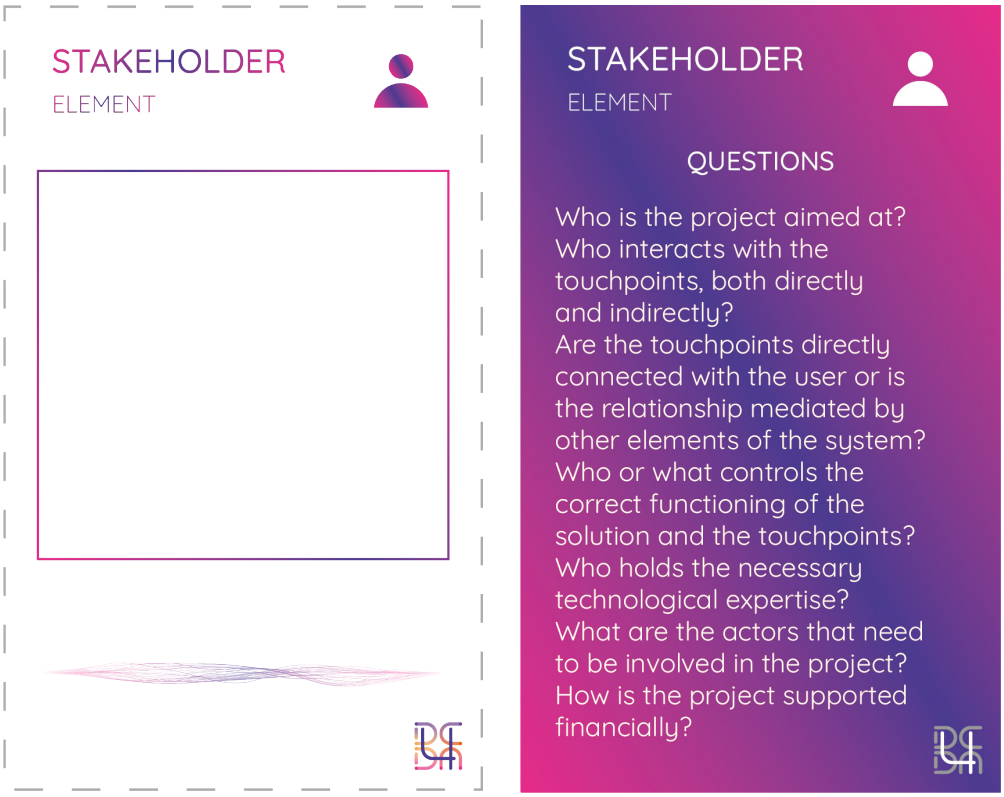


Fig. 9.2
Stakeholder card, front and back.

Resource

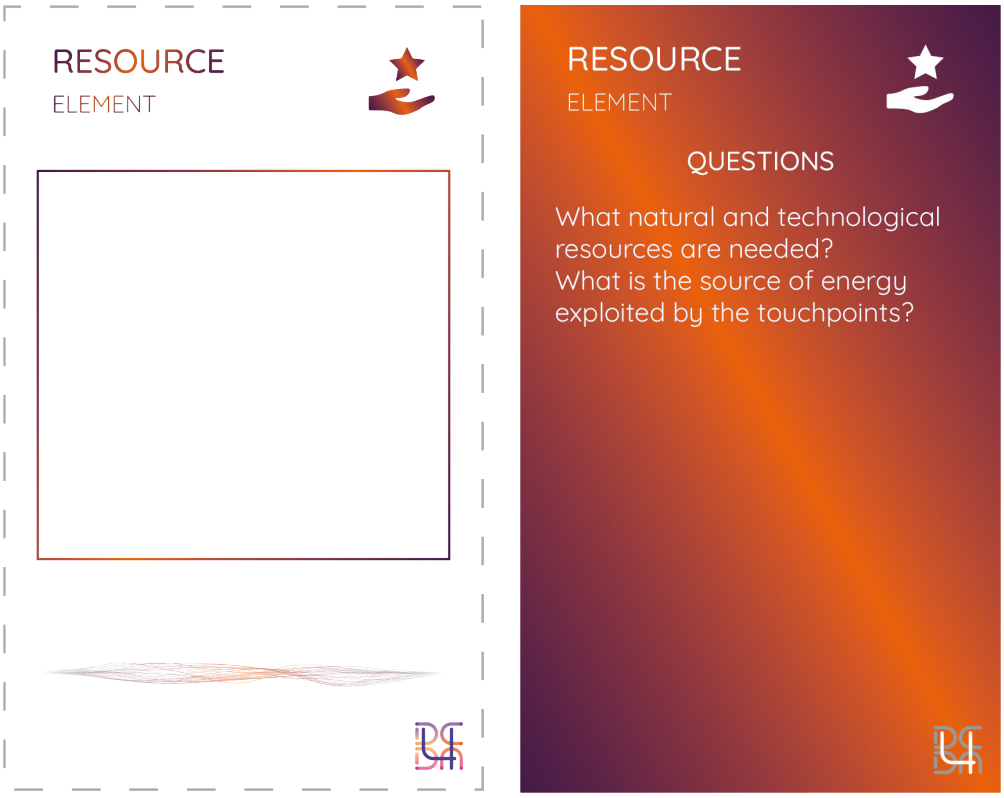


Fig. 9.3
Resource card, front and back.

Context

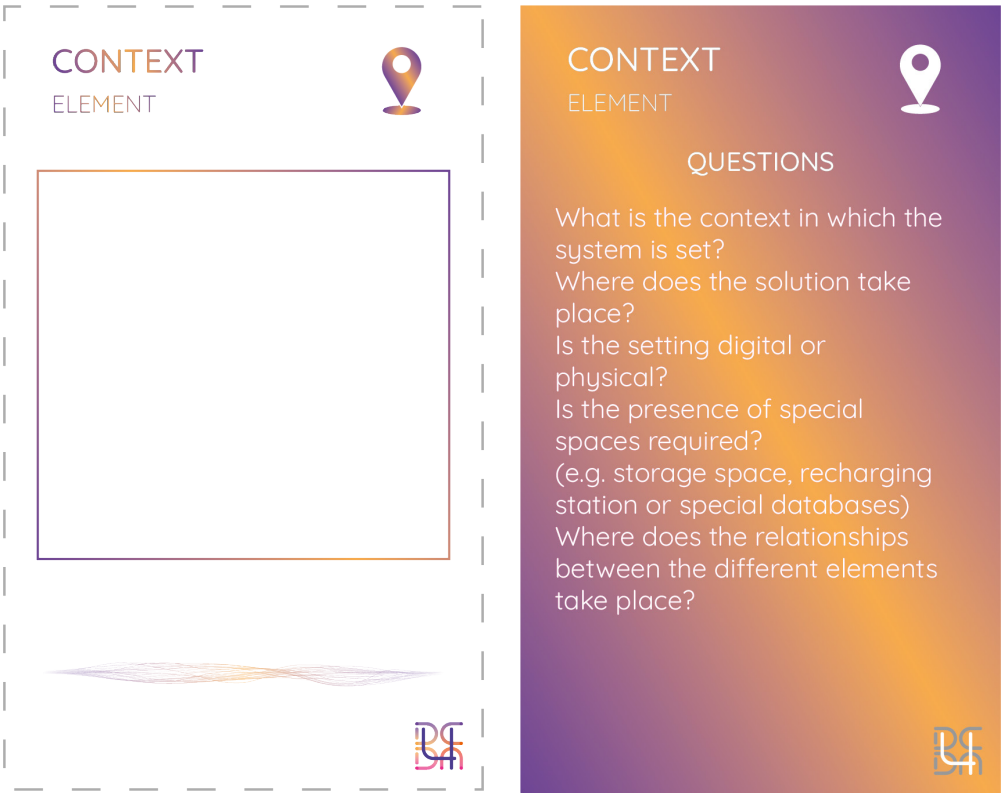


Fig. 9.4
Context card, front and back.

Fig. 9.5
Technology card, front and back.

Second step

The second step was developed to analyse the last property of complexity not analysed in the first step: interdependence. As pointed out by Manson, this step is of critical importance as a complex system is best defined by the relationships between the elements, rather than the definition of its elements (Manson, 2001). In this respect, it was decided to focus on the relationships established between the various elements that compose the system. In order to facilitate this analysis and the identification of the different types of connections, it was decided to visually connect the cards through different coloured arrows.

In addition, a further step has been added to highlight and to analyse the emotions arising from relationships. On top of this, it was considered appropriate also to identify all the critical or fragile relationships, which are the ones to be kept under greater control during the development of the project. In order to facilitate their identification, also in this case, a set of cards and questions were developed to support the learner. The following images show the “Emotions” and “Critical or Fragile relationships” cards with the related questions.

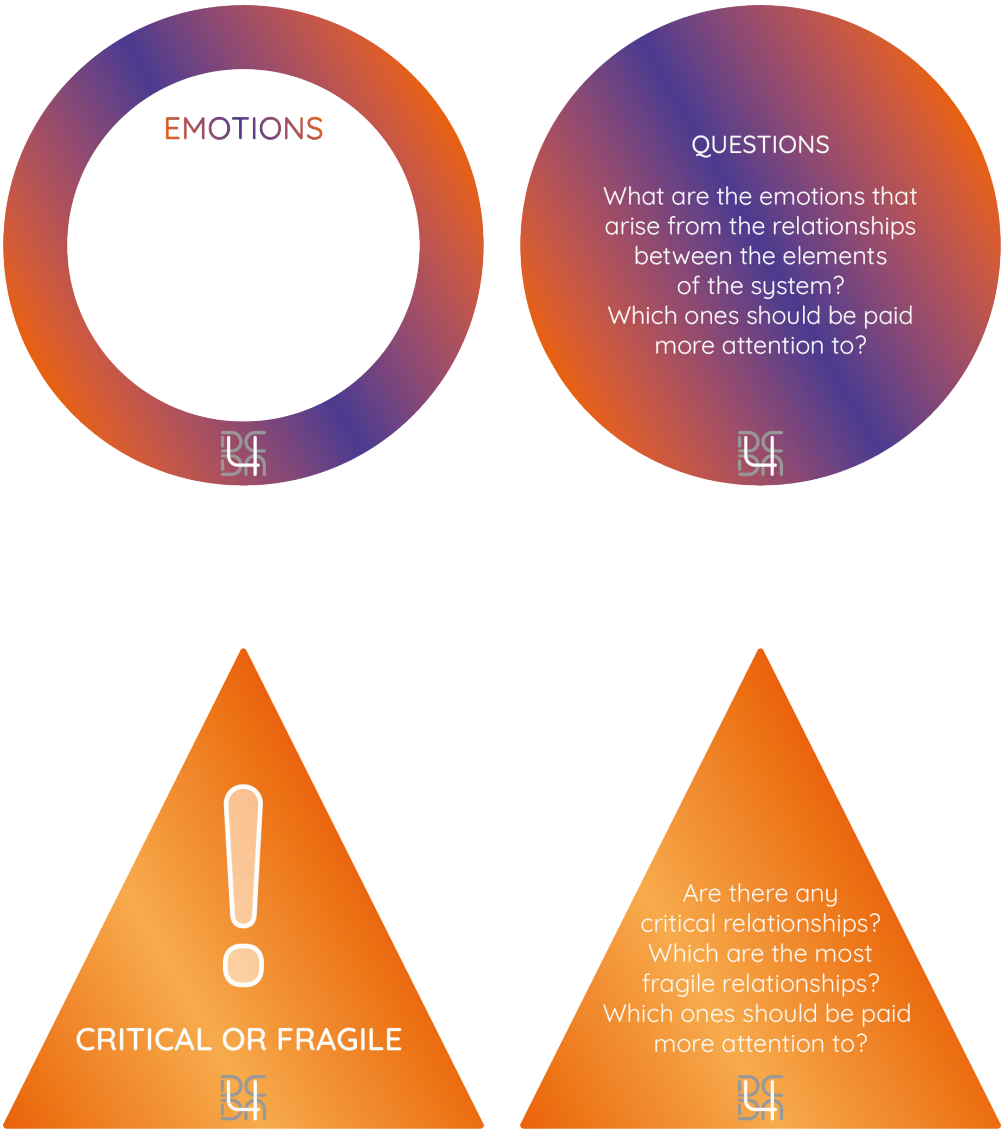


Fig. 9.6
Emotions and Critical or Fragile relationships cards, front and back.

Third step

The third and last step was added later as it includes two aspects that are unrelated to the definition of complexity. In fact, this step focuses on the ethical and sustainable aspects of the project. However, they are central and of great influence in any complex system and in the DC4DM Project itself. For this reason, some additional considerations to be made in these two contexts have been introduced. These are aimed at anticipating latent issues in the project, which may arise once consolidated and applied in the target system. As for the previous steps, supporting cards were developed for the learner, together with questions to facilitate reflections and debates. The sustainable questions were developed from the analysis of tools such as the Business Model Canvas developed by the Ellen MacArthur Foundation and IDEO (Ellen MacArthur Foundation, 2016).

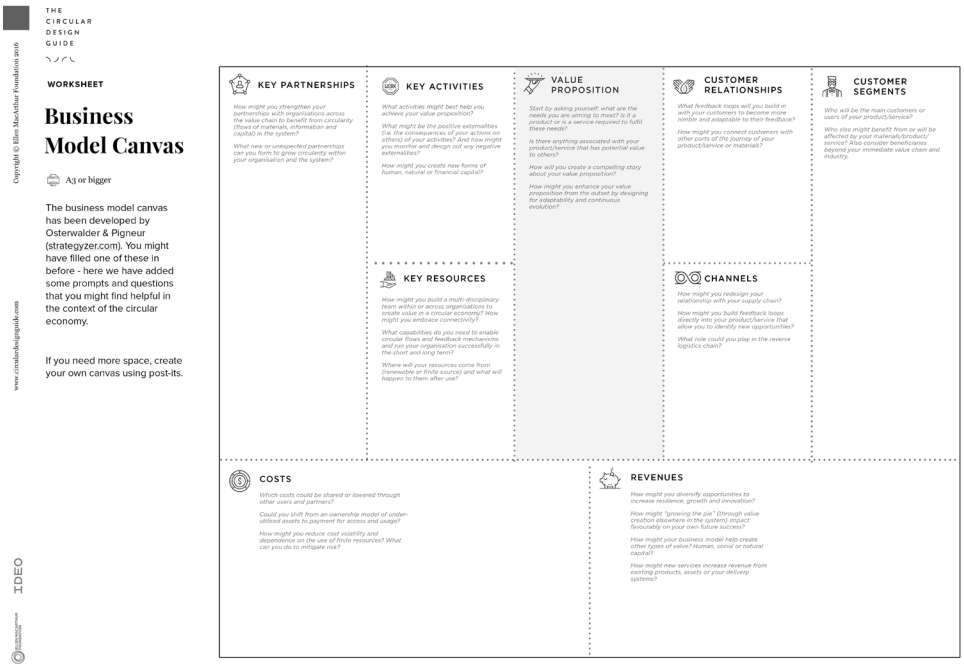


Fig. 9.7
Business Model Canvas (Ellen MacArthur Foundation & IDEO, 2016).

The ethical questions, on the other hand, were based on considerations arising from a visit to the YOU&AI exhibition at Museo Nazionale della Scienza e della Tecnologia Leonardo da Vinci in Milan. During this exhibition, which was held as an interactive workshop, the visitor is presented with a series of case studies. The visitor is then asked to answer key questions about artificial intelligence. These point out some critical issues such as data management and rules regulations, topics that are also found in the cards.

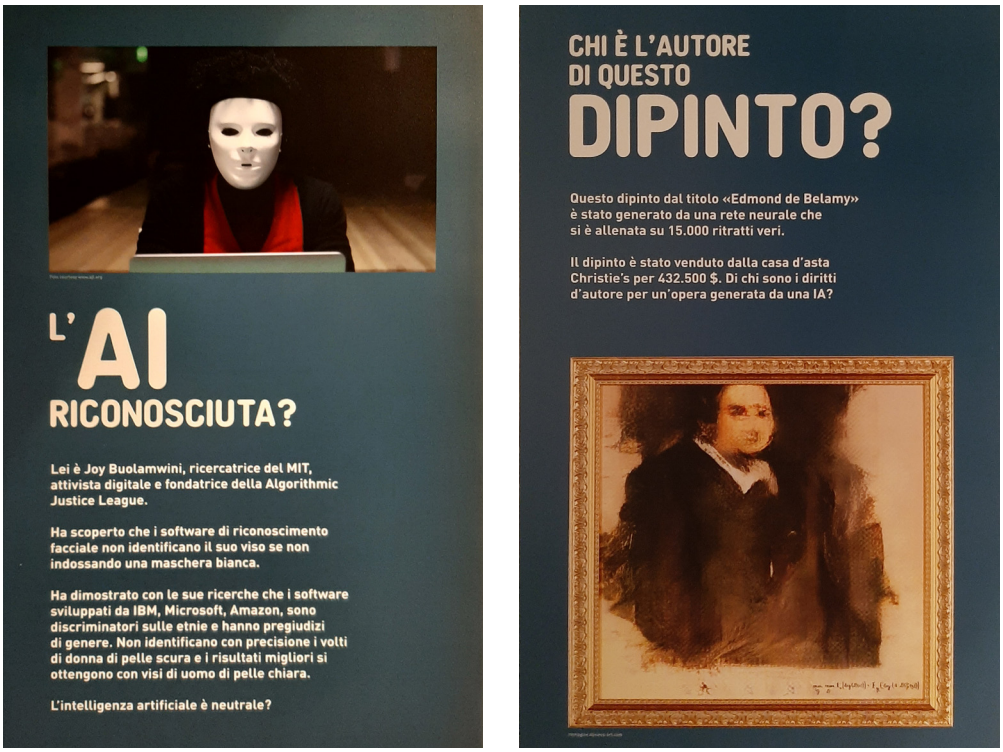


Fig. 9.8
Some interesting reflections about Artificial Intelligence found at the YOU&AI Exhibition.

The following images show the “Ethical and Sustainable Reflections” cards with the related questions.

Fig. 9.9
Ethical and Sustainable Reflections cards, front and back.

Regarding the considerations, it was decided to develop a special card where it is possible to conveniently record them. In addition, in order to have a quicker visual impact on the analysed aspect, it was decided to include a section to indicate the general mood, as shown in the following figures.

Fig. 9.10
Ethical and Sustainable Considerations cards, front and back.

All the cards have been developed by the author and placed on a Figma board, in order to be accessible to everyone.

They can be accessed through the following link: https://bit.ly/3tvTtkg

Or through the following QR code:

9.2.2 Analysis of the case study

The analysis of the case study was carried out in two distinct rounds. The first time was dedicated to understand the critical points and moments of the system. The second time, instead, was aimed at testing the effectiveness of the method and at understanding what improvements could be developed.

The case study was selected from a list of projects available on the techDetector website. The choice fell on the Delivery Robot project (techDetector, 2021), according to some criteria defined by the author. More specifically, this project was selected because it is a fairly simple project to imagine its operation and application and it has a high Technology Readiness Level (TRL). This means that the technology is available and ready to be implemented in the real world. Therefore, not surprisingly it is

possible to spot some applications of this project in everyday life.

The selected project consists of employing robots controlled by artificial intelligence to carry out deliveries. Although these robots navigate autonomously, they can be controlled by specialised personnel if required.

During the first step all the elements of the system were analysed, starting from the identification of the main touchpoint. Once this was recognised, the next stage was to analyse all the surrounding elements. In this phase it is important to think in the digital as well as in the virtual and real domain.

The main touchpoint of the selected project is the robot, from this it was possible to identify all the others, such as the technological producers, the shop that uses it for deliveries and the people who buy from the shop.

Fig. 9.11
During the first step all the elements of the system were analysed.

Starting from the elements identified in the first step, during the second one the relationships between them were analysed. In this particular case, four types of relationships were found, identifying the flows of:

- resources;

- goods;

- information;

- money.

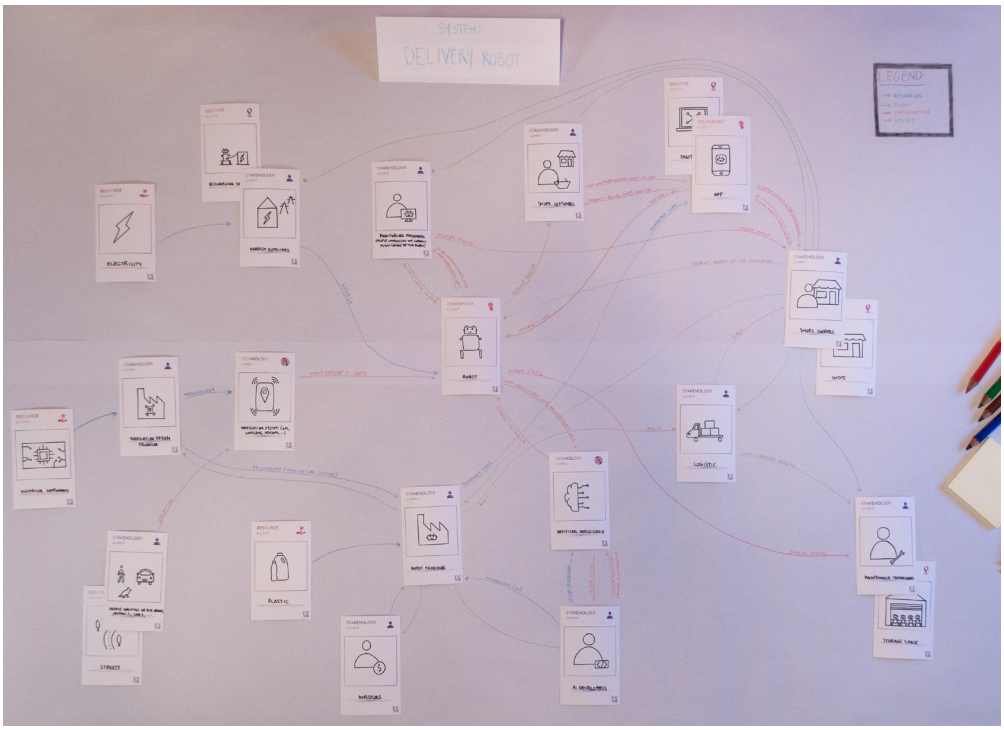


Fig. 9.12
The system and its relationships are mapped during the second step.

After that, the relationships were analysed in more detail, understanding which emotions they stimulated and which were the main criticalities triggered. An example of this is the flow of information between the robot, the artificial intelligence, and the developers: this causes fragility as it is necessary to understand how this data is handled and managed.

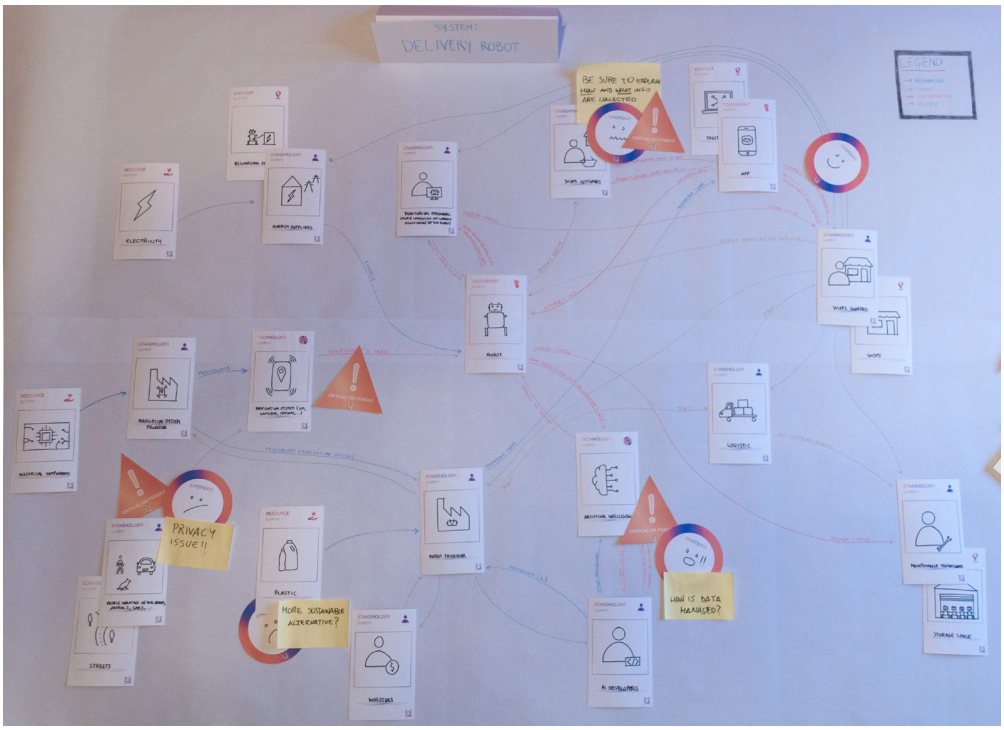


Fig. 9.13
The second aim of the second step is to analysing the emotions arising from the relationships and to point out critical or fragile connections.

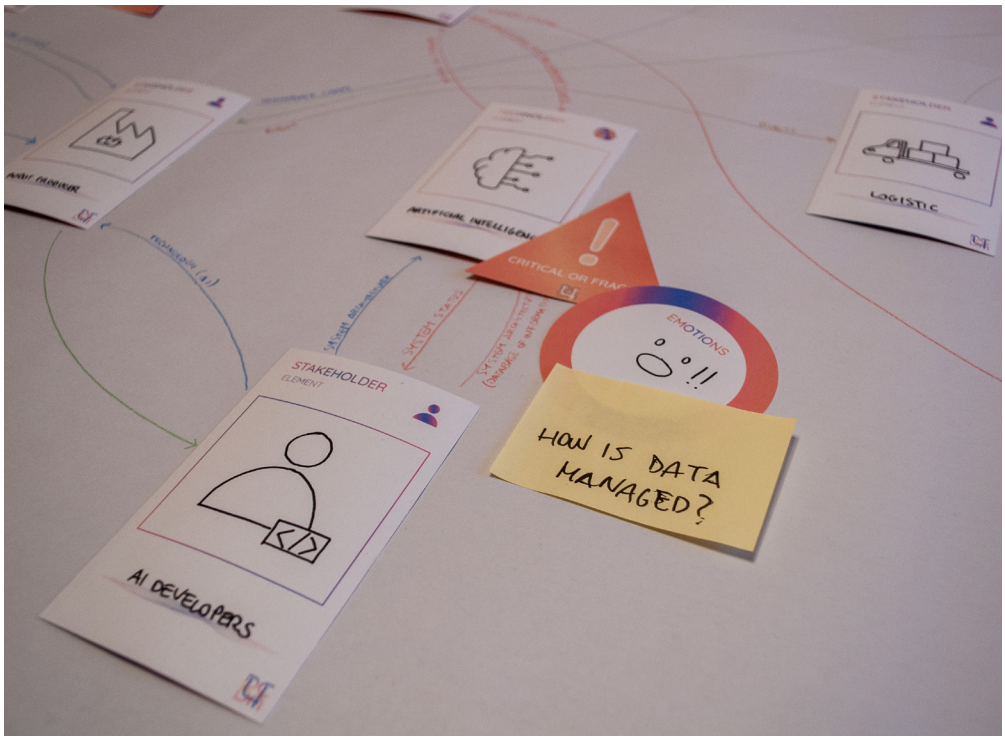


Fig. 9.14
A focus on a critical relationship. Some additional information was added on post its.

The last step was used to identify all the ethical and sustainable considerations of the project. By exploiting the proposed reflections, some ethical criticalities were found, such as data management issues, and sustainable ones, such as the long production chain and the difficulty in the maintenance of the main touchpoint. By recording these reflections, it was also possible to begin to understand how to try to solve them in order to improve the project in the two domains.

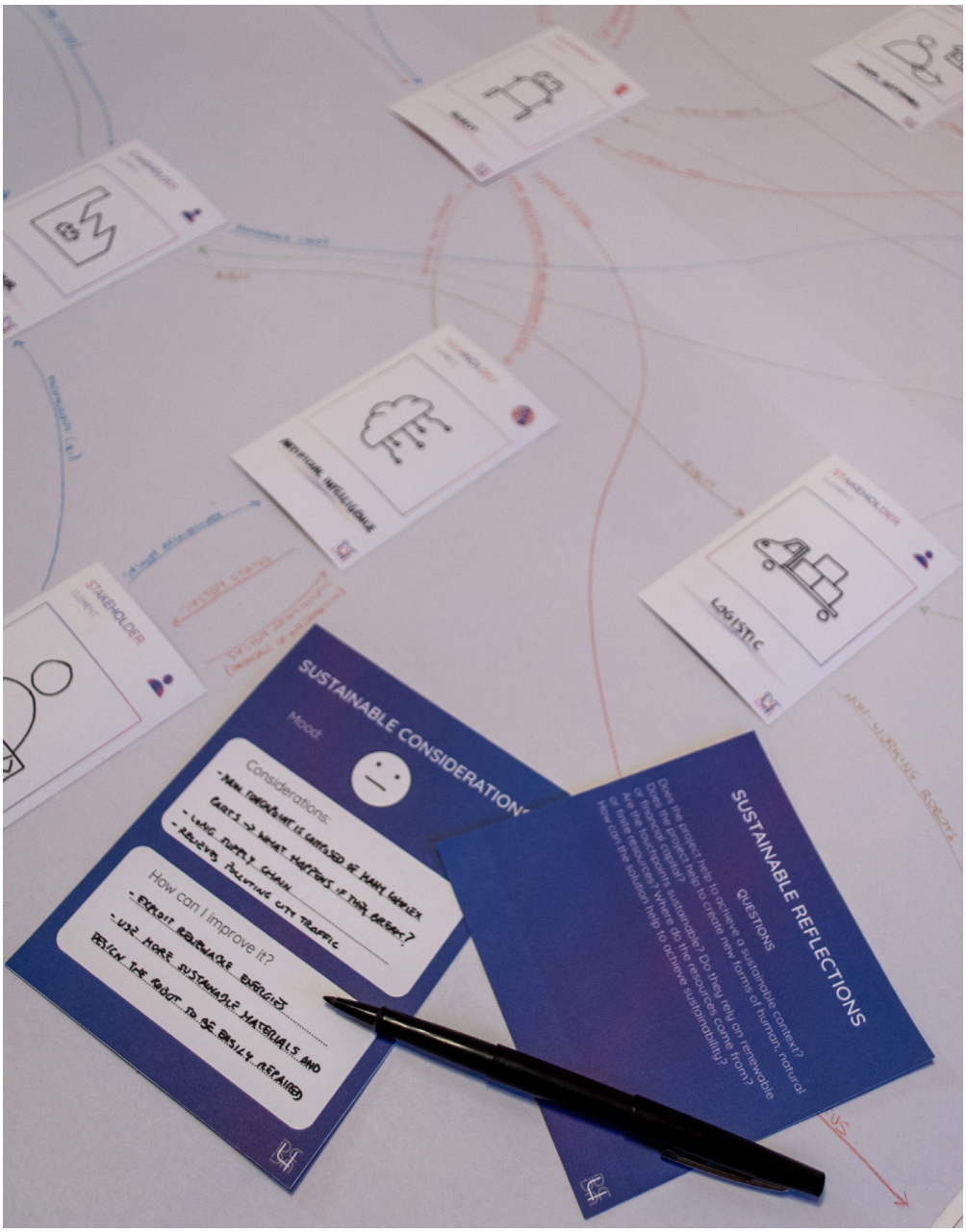


Fig. 9.15
Through the reflections proposed in the third step it was possible to find ethical and sustainable criticalities. Once this was done, it was also possible to understand how to solve them to improve the project.

9.3 The method guides: the brochure and the video

The guide was developed in two different modes: one in the form of written text and one in the form of video. The following sections provide an overview of these two resources.

9.3.1 The brochure

The purpose of the brochure is to provide a written guide for learners, where they can find all the detailed information. The guide is structured in four sections, as described hereafter.

The first section introduces the proposed resources by defining the DC4DM Project, the Drivers and then focusing specifically on the Driver Complexity.

After that, it is proposed a short theoretical excursus concerning the context of application of the method, complex ecosystems, complexity, defining its properties and at last when and how to apply the method.

The third chapter is focused on the case study: the selected project and the path performed divided into the three steps are presented, highlighting the main objectives of each one.

The fourth section focuses on the cards to be used for each activity. This chapter analyses their structure and explains how to use them in each step.

4. Our context: digital ecosystems

Digital transformation is changing current systems, accelerating their development process. This process also implies an increasing number of links between different systems, spanning across several industries. The new scenario that is emerging is highly complex and is called digital ecosystem.

What is a digital ecosystem?

A digital ecosystem is a complex network of stakeholders that connect online and interact digitally in ways that create value for all.

DEFINITION

To create extra value, digital ecosystems optimize data and workflows and exploit technologies and systems to fulfill every individual's need.

What are the main challenges of digital ecosystems?

- Inability to predict outcomes;
- Fast-paced evolution processes;
- Large amount and continuous flow of information;
- Presence of many different stakeholders.

5. What is complexity?

What is "complexity"?

The state of having many parts and being difficult to understand or find an answer to.

DEFINITION

Three main properties of "complexity"

- Multiplicity: represents the number of the elements that can potentially interact;
- Interdependence: shows how those elements are connected;
- Diversity: refers to the degree of heterogeneity of those elements.

The greater are these three properties, the greater is the complexity in the system.

9 / THE THEORY

6. When and how to apply this method

When should you apply this method?

The method identified in this guide fits into the DC4DM project in two parts:

- *Pre-process: the method can be used as a training tool on existing case studies;*
- *Process: the method is used to analyse the reference system and consider all the elements and the relationships between them.*

WHEN:

Apply this method during the Pre-Process or Process

The activity is structured in three main steps, each of which has a specific objective:

1. Analysis of the system;
2. Analysis of the relationships;
3. Reflection on ethical and sustainable issues.

Each step will be analysed and described more specifically in the following chapter of this guide through the analysis of the case study.

What do you need for this method?

For the proper carrying out of this activity, it is important to specify all the resources needed.

Team

PARTICIPANTS:

Alone or in small groups

It is not strictly necessary to workin in teams to carry out the activities properly: it is also possible to complete the three steps alone. However, being in a team helps in performing the tasks and in identifying all the elements, relationships and problems that may arise from the system. This is facilitated even more if the team includes multidisciplinary, proactive, open-minded and flexible figures. Nevertheless, it is better not to form groups with a large number of participants: a proper number of participants is between 4 and 6.

TIP:

Form groups of 4-6 people

It is not strictly necessary to have key figures in the group, but it is suggested to identify precise roles. One role model may be the group leader, the person who leads the group through the activities, explaining the objective of each task, the process to be followed and reading the supporting questions.

THE THEORY / 10

Fig. 9.16
The brochure.

9.3.2 The video

The video is conceived to offer a visual and narrative support to the learner, concentrating the explanation of the method and its purpose in a few minutes. It broadly follows the same structure as the brochure, focusing with more emphasis on the key points that need to be explained and presented.

The video tutorial starts with a theoretical introduction on digital ecosystems and complexity and then it focuses on the method. This is explained in more detail, following the three-step framework. The objectives of each step are explained and it is shown how to conduct the activity, with the support of the cards.

The video includes graphic signs to facilitate its comprehension and to make the two guide formats consistent.

Fig. 9.17
A screenshot of the video tutorial.

The video has been uploaded online to be visible to everyone.

It can be accessed through the following link:
https://bit.ly/3KF68ID

Or through the following QR code:

10 CONCLUSION

The on-field research activity led the study group to define six specific Drivers, each characterised by its own Digital Creative Abilities (DCAs). These Drivers are considered to be of fundamental importance in boosting the development of the Digital Maturity Enabler figure.

Focusing on the Driver Complexity, the attention was shifted on the various types of systems in which projects are conducted. What has emerged is that, due to the Digital Transformation, the old concept of the linear system has turned into a complex ecosystem: a set of systems whose behaviour and final outcome is impossible to predict.

In order to understand how to act in this kind of system, it was firstly analysed its main characteristic: complexity. This led to the identification of three main features: diversity, multiplicity and interdependence. After that, it was analysed which are the methods and tools available to facilitate the analysis of these systems and support the design process. This research yielded several strategies and tools. However, these lack an educational purpose and do not refer to the three main properties of complexity.

Therefore, to overcome this shortcoming, it was developed a set of resources aimed at analysing complex ecosystems, starting by framing the definition of complexity. This helped to identify a method based on three main steps, the first two addressing the three main characteristics, and the last one helping to prevent ethical and sustainable issues of the project. The framework is supported by a guide, available in two versions: a textual version and a video tutorial. It was considered appropriate to develop these two additional tools not only to explain how to carry out the activities of the method, but also to give a theoretical basis regarding complexity.

The resources developed during this thesis project will be tested during the Learning Lab days. This implies that they are an initial version of the tools, still with great potential for development, which can be modified according to the results of these working days.

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On the left the two-dimensional representation of the adaptive cycle as originally conceived by Gunderson and Holling (2002) and, on the right, the model reviewed by Burkhard et al. (2011). The latter version has two main modifications: it is rotated 45° to avoid increase in resilience at the end of the release phase (Ω), and to capture non-monotonic growth in the exploitation (r) and conservation (K) phases.
Source: Fath, B. D., Dean, C. A., & Katzmair, H. (2015). Navigating the adaptive cycle: an approach to managing the resilience of social systems. *Ecology and Society*. 20 (2). Available from: http://www.jstor.org/stable/26270208 [Accessed 6th October 2021].

Fig. 5.2
The panarchy model, showing three nested adaptive cycles. The main characteristic of this model relies in its bi-directional cross-scale feedbacks that encompass all the spatial and temporal scales of system processes and dynamics (Gunderson and Holling, 2002).
Source: Sundstrom, S. M. & Allen, C. R. (2019) The adaptive cycle: More than a metaphor. *Ecological Complexity*, 39. Available from: https://doi.org/10.1016/j.ecocom.2019.100767 [Accessed 6th October 2021].

Fig. 5.3
Drive change and innovation card.
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Fig. 5.4
Coping with uncertainty, ambiguity and risk card.
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Fig. 6.1
An example of GIGA map, The Small Scale Energy Harvesting project (Sevaldson, 2013).
Source: Sevaldson, B. (2013) Systems Oriented Design: The emergence and development of a designerly approach to address complexity. In: Reitan, J. B., Lloyd, P., Bohemia, E., Liv Merete Nielsen, L. M., Digranes, I. and Lutnæs, E. (eds.) *DRS // CUMULUS 2013 Design Learning for Tomorrow Design Education from Kindergarten to PhD: Proceedings from the 2nd International Conference for Design Education Researchers, 14-17 May 2013, Oslo, Norway*. Oslo, ABM-media. pp. 1765-1786.

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Fig. 9.1
Touchpoint card, front and back.
Source: Image of the author.

Fig. 9.2
Stakeholder card, front and back.
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Fig. 9.3
Resource card, front and back.
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Fig. 9.4
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Technology card, front and back.
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Fig. 9.6
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Business Model Canvas (Ellen MacArthur Foundation & IDEO, 2016).
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Fig. 9.8
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Source: Image of the author.

Fig. 9.9
Ethical and Sustainable Reflections cards, front and back.
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Fig. 9.10
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Source: Image of the author.

Fig. 9.11
During the first step all the elements of the system were analysed.
Source: Image of the author.

Fig. 9.12
The system and its relationships are mapped during the second step.
Source: Image of the author.

Fig. 9.13
The second aim of the second step is to analysing the emotions arising from the relationships and to point out critical or fragile connections.
Source: Image of the author.

Fig. 9.14
A focus on a critical relationship. Some additional information was added on post its.
Source: Image of the author.

Fig. 9.15
Through the reflections proposed in the third step it was possible to find ethical and sustainable criticalities. Once this was done, it was also possible to understand how to solve them to improve the project.
Source: Image of the author.

“Any intelligent fool can make things bigger, more complex, and more violent. It takes a touch of genius - and a lot of courage to move in the opposite direction.”
- E. F. Schumacher