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An Agile Approach based on Mobius for Open Innovation in Cities

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Abstract

The social and economic growth of cities comes with several benefits, namely when it comes to diversity, education, and marketplace competition. At the same time, it also raises sustainability issues, which can potentially be addressed by open innovation and co-creation, thus contributing to a more integrated and efficient urban management. Open innovation processes for cities are complex and often need to involve a plurality of entities and resources, hence why they may benefit from more agility.

The Agile Manifesto was introduced and is deeply rooted in the software industry, addressing topics such as customer collaboration, frequent working software delivery, and sustainable development. Over the years, it has been increasingly adopted and branched into different methodologies and frameworks to better adapt to each team's or organization's needs. Since then, the Agile values and practices have been successfully applied in other areas of activity and might also be valuable to support open innovation and co-creation in smart cities.

This work aims to study and apply agile methodologies in the context of innovation for cities, having the Mobius framework as a starting point, and then refining and complementing it with new elements to fit the specific open-innovation needs of cities and the City Catalyst project.

City Catalyst is an R&D project funded by Portugal 2020 and the European Commission involving the cities of Porto, Aveiro, Guimarães, Famalicão, and Cascais in a consortium involving other 18 organizations from academia and industry [26]. The City Catalyst project aims to investigate and develop new products, processes, and services with high potential to address problems affecting citizens and industries [26].

This dissertation aims to contribute to the success of City Catalyst by proposing a framework with practices to carry across the various phases of an innovation process and defining a set of requirements for eventual supporting tools that enhance or contribute to their effectiveness [10]. In the context of smart cities, where new ideas for products and services are frequently discussed, agile methodologies can play a huge role in ensuring that the right ideas are prioritized and executed based on shortened feedback loops, helping achieve the outcomes that truly matter and thus fostering the development of cities with optimal usage of resources.

The validation of this work involved surveying the members of City Catalyst, including Agile and Innovation experts. The results are positive, confirming that agility is an important factor in open innovation, and supporting our approach and proposed practices.

Keywords: Agile Methodologies, Open Innovation, Co-creation, Smart Cities.

Resumo

O crescimento social e económico das cidades traz vários benefícios, nomeadamente no que diz respeito à diversidade, educação e concorrência no mercado. Ao mesmo tempo, levanta também questões de sustentabilidade, às quais a inovação aberta e cocriação poderão dar resposta, contribuindo assim para uma gestão urbana mais integrada e eficiente. Os processos de inovação aberta em cidades são complexos e normalmente envolvem um elevado número de entidades e recursos, podendo por isso beneficiar de mais agilidade.

O Manifesto para o Desenvolvimento Ágil foi introduzido e encontra-se profundamente enraizado na indústria de *software*, abordando questões como a colaboração do cliente, entrega frequente de *software* em funcionamento e desenvolvimento sustentável. Ao longo dos anos, foi cada vez mais adotado e ramificado em diferentes metodologias e frameworks, para melhor se adaptar às necessidades de cada equipa ou organização. Desde então, os valores e práticas ágeis têm vindo a ser aplicados com sucesso noutros setores de atividade, podendo igualmente apoiar processos de inovação aberta e cocriação em cidades inteligentes.

Este trabalho visa estudar e aplicar metodologias ágeis no contexto da inovação para as cidades, tendo como ponto de partida a framework do Mobius, e procurando refiná-la e complementá-la com novos elementos para ir de encontro às necessidades específicas da inovação aberta em cidades e do projeto City Catalyst.

O City Catalyst é um projeto de I&D financiado pelo Portugal 2020 e pela Comissão Europeia, envolvendo as cidades do Porto, Aveiro, Guimarães, Famalicão e Cascais num consórcio que envolve outras 18 organizações academicas e industriais [26]. O projeto City Catalyst visa investigar e desenvolver novos produtos, processos e serviços com alto potencial para solucionar problemas que afetam os cidadãos e a indústria [26].

Esta dissertação pretende contribuir para o sucesso do projeto City Catalyst, propondo uma *framework* com práticas aplicáveis às várias fases de um processo de inovação e definindo um conjunto de requisitos para eventuais ferramentas de apoio que melhorem ou contribuam para a sua eficácia [10]. No contexto das cidades inteligentes, onde novas ideias para produtos e serviços são frequentemente discutidas, as metodologias ágeis podem desempenhar um papel preponderante em garantir que as ideias certas sejam priorizadas e executadas com base em ciclos de *feedback* reduzidos, ajudando a alcançar os resultados que realmente importam e, assim, fomentando o desenvolvimento das cidades através de um aproveitamento ótimo dos recursos.

A validação deste trabalho envolveu a realização de inquéritos a membros do City Catalyst, incluindo especialistas em Agile e Inovação. Os resultados são positivos, confirmando que a agilidade é um fator importante na inovação aberta, além de apoiarem a nossa abordagem e práticas propostas.

Palavras-chave: Metodologias Ágeis, Inovação Aberta, Cocriação, Cidades Inteligentes.

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Sérgio Dias

"Don't be afraid to give up the good to go for the great".

John D. Rockefeller

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Abbreviations

IT	Information Technology
IoT	Internet of Things
MVP	Minimum Viable Product

Chapter 1

Introduction

1.1 Context

Over recent years, we have witnessed an increasing growth of cities in areas ranging from demography to economics [53]. While this trend potentially improves the quality of life of urban citizens, considering the existence of more infrastructure, services, as well as education and employment opportunities, it also threatens to destroy biodiversity and increase carbon emissions associated with deforestation and land-use change [53].

Therefore, it is paramount to address new ways of developing cities and promoting their success in a sustainable way, as happens in so-called smart cities, where collective human intelligence is applied to efficiently solve problems affecting citizens and businesses [26].

Making cities smarter and more sustainable is not only in the interest of the local government entities, but also of industry, universities, and society in general. Hence, the City Catalyst project, to which this dissertation aims to contribute, is based on a quadruple helix model[1]. In concrete, this initiative aims to develop innovative products, processes, and services through open innovation and co-creation, ultimately contributing to a more integrated, efficient, and innovation-catalyzing urban management [26].

1.2 Problem & Motivation

In an open innovation environment, particularly in the case of smart cities, a considerable amount of product and service ideas may emerge. However, in reality, we may not expect all the proposed ideas to have the same impact on meeting the needs of a city. Since resources are limited, not every idea can move forward and be implemented. Therefore, knowing which ones to discard or eventually rethink allow us to address genuine areas of need, maximizing the social return.

The Agile methodologies have proven their value in the Software Industry, first, and other domains after. Consequently, they are also tightly related to the creation of value. Applying the Agile

[1]The quadruple helix framework refers to the interactions among academy, industry, government, and civil society within a knowledge economy [55].

mindset to open innovation and co-creation processes can result in substantial outcome improvements, considering that breaking them up into several phases can facilitate the accommodation of changes within a dynamic environment that characterizes cities. In addition, a more iterative approach can potentially mitigate the chance and the respective impact of an eventual failure as the developed ideas are progressively validated and tested in the field.

1.3 Objectives

This dissertation aims to discover if and how Agile methodologies can be applied in the context of innovation for cities, particularly within the framework of the City Catalyst project.

We aim to contribute to the success of this initiative by proposing a framework with practices to carry across the various phases of an innovation process, including discovery, design, and implementation. The developed methodologies should be based on a quadruple-helix model, thus impacting academia, industry, government, and citizens. Additionally, we will define a set of requirements for eventual supporting tools that encompass the definition, tracking, and visualization of innovation outcomes.

Ultimately, the findings from this investigation should result in more optimal resource usage when creating innovative solutions for sustainable cities and thus maximize the success of initiatives that share this objective.

1.4 Document structure

This dissertation is divided into 6 chapters, which are enumerated and briefly described below.

- **Introduction** — Presentation of the subject, motivation and objectives of the dissertation.
- **Literature Review** — Background on the concepts of open innovation, co-creation, and Agile innovation, including definition, context, motivation, adoption criteria, and real-world examples. This section also introduces the Mobius framework.
- **Problem Characterization** — Further exploration of the problem and definition of requirements.
- **Methodology** — Description of the paradigm in which this research was conducted and how results were evaluated.
- **Mobius for City Catalyst** — Presentation of our proposal, including a more in-depth analysis on the Mobius framework, prioritization of practices, complementary background, and concrete application scenarios.
- **Results** — Validation of the proposed solution and discussion of results.
- **Conclusions** — Summary of the work developed and findings. Additionally, we include the limitations of this work and future research suggestions.

Chapter 2

Literature Review

2.1 Open Innovation

Open Innovation can be understood as a paradigm in which external and internal ideas have the same importance for a company [19]. According to this approach, companies should recognize that valuable ideas may either come from inside or outside the firm, instead of entirely relying on their own R&D personnel. No matter how qualified and talented the latter might be, it should be assumed that even more brilliant workers exist outside the boundaries of the company, not just in the corporate world but also within universities. Similarly, underutilized ideas and technologies in a company can be licensed and shared with the outside, as that know-how can potentially be used to tackle yet unknown opportunities and create new capabilities.

Therefore, we have two different perspectives of Open Innovation: the outside in, where companies incorporate external knowledge into their innovation process, and the inside out, where internal ideas are sent to the outside. Naturally, the wisdom shared with the outside or imported to the inside depends entirely on a company's business model.

Chesbrough, the originator of Open Innovation, argues that the innovation process should be more distributed, participatory, and decentralized [20]. On this note, reducing the gap between business and academia is essential, as universities are a great source of useful knowledge that can be used to accelerate internal innovation.

Hence, Open Innovation contrasts with the traditional vertical integration approach in which R&D activities are carried out internally and stealthy by the company.

2.1.1 Benefits of Open Innovation

One of the main focuses of large enterprises is to pursue and rapidly concretize visionary ideas so that they lead the market with the most innovative solutions [16]. Deadlocked and rigid processes and structures are a massive obstacle in this direction, wherefore Open Innovation advocates more flexibility and openness in such processes.

In order to remain competitive, companies seek talent actively and try to keep it inside doors, as well as new ideas and solutions. However, some companies lack the facilities or funds to develop

ideas properly. Open Innovation addresses this issue by allowing such companies to access other forms of talent and infrastructure, strongly improving their innovation capacity [20].

Nevertheless, larger enterprises can similarly benefit from being part of a more comprehensive network (including other organizations, universities, research laboratories, among others). They may find in Open Innovation an excellent opportunity to capture or refine innovative ideas and reduce costs by increasing the efficiency of their processes.

In conclusion, Open Innovation promotes the engagement of all the community to whom a product or service may concern, assuring the match between ideas and needs. For businesses, this innovation approach is 'a more profitable way to innovate, because it can reduce costs, accelerate time to market, increase differentiation in the market, and create new revenue streams for the company' [20].

2.1.2 Types of Open Innovation

Although Chesbrough, considered "the father of Open Innovation", first introduced the concept, many other authors have extended and dissected it. According to Isomäki (2018), Open Innovation can be classified from two points of view: inclusion and purpose of use [40].

The "inclusion" dimension is related to the group of people that Open Innovation targets. Specifically, the levels of inclusion can be broken down into four types [40]:

- **Intracompany** – information is only shared inside the company or organization. Even though it may sound contradictory to restrict Open Innovation to a single company, it can make sense in the context of large organizations in which there is a collaboration between different functions or business units;
- **Intercompany** – information is shared between a plurality of organizations but is not widely available for arbitrary collaborators;
- **For experts** – information is shared with a restricted group of experts outside the company who can provide significant input;
- **Publicly open** – information is available for everyone. This is the most common and open form of Open Innovation, integrating anyone willing to contribute, regardless of previous knowledge or stature.

The purpose of use relates to the objective that Open Innovation targets. This dimension includes the following four areas [40]:

- **Marketing** – adoption of Open Innovation to gain a strategic competitive advantage.
- **Gathering insight** – adoption of Open Innovation as a way of gathering valuable information on the market and customers.
- **Finding talent** – adoption of Open Innovation to promote discovery of new talent.

- **R&D** – adoption of Open Innovation to develop products and services. It is the most typical form.

It is possible to cross-reference these two dimensions, leading the author to envision 14 different types of Open Innovation, as shown in figure 2.1.

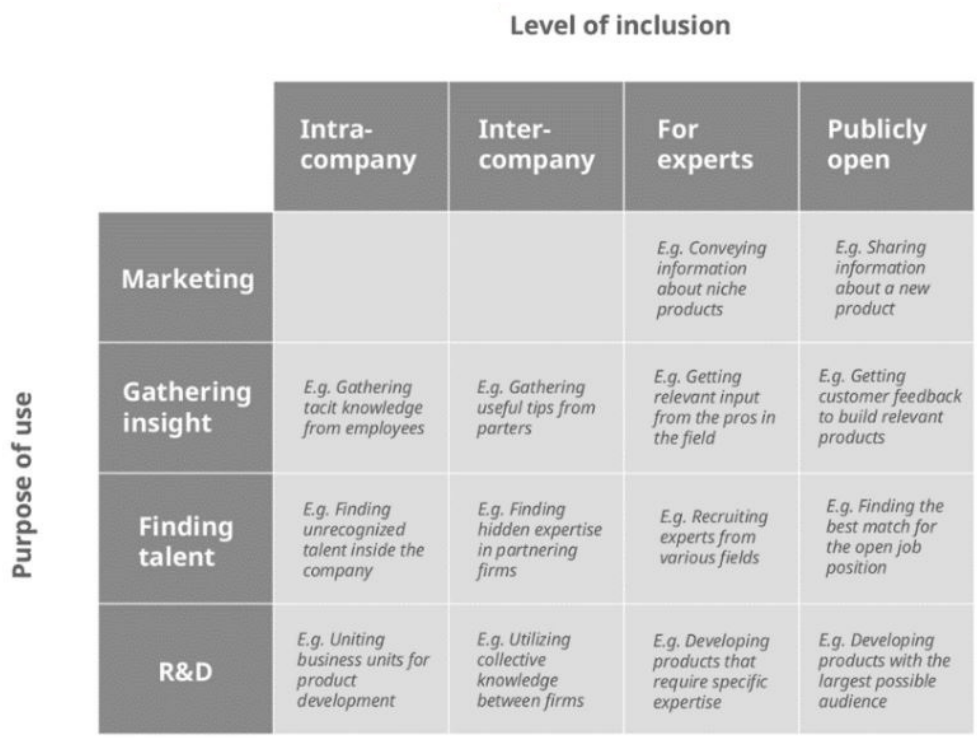


Figure 2.1: Types of Open Innovation [40].

2.1.3 Examples of Open Innovation Initiatives

In virtue of its success, it is today possible to easily find numerous real-world examples of Open Innovation. These illustrate the benefits and outcomes that a successful Open Innovation initiative can yield in practice.

Dokk1 Library

Dokk1 is a public library in Aarhus, Denmark [1]. Besides being a center for knowledge and culture, it is also considered a hub for the community and a significant component of the smart city where it belongs [47]. The building incorporates advanced technology and was developed based on the interests of users, staff, partners, and citizens [47]. This approach resulted in better-tailored services and products and made the library an attractive and relevant place within the smart city of Aarhus [47]. The success of Dokk1 can also be attributed to the seven core values established by this library [1]: citizen as a key factor; continuous learning community; fomentation of diversity,

cooperation, and networking; promotion of culture and experiences; bridging citizens, technology and knowledge; flexible and professional organization; sustainable icon for Aarhus.

Helsinki Central Library

Libraries in Finland are turning into community hubs and places with increasing importance for civil society, democracy, civic engagement, and sense of place excitement, as is the case of the new Central Library [47]. Even though this library has adopted user-centered methods from early, it is visible how user involvement has been prioritized in recent years [47]. Visitors are encouraged to come up with ideas for the library and even participate in its planning, as well as in participatory budgeting and policymaker networking activities [47]. Consequently, visitors feel more substantial ownership of the place and visit it more often [47].

Samsung Electronics

Samsung Electronics is an information technology company and one of the largest manufacturers of electronic components and semiconductors worldwide [18]. Despite a significant internal R&D unit, the company has made a strong commitment to Open Innovation, establishing partnerships with hundreds of companies, institutes, and communities throughout the world [18]. Sharing innovation processes with the exterior has been a thriving decision from Samsung, as illustrated by the contributions to its IoT platform, which have allowed Samsung to gain strategic positioning in an emerging technology area [50].

2.2 Co-creation

Over the years, the relationship between customers and companies has changed and become tighter. As opposed to the past, companies are no longer seen as mere providers, nor are customers perceived as sources of money or passive targets of marketing actions [62]. New forms and shapes of interaction have allowed customers and companies to work together to create value.

Co-creation designates the collaboration among developers, customers and other stakeholders to develop products, services or systems [56]. The term "co-creation" originates from co-production, the participation of end-users in the process of developing a product or a service [78]. This means of cooperation has proven to minimize costs [49], increase customer satisfaction [24] and promote product differentiation [69].

2.2.1 Risks of Co-creation

Despite the large number of contributions to the domain of value co-creation, it is not an approach that fits every organization [62]. Not all companies are a fan of co-creating value with customers, and similarly, customers may also not be willing to integrate the company's processes [62]. Therefore, it is crucial for them to carefully assess the opportunities that co-creation entails.

Furthermore, joining a co-creation environment comes with implications and risks that companies should be aware of. These tend to be proportional to the adopted level of co-creation: the more the customers are engaged in the co-creation process, the higher the dissatisfaction in case of a failure [35]. This, however, does not mean that the co-creation level should necessarily be weakened, especially considering how it can improve service effectiveness when successful [35]. It is essentially a double-edged sword, asking for moderation and risk measuring. Since successful co-creation and increased client satisfaction are tightly correlated, failed co-creation is destructive in two ways: when customers are upset with the service performance and when customers are unhappy about the co-created service [35].

2.2.2 Success factors for Co-creation

Companies embracing co-creation processes should promote a good experience for their participators, including fun, excitement, good quality of the platforms used, reliability, and easiness of use. By emphasizing the activities themselves and the fulfillment they can provide rather than the final results, it is possible to mitigate the negative customer judgments.

In addition, organizations should be aware of their knowledge, aptitudes, and resources to evaluate their co-creation potential and which co-creation level best fits their business model [35].

The implementation of co-creation processes entails an added responsibility for managers, who must weigh the inherent risks and monitor the results to guarantee long-lasting and interactive relationships with customers, good communication, and encouraged customer participation in each stage of the value creation process. These are essential requirements to ensure that companies benefit the most from a co-creation strategy. Unexperienced companies in this regard should, inclusively, take extra precautions, and are encouraged to begin with a lower level of co-creation and increase it as they acquire more experience [35].

2.2.3 Examples of Co-creation Initiatives

Despite the care that adoption of co-creation requires, this approach has been the formula for success for many companies worldwide. In order to provide a better overview of how these companies have evolved through this practice, we collected three practical cases of co-creation with large audiences.

Lego

Lego is arguably one of the best examples to illustrate the potential of a co-creation approach. This company is known for its creativity, mostly thanks to the massive number of ideas and suggestions provided by fans around the world [8]. Lego also ensures to properly recognize and reward the owners of winning ideas with a percentage of product sales, motivating fans to continuously create value alongside the company [8].

IKEA

IKEA, a large furniture and home goods retailer, has developed and launched its own co-creation platform with support for product idea suggestions, collaboration with university students on product solutions, and connection with innovation labs worldwide [8]. This approach has resulted in excellent customer engagement, allowing the company to capture valuable design insights and competitive advantage [8]. Inclusively, some of these customers are actual designers and technically talented, so IKEA provides resources such as test labs and prototype shops to help them develop and refine their suggestions [8].

DHL

DHL, the world's largest courier, exemplifies how co-creation can focus on the improvement and development of services rather than final consumer products [8, 52]. DHL organizes co-design workshops with customers where innovative solutions have emerged, such as the Parcelcopter, a drone capable of making fully autonomous deliveries in secluded areas that are of difficult access for postal trucks [52].

2.3 Agile Innovation

2.3.1 The Agile origins

The original principles of Agile were solidly established in 2001, with the manifesto for Agile software development. Seventeen professionals wanted to define values and basic principles to improve the software development process [39].

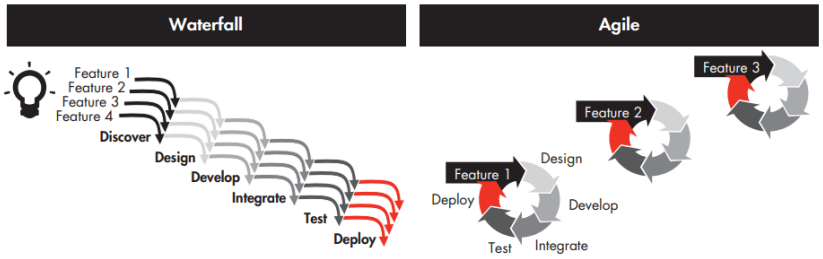
Since it was brought into focus, the manifesto has been widely adopted by developers, not only in software companies but also beyond the world of IT [39], where it has allowed organizations to tackle opportunities by empowering small, focused, cross-functional, self-managing teams [60]. These teams should be protected from distractions and instead concentrated on putting their collective intelligence to work [60]. Besides, the fundamentals of Agile involve frequent close contact with the stakeholders, ensuring that the most promising ideas or features are prioritized according to estimates of values for customers, financial outcomes, and other innovation endeavors [60].

During development, agile teams break top-priority tasks into small items, plan what work to take on, and start building functioning versions in short cycles, also known as iterations. It is also common for team members to hold small meetings daily, where progress and obstacles are reviewed and discussed in a transparent way [60]. If disagreements occur, the decisions are not achieved via exhaustive debates or appeal to authority. Instead, experimental feedback takes place and dictates where a new feature or increment should or not be released [60]. These principles are closely aligned with the vision of Open Innovation, according to which the power should be decentralized (c.f. section 2.1), since the priority is to meet the needs of a target audience.

Another fundamental proposition of Agile is the capacity to react to changing or evolving requirements. Back in 1958, Koontz claimed that 'no effective manager makes a plan and then

proceeds to put it into effect regardless of what events occur' [68]. Such a statement resembles the Agile mindset, advocating the inevitability of deviation (i.e., the existence of situations that do not reflect initial expectations) in project plans. Therefore, projects that employ Agile methodologies tend to be more prepared to accommodate changes and thus better adapt to dynamic or unpredictable environments, thanks to its iterative approach [68].

A summary of the differences between traditional (Waterfall) and Agile methodologies is presented in Figure 2.2.



Team	Large, functional teams	Small, cross-functional teams
Customer and business involvement	Heavy at the beginning and end	Constant collaboration
Design	Predict and design all features up front with exhaustive documentation	Modularize and prioritize design features; welcome changes to undeveloped modules
Development	Build all features at once to exact specifications	Iterative; build only what is proving valuable
Testing and integration	Integrate and test when development is complete	Continuous, real-time testing and integration
Delivery	Large, infrequent releases	Rapid, frequent increments

Figure 2.2: Agile vs Waterfall processes [60].

2.3.2 Agile in innovation processes

After the notable success of Agile methodologies within the software industry, they have migrated to other parts of the business and industries [60]. Inclusively, many experts started believing it could make its way onto innovation processes [59].

A thorough analysis may, in fact, reveal common ground between innovation and Agile methodologies. The latter contrasts with introverted development, where the development team is disconnected from the customer. Instead, it fosters continual customer involvement, supposedly resulting in more innovative and therefore more valuable information [21]. Nevertheless, innovation (and especially open innovation) processes comprise a plurality of stakeholders, which may include but are not restricted to customers. For instance, it has been suggested that corporations should increasingly collaborate with each other to improve their agility in adapting to market developments and conceiving new products cheaper and faster [71]. Such advancements or rather extensions of the original Agile principles led to the concept of Agile Innovation, i.e., the introduction of value and flow in all operations, releasing resources and combining them, particularly to the innovation process [71].

Conditions	Favorable to Agile	Favorable to traditional
Market environment	• Customer preferences and solution options change frequently	• Market conditions are stable and predictable
Customer involvement	• Close collaboration with customers; rapid feedback from customers is feasible; customers learn more about what they want as the process progresses	• Customer requirements are clear at the outset and will remain stable throughout the process; customers are not available for constant collaboration
Innovation type	• Problems are complex, and solutions are unknown; scope is not clearly defined; product specifications may change; creative breakthroughs and time to market are important; interactive, cross-functional collaboration is vital	• Similar activities have been done before; innovators believe solutions are clear; detailed product specifications and work plans can be forecast with confidence; conformance to specifications is important; problems can be solved sequentially in functional silos
Modularity of work	• Incremental developments have value and can be used by customers; work can be modularized and conducted in rapid, iterative cycles; late changes are manageable	• Late changes are expensive or impossible; customers cannot start testing parts of the product until everything is complete; the minimum viable product is the fully completed product
Impact of interim mistakes	• Interim mistakes provide valuable learning opportunities	• Interim mistakes can be catastrophic
Corporate culture	• The culture is team-oriented, collaborative, innovative and eager to delegate; employee turnover is relatively low	• The culture relies on top-down direction and functional specialization; employee turnover is high, and mutual trust is low

Figure 2.3: Favorable to Agile vs Favorable to Traditional [60].

2.3.3 Favorable to Agile environments

Much as Agile principles are proving superior in a wide range of applications, they should not be seen as a one size fits all approach. Before deploying Agile practices in a given context, it is important to understand the surrounding atmosphere and ensure that the conditions under which a product or service will be developed are favorable [11]. In the case of a company, these conditions can be divided into market environment, customer environment, innovation type, modularity of work, impact of interim mistakes, and corporate culture. A more detailed description on what characterizes an Agile compatible environment can be found in figure 2.3.

Other authors have also pointed out limitations of Agile approaches, such as Cockburn and Highsmith, who state that they become harder to implement as the size of teams grow, especially because coordinating interfaces becomes a dominant issue [11]. Similarly, Agile is not known for its suitability for critical software development, as per contended by Boehm [11]. Such systems often require characteristics such as predictability, repeatability, and optimization, which are better aligned with traditional heavyweight methodologies.

However, unfavorable conditions and averse points of view related to the application of Agile methodologies should not be regarded as discouraging factors. Instead, knowing the constraints of this methodology can help to anticipate obstacles and thus increase the chances of success.

2.3.4 Phases of an innovation process

Innovation processes have been defined as complex phenomena involving multiple social and psychological variables with interdependent relationships [32]. Through innovation processes, new or existing knowledge is converted into marketable solutions [29].

An innovation process comprises several phases that are not necessarily passed linearly. Even though there is a left to right tendency, the iterative approach is the most common.

Several authors, namely Myers and Marquis (1969) and Corsten (1989) [16], have enumerated different sets of generic phases for an innovation process, however, we will take the model proposed by Annette Böhmer et al. (2015) as reference [16]. According to this model, the phases are:

- **Recognition** – the first stage of an innovation journey, where the problem to be solved or the opportunity to respond to is identified [9].
- **Idea Generation** – gathering of thoughts in order to generate a pool of ideas. Then, according to given criteria (e.g. risk and attractiveness), a set of ideas is selected to move onto the next phase [16].
- **Concept Development** – phase in which ideas start being materialized, both from a technical and marketing point of view, in the form of prototypes. The latter allows target users to test the main functionality of the product, consequently providing an estimate of market acceptance [16].
- **Development** – phase in which the intended features of the product are extended until it is fully developed [16].
- **Test** – testing of the product, including processes for later large-scale production. This phase is fundamental to validate the proposed new product under real-life conditions [22].
- **Launch** – beginning of commercialization, from production to marketing, distribution, and selling [22].
- **Controlling** – examination of KPIs after introduction to market, providing an important input for incremental innovation processes [16].

2.3.5 Agile frameworks for innovation processes

Below are some Agile frameworks that support the development of innovative products and encompass practices that fit some of the phases defined in the previous section:

Scrum

Scrum has been claimed to be the leading Agile development framework [16]. It is an iterative and incremental framework that encompasses practices and rules that involve transparency, inspection, and adaptability to evolving requirements [66, 16]. Iterations in Scrum are referred to as a *sprint*: fixed length events of one month or less where ideas are turned into value [66].

When practicing Scrum, it is important to understand the roles of the actors that this framework envisions:

- **Developers** – people in the Scrum Team that are in charge of achieving the goals defined for each sprint [66]. They also attend regular meetings and report progress of the allocated work [66].
- **Product Owner** – element in the Scrum Team that is responsible for maximizing the value of the product deriving from the work of the Scrum Team [66]. They are likewise accountable for effective Product Backlog management, which entails, among others, the explicit communication of the product goal and ordering the backlog items [66].
- **Scrum Master** – element in the Scrum Team that is in charge of enforcing Scrum principles as per the Scrum Guide, as well as helping everyone understand Scrum theory and practice, thus improving its effectiveness in the environment where it is applied [66].

When mirrored on the phases of a generic innovation process defined in the section 2.3.4, it is noticeable how Scrum does not explicitly cover the Recognition and Idea Selection phases, even though the latter may be matched with the prioritization of ideas by the Product Owner [16]. The following three phases (Concept Development, Development, and Test) are foreseen by this framework and occur iteratively [16].

Lean Startup

The Lean Startup methodology emerged as a response to environments and circumstances of notable uncertainty, complexity, and pace of change, particularly within new business ventures or startups [15, 57]. This methodology favors experimentation over comprehensive planning, customer feedback over intuition, and iterative design over waterfall approaches [57]. In Lean Startup, an iteration follows the Build, Measure, Learn cycle, in which, according to Ries (2011), the following actions take place [16]:

- Definition of hypotheses about the perceived value of a product by customers and how they become introduced to it.
- Development of a Minimum Viable Product (MVP): a lightweight version of the product that only features the minimum functionality needed to test the hypotheses and is built as fast and efficiently as possible.
- Evaluation of the MVP's success and drawing conclusions from the gathered results, which are then used to decide if the product strategy should be maintained or rather pivoted.

The smaller the length of Build, Measure, Learn cycle, the higher the adaptability to dynamic environments [16].

Lean Startup does not handle the Ideation phase, allegedly because the lack of ideas was never a problem for the authors who developed the methodology [16, 15]. Instead, it begins with the selection of ideas and then focused on Concept Development to rapidly understand if the product fits the needs of its intended target [16, 15].

Design Thinking

Design Thinking emerges as a model of innovation that includes methods of research and development of solutions with a strong emphasis on the user, thus yielding great results for organizations seeking leadership [14].

Briefly, the Design Thinking process comprises the following phases [16, 65]:

- **Understand** – Definition of the problem.
- **Observe** – Analysis of the identified target group by confronting people with the problem and observing their interaction within their environment.
- **Define point of view** – evaluation and interpretation of the knowledge obtained in the previous phase in order to capture needs and insights.
- **Ideate** – generation of ideas through brainstorming, after which the most structured and promising ones are selected for further development.
- **Prototype** – development of prototypes to obtain feedback as soon as possible and gain new ideas.
- **Test** – Management of feedback provided by users, including reactions to and interactions with the prototype, to guide design thinkers on which course to adopt for further development.

Following the tendency of a generic innovation process, these phases are not usually passed linearly. The Understand and Observe phases resemble the Idea Generation phase of a generic innovation process. On the other hand, the Prototype and Test phases correspond to Concept Development and Concept Test, respectively.

Hackathon

Although Agile and lean methods allow companies to respond to incremental development needs, they have a stronger emphasis on efficiency than creative thinking and techniques [45].

Even if the term "Hackathon", resulting from the combination of "hacking" and "marathon", is commonly associated with intensive and uninterrupted periods of programming, it can be more widely seen as an event whose purpose is to generate ideas and prototype them as quickly as possible [45].

Komssi et al. (2014) has proposed a process for Hackathons, which encompasses the following phases [16, 45]:

- **Creation of ideas & Team building** – Gathering of ideas and formation of small teams based on the ideas, skills, and interests of the participants. These activities, which match the Idea Generation and Idea Selection phases in the innovation process, may happen before the event itself to free more time for development.

- **Intense hacking** – Fast-paced development of a "demo-able" version of a certain idea within a restricted time frame (1-3 days), corresponding to the Concept Development phase in the generic innovation process.
- **Demoing results** – Demonstration of the concept and value of the product to an audience. The demo should be easy to understand and focus on the key aspects of a novel idea.

After the end of event, it must be decided whether the idea is worth continuing or should be abandoned [45]. Promising ideas might receive funding for further development, especially when presented by teams that prove to be sustainable considering their performance during the event [45].

2.4 The Mobius framework

2.4.1 Motivation and rationale

The Mobius framework is considered a "one-stop-shop" for Design Thinking, Lean Startup, Business Model Innovation and Agile [2]. It proposes to help organizations to improve process efficiency, increase iteration speed and, above all, deliver the outcomes that truly matter [2].

By developing with outcomes in mind, rather than mere outputs that may not necessarily translate into meaningful results, it becomes possible to build less, get to market faster, and make an impact [2].

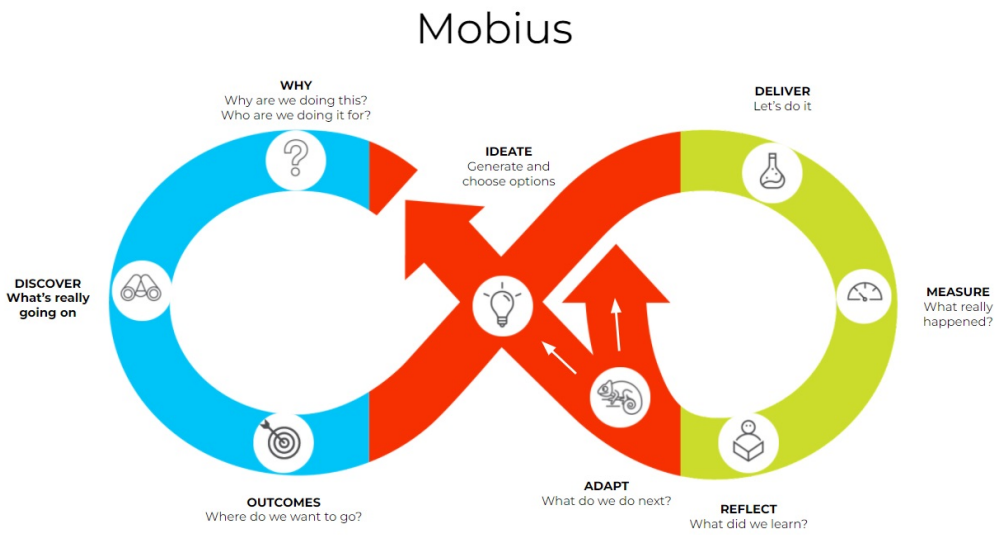


Figure 2.4: The Mobius Loop – Adapted from [2].

Mobius Loop, as illustrated in figure 2.4, can be split into 3 phases, passed iteratively:

- **Discovery loop** – Exploration of the situation that needs to be addressed and definition of intended outcomes before jumping to solutions.

- **Ideation / Option pivoting** – Generation of ideas according to the needs discovered in the previous phase and prioritization of activities.
- **Delivery loop** – Experimentation and delivery of outcomes through the simplest path in a continuously learn and adapt cycle.

2.4.2 Balancing discovery and delivery

With the kind of structure defined above, this framework proposes to address two critical topics: building the right product and building the product right [13]. Ensuring an appropriate balance between discovery and delivery is paramount. Exclusively focusing on the left part of the loop can result in being stuck in the discovery phase, without ever checking the effectiveness of solutions when tested in the field [13].

On the other hand, placing a high emphasis on the delivery component is also not a guarantee of positive outcomes. The numerous Agile frameworks, such as Kanban or Scrum, which have proven their worth in this department, will not yield positive results alone. If the end purposes of the products under development are not explored enough, the increase of agility in the delivery process only leads to obtaining the wrong product faster [13].

The Mobius Loop framework is based on the assumption that a higher number of features does not always translate into better products or services. Instead, it advocates enough discovery before jumping to the implementation of valuable features, always focusing on outcomes.

2.4.3 The Mobius trigger cards

Besides proposing a disruptive approach for the flow of discovery and delivery, the Mobius framework contemplates specific practices for each phase envisioned. These are presented in the form of trigger cards, whose one of the faces contains an image and some actionable keywords and the other one includes a more dense description of how to implement the respective procedure.

The appearance of these "visual guides" [2] is illustrated in Figure 2.5. They come in blue, orange, and green colors, matching the discovery, ideation, and delivery phases, respectively.

2.5 Conclusions

In this chapter, we performed a problem and state-of-the-art analysis, which will constitute a valuable input for the further development of this dissertation. In particular, several existing Agile frameworks for innovation processes were presented and analyzed in light of the phases of a generic innovation process. This way, we have a clear vision on which exact aspects each framework covers and disregards, which will be helpful when developing our approach.

In addition, we have introduced the definition and main concerns about open innovation and co-creation, providing background that will support the development of Agile methodologies for innovation in smart cities. Lastly, we gathered a few examples of successful application of open

Figure 2.5: A few examples of Mobius trigger cards [3].

innovation and co-creation in the framework of both cities and the corporate world, which may likewise function as an inspiration for this work.

Chapter 3

Problem Characterization

3.1 Context

This work was developed primarily in the context of the City Catalyst project – funded by Portugal 2020 and the European Commission involving the cities of Porto, Aveiro, Guimarães, Famalicão, and Cascais, in a consortium with other 18 organizations from academia and industry [26].

This initiative intends to provide Portuguese cities with new technological solutions and innovative services, ultimately becoming a reference stage for other cities in the world [26]. To this aim, the project will rely on an open innovation platform that promotes collective intelligence, transparency, and an efficient resolution of problems affecting citizens and industries [26].

The recognition that the development of cities is in the interest of several fronts leads to a quadhelix model, in which local governments, industry, universities, and society may participate in the creation of innovative products, processes, and services through open innovation and co-creation, thereby contributing to a more integrated, efficient, and innovation-catalyzing urban management [26].

3.2 The City Catalyst process

The City Catalyst project provides a platform under development where challenges led by companies or municipalities will be launched. In parallel, the platform is planned to work as a bank of solutions, where everyone can submit new solutions to open challenges and post comments or suggestions on existing candidate solutions.

In addition to the process defined above, the City Catalyst project promotes initiatives to support and maximize the success of innovation. The platform also streamlines group sessions and shares questionnaires to obtain data about the users to stimulate co-creation processes.

In order to increase the quality and effectiveness of co-creation processes, it is fundamental to train and educate the participants. Hence, social formation and sensitization actions are also carried out and disseminated on the platform. Likewise, living labs are made available, ensuring that products and services are tested in the early stages of development.

For monitorization of the innovation impact, the current process foresees the implementation of KPIs (Key Performance Indicators) to measure the overall results of the set of implemented solutions. In the interest of transparency, these should remain up-to-date and accessible to all the users of the platform.

Last, the project recognizes participatory citizens and seeks to raise awareness of open innovation, actions that are complemented with the publication of the projects and ideas with the most potential. Similarly, the efforts of the companies which collaborate toward the development of cities are also publicly recognized.

3.3 The need for Agile methodologies

As can be derived from the section above, the best process for open innovation within City Catalyst must clearly consider the need to integrate the contribution of multiple groups of entities, aiming for a quadruple helix model and a considerable level of detail.

Besides, it is possible to immediately identify some challenges, namely the exploration of a problem origin. Studying the core and roots of the problems before jumping to concrete challenges is fundamental to increasing the chances of success of any approaching solutions. Skipping or partially neglecting discovery may result in spending precious resources on building products or services that are correctly conceived but are unable to satisfy the actual needs of the original issue.

Another challenge has to do with the destination of the poorly rated solutions, or rather those that are not selected to move forward. While choosing the best among the available solutions and ignoring the remaining ones is a common intuition to quickly solve a problem, it may not be the best approach to building a broad knowledge base over the long run. Hence, it is important to define a strategy to take benefit of the solutions left behind, as they can possibly contribute to the target situation after being refined or serve as a resolution to a different problem.

All in all, a candidate methodology poses several challenges. It should be more oriented towards outcomes than outputs, and the lifespan of proposed ideas should be adequately defined. These are two areas that will deserve our special attention. Concurrently with this work, the innovation platform adopted by City Catalyst will be enhanced to better support the Agility and co-creation in open innovation for cities [67].

3.4 Requirements

In light of the goals of the City Catalyst project, as well as the challenges encountered and presented in Section 3.3, we have defined a list of requirements to be considered during the development of the new methodology to attend the open innovation and co-creation needs of this project.

3.4.1 Promoting agility throughout the innovation cycle

The proposed methodology must address the different phases of open innovation processes. This is a critical requirement, as most available Agile frameworks tend to focus on specific stages of the innovation life cycle.

3.4.2 Listening to all stakeholders

The long-term success of open innovation and co-creation initiatives depends on the degree of satisfaction of all the involved parties. Accordingly, it is vital to understand the concerns of the quadruple helix stakeholders and ensure that they remain happy about their form of participation, the obtained return, and the final solutions.

3.4.3 Efficient use of resources

Innovation requires valuable resources such as time, labor, and infrastructure. These must be used with great discretion to maximize the success of innovation outcomes and thus foster as much and fast as possible the development of smart cities. Although the concerns about resource efficiency must be evident in the discovery and implementation of victorious ideas, it is likewise important to minimize the waste of resources with the immensity of less well-conceived ideas that are bound to arise.

3.4.4 Capturing valuable ideas

The purpose of an open innovation approach is to gather insight from multiple actors, but doing so demands the organization of activities and events that encourage the participation of the former. Provided that enough ideas are collected, it is then necessary to implement proper mechanisms to filter them out and decide to which extent they will be explored. These decision points also have a strong influence on the efficient use of resources.

3.4.5 Increasing learn-ability

Taking meaningful innovation steps is not limited to the development of final solutions. Instead, they also include the development of existing knowledge on relevant subjects, which can possibly turn into a considerable contribution to the ideation or concretization of current or upcoming solutions, as a consequence of the confidence increase.

3.4.6 Objective assessment of the innovation outcomes

The definition of successful solutions must be based on concrete indicators for a more objective assessment. Accurately evaluating the real impact of implemented ideas provides precise and helpful feedback for future endeavors. In addition, the definition of metrics early on helps stay focused on the intended goals and iteratively validate the progress made.

Chapter 4

Methodology

4.1 Research methodology

Design Science Research (DSR) is proposed as a methodology to foster human and organizational capabilities by creating new and innovative artifacts [36]. An effective application of this research technique often begins with identifying opportunities and problems in a real application environment [37].

As design science inherently aims to solve a problem, there have been proposed a few guidelines – presented in Table 4.1 – based on the principle that the application and building of an artifact highly rely on the knowledge and understanding of a design problem and its solution [36].

4.2 Evaluation of results

Considering the goals of this dissertation, involving the iterative development of Agile methodologies to satisfy the open innovation needs of smart cities, it is necessary to define ways to evaluate their effectiveness. In particular, it is essential to determine under which paradigm all the collected data will be analyzed.

The quantitative paradigm pragmatically argues that there is only one truth, as the research objective has no relation to human perception [63]. This allows the investigator to study a phenomenon without influencing it or being influenced by it [63]. In this type of research, the goal is to gauge and look into causal relationships between variables in an environment free from any criteria imposed by subjective values or standards [63].

In opposition, the qualitative paradigm is based on interpretivism and constructivism, accepting the existence of multiple truths according to one's construction of reality, which is not just subjective but also continuously evolving [63]. Thus, in qualitative research, the investigator and studied phenomenon are tightly connected, and the final results are strongly dependent on the context of the situation in which the research is conducted [63].

Table 4.1: Design-Science Research Guidelines [36, Table 1, p. 10].

Guideline	Description
Design as an Artifact	Design-science research must produce a viable artifact in the form of a construct, a model, a method, or an instantiation.
Problem Relevance	The objective of design-science research is to develop technology-based solutions to important and relevant business problems.
Design Evaluation	The utility, quality, and efficacy of a design artifact must be rigorously demonstrated via well-executed evaluation methods.
Research Contributions	Effective design-science research must provide clear and verifiable contributions in the areas of the design artifact, design foundations, and/or design methodologies.
Research Rigor	Design-science research relies upon the application of rigorous methods in both the construction and evaluation of the design artifact.
Design as a Search Process	The search for an effective artifact requires utilizing available means to reach desired ends while satisfying laws in the problem environment.
Communication of Research	Design-science research must be presented effectively both to technology-oriented as well as management-oriented audiences.

By crossing these two research paradigms with the purposes and objectives of this work, which include the development of new theories/processes, we concluded that a qualitative approach should be adopted to evaluate the progress and final results of this dissertation.

4.3 Expected results

As mentioned in Chapter 1, our planned contribution involves the development of an Agile methodology that is suitable for open innovation processes. The background and state-of-the-art analysis that we have carried out and presented in Chapter 2 has led to a better understanding of the open innovating and co-creation processes, including their general structure, risk handling, and other critical factors. Furthermore, we explored the relationship between Agile and Innovation, as well as existing Agile frameworks and their contribution to each phase of an innovation process.

Considering our objectives (c.f. Section 1.3) and the information we have gathered so far, we expect to design a solution based on Mobius that is able to increase agility across all phases of open innovation initiatives and attend to the specific needs of the City Catalyst project (c.f. Section 3.4).

Chapter 5

Mobius for City Catalyst

5.1 Overview

As described in Section 1.2, Open innovation processes in cities may benefit from more agility and efficiency, especially considering the pace at which ideas emerge and circumstances change.

During literature review, we came across different innovation catalyzing frameworks but none of them covers all the phases of an innovation process (as per listed in Section 2.3.4). Hence, although these represent great references of successful and hugely adopted Agile frameworks, our proposed solution will have the Mobius framework as the starting point.

Even though this framework was not initially designed to improve processes in cities, it is specially tailored to open innovation. It can potentially adapt to multiple environments, considering the vast number of practices that it encompasses, which are not meant to over-complicate the methodology but rather to make it suitable for different application scenarios. Additionally, this framework explicitly addresses the significant issues and gaps of the initial process (c.f. Section 3.2).

5.2 Mobius cards

The Mobius framework is conveyed in the form of trigger cards, each referring to a practice that fits within one of the phases designed for the Mobius loop (c.f. Section 2.4).

Among the more than two hundred cards available, we decided to make a pre-selection and only review and synthesize the ones that have the higher applicability for open innovation in cities. In practice, this implies that we decided not to present some of the practices that are mostly business-focused, considering that we aim to satisfy the needs of a quadruple helix model rather than an isolated profit-seeking company. Additionally, we noted a few cases of interchangeable cards, with minor differences between and sometimes extending one another. For such cases, we only presented the practice that best fits the applicability scenarios envisaged in City Catalyst.

After sieving the vast amount of practices proposed by this framework, we were still left with over 60 trigger cards, which are presented in the sections below, each referring to a different phase

of the Mobius loop. Besides, they are found prioritized according to the MoSCoW[1] method, as an attempt to remain focused on the techniques which are expected to yield the best outcomes in light of the requirements defined in Section 3.4.

5.2.1 Discovery cards

The Discovery cards are blue and present guidelines on how to get started with an innovation initiative. Their primary focus lies on understanding the existing problems, whom they affect, the context in which they appear, and desired outcomes.

Our preliminary selection resulted in 18 cards, shown in Table 5.3, corresponding to the practices that are most aligned with the discovery needs of City Catalyst.

Table 5.1: Action cards for the discovery phase - Mobiusloop [3].

Card title	**Description**	**Priority**
Frame the Problem	Build the problem map, including the problem description, the context in which it occurs, the respective impact and causes.	Must-have
Outcomes over Outputs	Maximize outcomes instead of outputs by finding the simplest way to deliver increased value.	Must-have
Impact Tracker	Describe the intended outcome, including expected benefits, unit of measurement, method to gather data, the starting point, and expected results.	Must-have
Guerrilla Research	Perform rapid and low-cost research by listing the key questions to be answered, finding the cheapest and quickest way to get answers, getting the whole team involved, and validating early and often.	Must-have
Constraints	Reflect on the limitations inherent to an idea, such as financial, regulatory, or others related to time, capabilities, and method constraints.	Should-have

[1] MoSCoW is an approach to prioritization in tending-towards agile environments, allowing teams to understand what is essential to launch and what is not [80]. Its name derives from the four classifications that this method proposes [80]:

- **Must have** – Features without which the product cannot be launched.
- **Should have** – Features that are not critical to launch, yet deliver important value.
- **Could have** – Features that are considered as nice to have but are first to be removed from scope if the project's timescales are later at risk.
- **Won't have** – Features that are excluded from scope for the planned duration.

Cause and Effect Map	Note down each effect and cause of a problem and draw connections among them in order to find the root cause and decide which to focus on first.	Should-have
What If	Reframe the problem by asking if it is possible to revert it, change the context, change the players, eliminate the problem, or by building on it.	Should-have
Research Card	Reflect on the goals, motivations, methods, and highlight points before initiating a research initiative.	Should-have
Interviewing	Listen to users uninterruptedly, treat them as experts, and frame questions neutrally during interviews.	Should-have
Research Questions	Create questions to discover the problems, outcomes and pain points of the end user.	Should-have
The Big Question	Understand the driving purpose behind an initiative, namely what is trying to be achieved and which obstacles should be considered.	Should-have
Stakeholder Target Map	List the different stakeholders of an initiative and organize them in order of importance, from end users to decision makers.	Could-have
Ishikawa Diagram	Build a diagram in the form of a fish where different facets of a problem are represented and explored into categories.	Could-have
Qualities	Define the quality levels of a product or service, i.e., metrics to measure desirability, build-ability, and maintainability.	Could-have
5 Whys	Ask "why" multiple times (presumably 5 times) until the root cause of a problem is found.	Could-have
Journey Map	Develop a visual model that describes the path that a user takes to accomplish their goals, including touch points and interactions with the service.	Could-have
Flow Efficiency	Focus on the whole flow rather than the efficiency of an individual component by measuring end-to-end cycle time and reducing bottlenecks.	Could-have

Mantra	Capture the essence of an idea in a single line and present it in the form of a pitch to a new person, checking if it sticks and is memorable.	Could-have

5.2.2 Ideation cards

The Ideation cards are orange and aim to help generate options that contribute to delivering the intended outcomes. In other words, they suggest ways to identify what work needs to be done according to the strategy defined.

Our preliminary selection resulted in 21 cards, shown in Table 5.2, corresponding to the practices that are most aligned with the needs of the project with regards to this innovation phase.

Table 5.2: Action cards for the ideation / options pivoting phase - Mobiusloop.

Card title	**Description**	**Priority**
Generate Options	Choose a validation and delivery approach, then estimate the impact of the outcomes using the ICE score.	Must-have
Design Sprint	Turn ideas into testable hypothesis by mapping the problem, sketching competing solutions, and making decisions.	Must-have
Generate Ideas	Naturally write down ideas as they emerge without any judgement or boundaries, build on other ideas, and finally converge by simplifying and choosing the ideas to pursue.	Must-have
Design Studio	Organize collaborative sketch lab events where new ideas are generated rapidly after framing the problem and the outcomes desired, and then presented to each other for feedback and improvement suggestions. The best ideas are collectively chosen to move forward.	Must-have
Options Pipeline	Classify the available options with an ICE score to help decide which are the upcoming options to be worked on.	Must-have

Learn Early, Learn Often	Invest in inexpensive and easy-to-run tests when uncertainty is high and learn as much as possible. Investment can be intensified as confidence grows to deliver the necessary quality levels.	Must-have
Prioritize Options	Define which jobs really matter by placing all the options on a graph based on the impact on the outcomes and effort needed. Confidence level should also be recorded on top of each option.	Should-have
Prototype	Rapidly develop and refine new ideas, simulating how they might work when applied to the real world.	Should-have
Invest on Demand	Invest only where and when is needed. In practice, invest based on assessed outcomes, i.e., in areas where the highest value is being created.	Should-have
Hypothesis	Structure a hypothesis as a testable idea, specifying what will be created, who will be affected, and expected improvements.	Should-have
Assumptions	Understand the beliefs that are being tested, on the desirability, viability, and feasibility level.	Should-have
Experiment	Carry out experiments, with defined setup, metric, and validation means, to validate or refute what is assumed to be true.	Should-have
Test Feasibility	Test options and ask questions to find out if it is feasible to implement and support them.	Should-have
A/B Split Testing	Test an alternative path by splitting a portion of users to a "B" version of a product of service and then comparing the results.	Should-have
Multi-Armed Bandit Testing	Begin with exploring between two different options (exploration phase) and later shift the focus onto the best-performing one (exploitation phase).	Should-have
Killer Idea Generation	Free creativity by promoting activities such as Storyboarding, Prototyping, Backcasting, Role-playing, and Co-Creation.	Should-have

Backcasting	Plan from the future backwards: anticipate what may potentially be the best or worst possible future and analyze what can be done to achieve or prevent the different future paths.	Should-have
Napkin Sketch	Solve problems with pictures by drawing each idea on a napkin or piece of paper and writing a headline descriptor and 1 or 2 sentences describing it.	Could-have
Urgency Model	Specify how time impacts the options, classifying them under one of the following urgency models: Expedite, Fixed Date, Standard Urgency, Intangible.	Could-have
Probe	Explore the unknown in a safe-to-fail environment when faced with an idea that brings high uncertainty or intuition tells it might be worth trying.	Could-have
Multivariate Testing	Test multiple combinations of elements and compare the results, allowing to compare a high number of variables than A/B testing.	Could-have

5.2.3 Delivery cards

The Delivery cards come in green color and target the building of prototypes and releases. Besides proposing ways to coordinate the work and release products to market, they also emphasize the measurement of impact, as well as learning and improving.

Our preliminary selection resulted in 24 cards, shown in Table 5.3, based on the aspects that appear to be the most fundamental when developing the ideas proposed within the context of City Catalyst.

Table 5.3: Action cards for the delivery phase - Mobiusloop.

Card title	**Description**	**Priority**
Minimum Viable Product	Develop a product using the minimum amount of resources needed to collect validated learning.	Must-have
Quick Win	Seek the simple gains that can be delivered swiftly so as to keep people motivated and focused.	Must-have
Guerrilla Testing	Setup regular user tests for fast feedback, thus reducing risk and validating that the right product is being built.	Must-have

Retrospective	Reflect on what worked, what needs to be changed, unanswered questions, and new ideas to try.	Must-have
Heart of Agile	Iteratively deliver features, reflect and learn from eventual mistakes, continuously improve based on gathered feedback and improve trust.	Should-have
Analytics	Gather evidence to support decision making before running another iteration of the discovery-run-validate loop.	Should-have
Walking Skeleton	Obtain an end-to-end slice (from backend to frontend) of a system running as early as possible.	Should-have
Dashboard	Keep track of the work in progress in a dashboard and update its state accordingly as it is reviewed or complete.	Should-have
Simple Path Map	Work backwards from the desired outcome, then mapping out the shortest path to reach it.	Should-have
Multi-Track Options	Test multiple ideas in parallel, progressively reducing and improving them, and eventually launching the best one to the market.	Should-have
Options Planning	Hold meetings to plan upcoming options in light of the intended outcomes and convert the former into stories. These meetings may be held regularly or on demand as needed.	Should-have
Team Sync	Synchronize teams with a check-in to ensure everyone is on the same direction and understands what the next steps are.	Should-have
Roadmap Tetris	Develop a dynamic roadmap to schedule the development-related events of products or services, such as releases, holidays and marketing actions.	Should-have
Decide Points	Anticipate the right timing of decision points, i.e. criteria and conditions which make an option worth executing or abandoning.	Should-have

Canary Launch	Adopt an increment launch strategy to reduce risk on big releases, only deploying a product to all users after smaller successful experiments are conducted.	Should-have
Containment	Implement a short-term fix to a problem and only then dig deeper to figure out the root causes and place a systemic fix.	Should-have
Review	Organize regular meetings with end users to share progress and gather feedback, so that impact on the outcomes and new options can then be discussed.	Should-have
Focus and Finish	Limit the amount of work in progress, thus reducing distractions and increasing time to market.	Should-have
Guerrilla Retro	Find the biggest challenge and fix it rather than fixing many small issues in parallel.	Should-have
Continuous Integration	Integrate new code to a software product early and often while obtaining rapid feedback on quality, possibly resorting to automatic mechanisms.	Could-have
Cumulative Flow	Develop a Cumulative Flow Diagram to show the status of work over time and identify bottlenecks.	Could-have
T-Shaped Design	Balance technical risk and user experience by technically building the product while in parallel prototyping the user journey.	Could-have
Toggles	Implement features as toggles that can be easily turned on and off, allowing to disable partially done features and to choose which group of testers gets which features.	Could-have
Dark Launch	Keep features hidden from the users until they are ready.	Could-have

5.3 Proposed practices

Among all the techniques summarized above, we decided to firstly focus on those that presumably add the highest value to the methodology proposed for City Catalyst and are considered essential. Our approach was to delve further into each of these to complement the background information available on the Mobius cards, and then combine it with the reality of City Catalyst in order to find concrete application scenarios and ways to support them. Considering that an innovation platform

for City Catalyst is being built in parallel with this dissertation, we also included a few feature suggestions in the *Applicability & Supporting Tools* section of some practices.

Figure 5.1: Mobius trigger cards [3] that represent the techniques proposed for City Catalyst.

5.3.1 Framing the Problem

Rationale

The City Catalyst project proposes to improve the quality of life in cities by making efficient use of the resources available, as stated in the methodology requirements (c.f. Section 3.4). This condition calls for a profound reflection on the problem being solved, ensuring it is well understood and therefore reducing the risk of generating and implementing ideas that deviate from the ideal solution to the problem. Hence, we classified this technique as a must-have for the proposed methodology and deemed it the main focus for the delivery phase of the Mobius loop.

Background

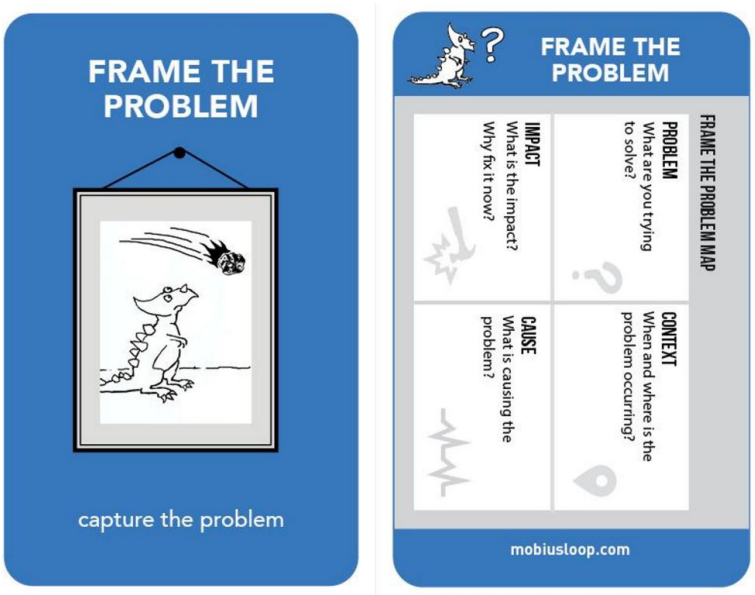


Figure 5.2: Frame the problem – Mobius trigger card [3].

Framing a problem helps capture its essence, obtain the necessary information to understand it fully, and ensure that everyone comprehends it the same way [17]. In particular, this activity involves clearly describing:

- The problem that needs to be solved;
- The temporal and spatial context in which the problem occurs;
- The impact that the problem is causing;
- The reasons for which the problem should be solved now;
- The causes/origins of the problem.

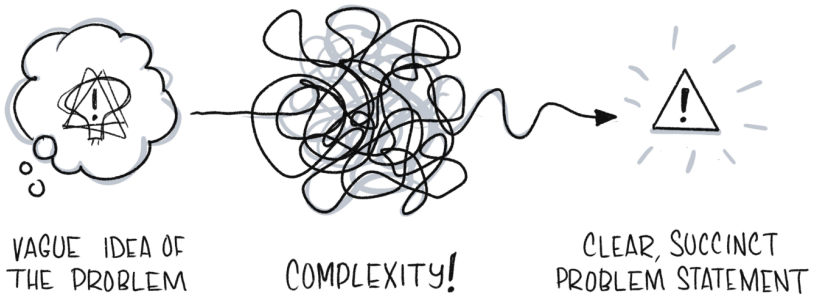


Figure 5.3: Process of defining a problem [23].

While this effort can be time-consuming, examining a potential challenge and understanding it thoroughly in its essence and implications may end up being invaluable when it comes to increasing the focus and certainty about an issue, which are fundamental for a successful change [17].

The way a problem is framed or described can determine the kinds of options considered to address the problem, stakeholders' perceptions of its importance, and the achievement of the desired solution [17].

Considering the way a problem is framed can be determinant of the stakeholders' perceptions of its importance and the accomplishment of a thriving solution, it is desirable to [17]:

- **State the problem in a simple way**, as the attempt to define it with fewer words helps in reaching its roots;
- **Research and collect information** in order to gain awareness of the context, implications, consequences, importance, and urgency of the problem;
- **Attempt to rephrase the problem**, either validating that the nature of the problem has been accurately defined (when reframing is not possible), or discovering a new, perhaps more strategic and success-leading, perspective of the problem;
- **Challenge assumptions** to check if decision-making is not being conditioned by unconscious assumptions.

Applicability & Supporting Tools

All the problems proposed within the City Catalyst project should be described as aforementioned before proceeding to ideation and implementation of solutions. Even though the problem details may be updated later according to feedback and suggestions received, it is important to describe the problem as precisely as possible and ensure it is well understood from the beginning, i.e., as soon as it is first submitted to the innovation platform. Preferably, the platform should implement forms specifically designed for problem description, following the format presented above.

5.3.2 Outcomes over Outputs

Rationale

The preference for outcomes over outputs is the heart of the Mobius framework, hence it is imperative to explore this mindset and guarantee that it is present in the various phases of the innovation process structure proposed for City Catalyst. The latter is driven by several objectives of huge complexity (c.f. Section 1.1 & 3.1), so attempting to draw a path that hopefully hits the target is a "shot in the dark". On the other hand, when the outcomes work as a compass and everything else is worked backwards, we expect to achieve much better results.

Background

Figure 5.4: Outcomes over outputs – Mobius trigger card [3].

Over the last decades, there has been an increasing interest from many stakeholders not to simply measure workloads and accomplishments, understood as outputs, but also to measure the results, typically referred to as outcomes, of government and nonprofit efforts [51]. Outcome data has been precisely adopted to measure management performance and assess the effectiveness of programs and policies [51].

When it comes to R&D, measuring innovation traditionally focuses on inputs, such as human resources for innovation, and the outputs that are generated by transforming research infrastructures and knowledge into tangible innovations [41]. Although innovation outcomes come as a consequence of the introduction of innovations [41], this does not mean that all the innovation outputs correspond to the desired outcomes [2].

On this premise, the Outcome-Driven Innovation paradigm emerged, a strategy and innovation process based on the assumption that learning the customer needs should be prioritized over

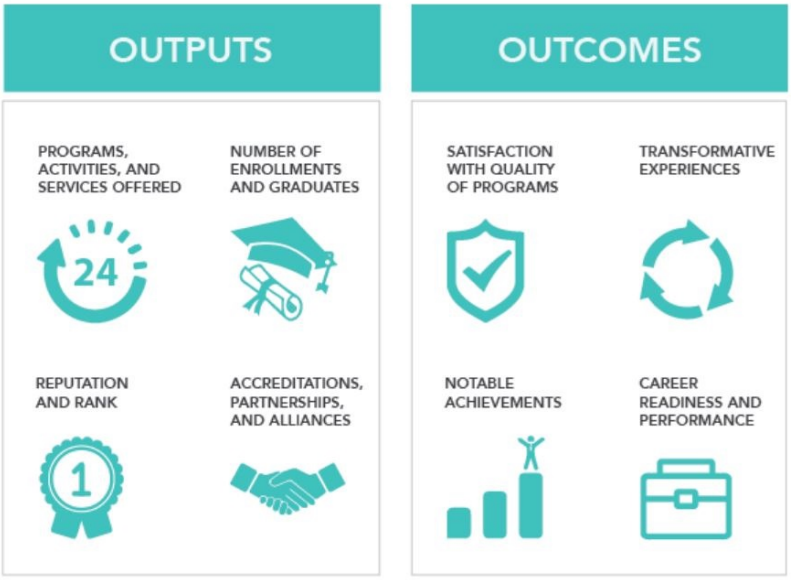


Figure 5.5: Examples of outputs and outcomes [79].

delivering features that may not necessarily fit their needs [76]. This approach has the results as a unit of analysis rather than the product [76] and thus aims to find the simplest way to deliver the so wanted outcomes.

Applicability & Supporting Tools

The principle that outcomes should be privileged over outputs should be inherent in every analysis and decision. The same philosophy applies when providing feedback to problem submissions, as it is essential to distinguish genuine problems that affect the actors of the quadruple helix from those whose resolution is more likely to yield outputs than meaningful outcomes. Therefore, in the context of problem framing and collaborative suggestions, we recommend that it is possible for other users on the platform to rate the relevance of the problems proposed. The definition of challenges targeting outcomes rather than outputs should not be neglected in any way, since it conditions not just the ideation and options pivoting process but also the objective judgment of innovative solutions.

5.3.3 Impact Tracker

Rationale

Keeping track of the results produced is fundamental to achieving the desired outcomes emphasized in Section 5.3.2. If the latter are pragmatically described and precise assessment methods are defined, it becomes much easier not just to evaluate the degree of success of the final solutions but also to monitor work in progress in light of the target outcomes.

Background

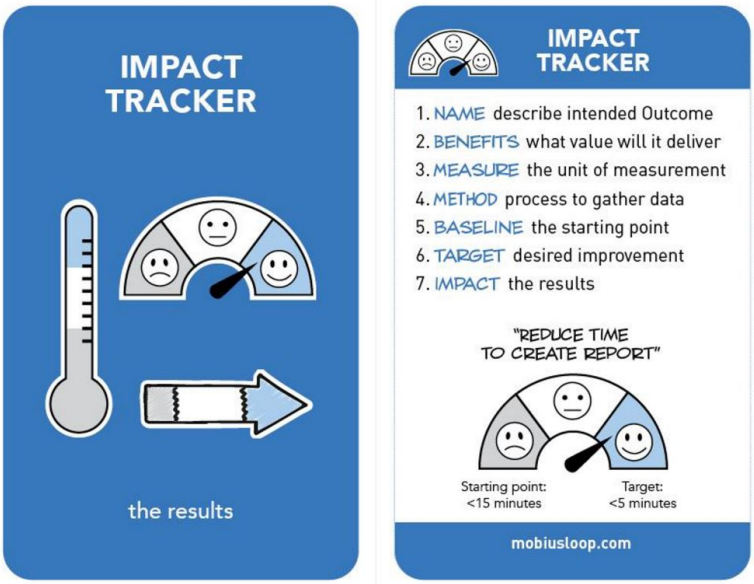


Figure 5.6: Impact tracker – Mobius trigger card [3].

The Agile culture strongly promotes continuous improvement and consequently requires metrics to measure the fitness or success of the solutions implemented [34]. Monitoring the development of products or services is extremely important not just to ensure that a project is on schedule, but also to evaluate to which extent a solution meets its purpose, allowing to readjust its direction often while learning from mistakes [34, 75].

The effectiveness of this activity is intimately connected with the evaluation metrics defined, as the truism "you get what you measure" suggests [34]. Appropriate metrics should privilege outcomes over outputs, as the Agile philosophy promotes simplicity and aims to maximize the amount of value delivered rather than the amount of work done [34]. Besides, they should measure at least one level above, i.e., play on a broader spectrum rather than sub-optimized parts of a whole [34]. For convenience and efficiency, it is also desirable that metrics are easy to collect, as they are expected to act as a recurrent benchmark that will run multiple times across the development of a project [34]. Last, they should be as transparent as possible, discourage false assumptions, and lead to meaningful conversations, as these can be a handy tool for process improvement [34].

In addition to defining clear metrics, tracking impacts includes early description of starting point, intended outcomes and subsequent benefits, and process to gather data [2].

Applicability & Supporting Tools

Once a problem is universally understood as an important target of action, it is time to start planning how to track the impact of eventual solutions. The City Catalyst project may benefit from defining metrics – as well as other aspects covered in the section above – early in the innovation process. Although they are more likely to prove useful in later stages, namely in the delivery

and options pivoting phases, exploring and establishing the sought benefits and methods to assess solutions can also help prevent distractions during the ideation phase. These should be registered in the innovation platform, attached or somehow linked to the problem description, and revised hereafter when warranted.

5.3.4 Guerrilla Research/Testing

Rationale

Successful outcomes involve not just the correct development of brilliant ideas but also the discovery of the latter. Despite all the strategies and exercises that one can put into practice to achieve reliable estimates on how a product or service may impact the satisfaction of a need, sometimes it can be challenging to reach consensus, and intuitions may diverge. In these situations, investigating such options further turns out to be desirable; however, traditional forms of research are time-consuming and costly, making them unviable for a dynamic environment where many ideas will emerge and fail. This is when Guerrilla Research comes in handy, as it is designed to aid decision-making, reduce risk, and help projects move more effectively with minimal investment.

Background

Figure 5.7: Guerrilla research – Mobius trigger card [3].

Guerrilla research aims to learn about and understand new experiences in a quick and low-cost way. The term "guerrilla" indicates the public, open, and "wild" nature of this research methodology, involving the interaction with people in the field [72, 5]. In comparison to full research programs, it also provides more time and spatial flexibility while still providing enough insight to support decision making [5].

Figure 5.8: Guerrilla testing – Mobius trigger card [3].

The limitations of guerrilla research appear when applied to complex or sensitive subjects or when "expert" personas with specific domain knowledge are required [72, 70]. Nevertheless, as long as the research has a small scope, it can prove to be an exceptionally effective tool to get questions answered and to get products or services tested at any level of fidelity, from paper prototypes to high-fidelity mockups [72, 5]. A summary of the scenarios that are more favorable to guerrilla recruitment and more rigorous recruitment is presented in Table 5.4.

Table 5.4: Summary of when to use guerrilla recruiting techniques and when to be more rigorous [70].

Guerrilla recruiting	**More rigorous recruiting**
When the situation doesn't require specific domain knowledge.	When background/domain knowledge is really important to the study's goals.
When gathering first impressions of something anyone may see, such as a landing page.	When sensitive topics such as health, money, or relationships will be discussed.
When budget or time is very cramped and the alternative is no research at all.	When the luxury of time and resources is available.

The success of guerrilla research can be maximized by taking the following aspects into account [72, 5]:

- **Definition of the goal**: prior to beginning a research initiative, it is crucial to clearly define what will be asked and/or tested at the feature level and how the findings will be used.
- **Definition of the participants**: even if the guerrilla approach does not target an audience with specialized knowledge, choosing the participants whose profile is most compatible with

the features being tested or questions asked can increase the reliability of results obtained. In order to find such participants, one may implement a recruitment screener, i.e. a set of questions to determine whether a given candidate qualifies for the research. Sometimes, it may also be desirable to contemplate a mix of people (for example, with different tech proficiency) as some solutions can be more comprehensive in terms of the target audience.

- **Location**: the location where the experiment takes place should, whenever possible, represent the realistic context of use of the solutions under test, while rich in human traffic and tendentially frequented by the target audience.
- **Independency**: during research, one should refrain from being biased about the people interviewed or selected for an experiment. These should be chosen arbitrarily even if that means higher rejection rates, the only exception being people who are clearly in a hurry and thus are unlikely to be available for a discussion.

Applicability & Supporting Tools

Guerrilla Research can be applied in different phases of the innovation processes in City Catalyst.

For the discovery phase, this technique comes as a solution to address potential doubts or difficulties when framing a problem and defining the intended outcomes. This lightweight form of research can be used to better understand the problem to be solved, its origins, and its impact (c.f. Section 5.3.1). Concrete examples within the context of City Catalyst may include conducting field surveys of citizens affected by the proposed problems.

On the other hand, later in the delivery phase, this practice comes in handy when testing individual aspects of a product or service (i.e., features), allowing to obtain quick feedback either from experts or from the audience whom the solutions target. For the City Catalyst project, this means a better efficiency of resources usage when building products (including Minimum Viable Products, as covered later in Section 5.3.10), as these are built with a higher degree of confidence due to early validation of core features.

5.3.5 Design Sprint

Rationale

Problems affecting citizens and industries can sometimes be of considerable complexity, which constitutes a threat to the agility of their resolution. Tackling this issue involves breaking the problems down into parts and addressing more minor challenges, where Design Sprint can play a huge role. This framework helps convert ideas into testable hypotheses and validate them quickly (generally one week), which is elemental to increasing agility in the City Catalyst project.

Background

For enterprises, it is essential to accelerate time to market and allocate the resources toward the right ideas, under penalty of launching products that customers do not want [12]. Design sprint is

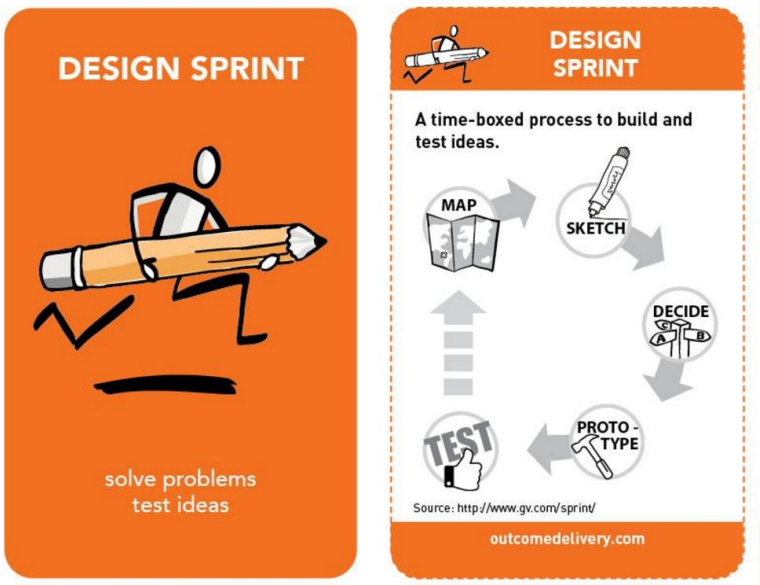


Figure 5.9: Design sprint – Mobius trigger card [3].

a flexible product design framework that aims to address this challenge by helping make sense of the complicated design considerations and reduce the waste of time going in the wrong direction [12]. With this goal in mind, design sprints usually involve converting problems or objectives into a narrative and then physically crafting potential solutions so that practical and emotional user feedback may be collected via testing and used to determine the path for further design and development work [12].

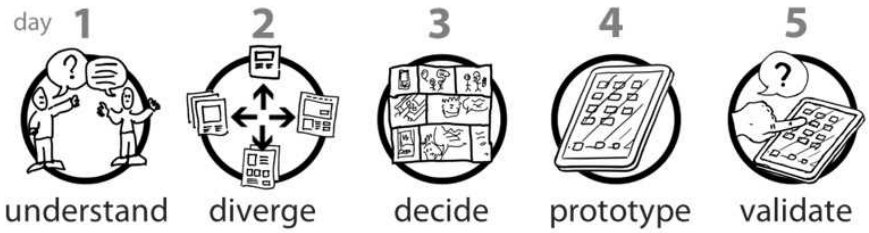


Figure 5.10: Phases of a one-week Design Sprint [25]

This iterative and experimental innovation-catalyzing approach [46] consists of five discrete phases [12, 6, 38]:

- **Understand / Map** – Mapping of the challenge and commitment to a long-term goal, followed by a background review, share of initial knowledge among the experts available in the project, and definition of an ambitious yet manageable target to be achieved in one week.
- **Diverge / Sketch** – Brainstorming of possibilities to solve the target problem based on sources of information such as solutions in alternative spaces, eventually leading to a broad range of individually sketched solutions.

- **Converge / Decide** – Converging from the stack of solutions obtained in the previous phase into a single one, after critically analyzing each of those and ranking them according to their likelihood of achieving the intended long-term goals. Reaching this consensus is fundamental as it marks the direction of the design sprint, including a plan for the prototype.
- **Prototype** – Development of a prototype that focuses on the customer-facing surface of the solution under test. This prototype should be concluded in one day and thus only integrate the barest elements needed to make it accurate enough to get an authentic response from users in the next phase, by when all the steps that need to be tested should already be mapped out and prepared.
- **Test** – Recording of the user interaction and reaction to the developed prototype, allowing to directly collect feedback from the target audience as to the flaws of the solution. This precious validation input also provides insight into the next steps for further iterations and the next aspects to test.

Applicability & Supporting Tools

After a problem is adequately explored, running a design sprint should be considered, especially in the case of complex problems for which ideating a complete solution without validating certain hypotheses is not viable. In order to quickly generate options with a reasonable degree of validation and confidence, a group of people from academia or industry may collaboratively work for one week to gather ideas, prototype one or some of them, and obtain feedback from real users in the field. The process and results should be documented in the open innovation platform, not just to ensure that everyone is aware of such experiments, thus ensuring transparency, but also to record them for later consideration when the time to rate options and make decisions comes.

5.3.6 Generate Ideas

Rationale

Successful innovation and brilliant ideas go hand in hand. After enough discovery of the problems impacting cities, it is necessary to start generating ideas with the potential to either address the problem as a whole or smaller pieces of it. However, just ideating solutions can be already challenging due to the creativity demanded, so being too logical in the process and hopelessly attempting to come up with the best solution right at the beginning can be very frustrating. Therefore, it is vital to avoid this negative impact by taking pressure off the process and creatively stimulating the participants.

Background

Generating ideas is considered the first phase of the innovation value chain, followed by conversion and diffusion [33]. The effectiveness of this phase can be determinant to unleashing a stream of profitable products or services in the case of a company [33].

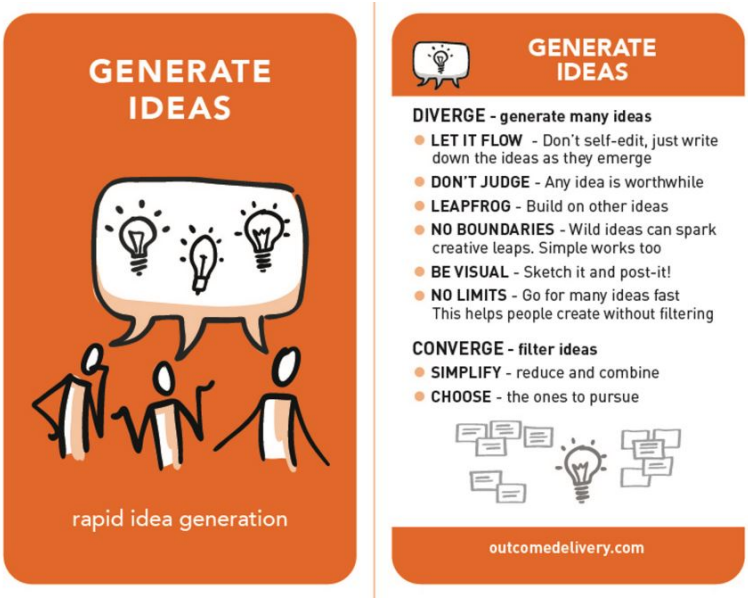


Figure 5.11: Generate ideas – Mobius trigger card [3].

Nevertheless, it is important to notice that many of the soundest ideas for products and services no longer originate from well-financed government and laboratories but rather from almost anyone [43]. The more recent democratic and open innovation approach has been victorious in taking advantage of distributed knowledge and diverse skills [43]. At the same time, opening the idea-creation process brings some complications, namely when participators and managers tend to underestimate its potential and overcontrol it [43].

The Mobius framework proposes concrete guidelines to follow in generating-ideas activities [2]:

- **Let it flow** – Ideas should not be self-edited but rather flow naturally and be written down as they emerge.
- **Do not judge** – During brainstorming sessions, every idea should be considered worthwhile, so natural inclination for critical thinking should be restrained.
- **Leapfrog** – Besides generating ideas "from scratch", building on other ideas can be likewise enriching.
- **No boundaries** – There should not be established any kind of boundaries during the idea generation process, as wild ideas can sometimes work or at least work as a creativity stimulus.
- **Be visual** – Having a visual support can help better convey an idea keep track of it for later discussion.
- **No limits** – Filtering ideas should be avoided as the primary goal of this activity is to generate as many ideas as possible.

Applicability & Supporting Tools

Generating ideas is not a practice itself but rather an activity that takes place in multiple events of the innovation process (e.g. Design Sprint). Given its relevance to drawing a solution path, it's crucial for the idea generation process to flow as per the mindset and guidelines noted above.

In spite of that, events that solely focus on the generation of ideas and involve a broad audience may similarly be held. For a matter of convenience and flexibility, we believe such events should occur online, since that way more participants can join and, consequently, more ideas are available.

When presenting ideas in public, one may easily fall into the temptation of self-editing them due to the fear of judgment. That is totally undesirable as it might be better to share row thoughts and also allow others to build on them. Therefore, means of providing ideas anonymously should be available (e.g., using an existing anonymous feedback tool).

This collective effort can potentially act as a deadlock breaker to problems whose solution is not apparent. By the end, the most promising ideas or solutions should be posted in the innovation platform, following the format addressed in Section 5.3.1.

5.3.7 Design Studio

Rationale

The practice of open innovation calls for mechanisms of participation for various stakeholders, including citizens who may want to contribute to cities' development and provide their input. Activities such as sketch labs can potentially promote the share of knowledge among the participants, foster creativity, and help collectively figure out the most promising concepts.

Background

The Design Studio methodology is a rapid iterative approach conceived for teams of varied individuals working together to analyze ideas, generate and evaluate alternatives, and eventually make decisions and take action to solve a design problem [30]. This process can be used not only for artifacts of physical form (e.g. architecture models) but also for non-physical ones (e.g. software) since designing follows common characteristics regardless of the domain [30].

Carrying out a collaborative event following this technique involves the following steps [73, 2]:

- **Align** – Introduce the participants to the problem framing (c.f. Section 5.3.1) and allow room for questions, thereby ensuring that everyone understands the problem. If necessary, the host may also ask questions to the participants to see if their answers are aligned with the actual issue.

- **Sketch** – Allow each attendee a few minutes to come up with ideas and sketch them quickly, such as in the form of UI wireframes, comic strips, or phrases (c.f. Image 5.13. During this period, participants should focus on quantity rather than quality, similarly to the Generating Ideas approach covered in Section 5.3.6.

- **Present** – Proceed with a pitch session, where people shortly present their ideas and also offer feedback and improvement suggestions to others.
- **Choose** – The team of participants collectively decides which ideas appear to be the best solution to the problem being solved. Those move forward for further refinement or implementation.

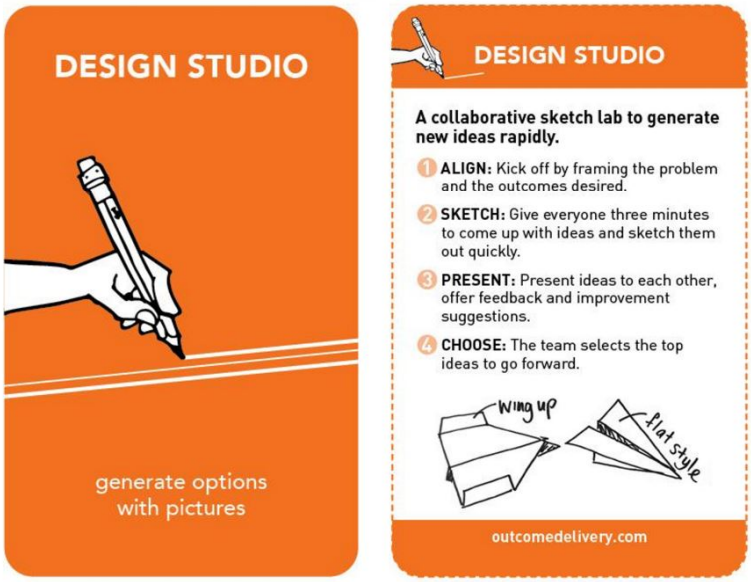


Figure 5.12: Design studio – Mobius trigger card [3].

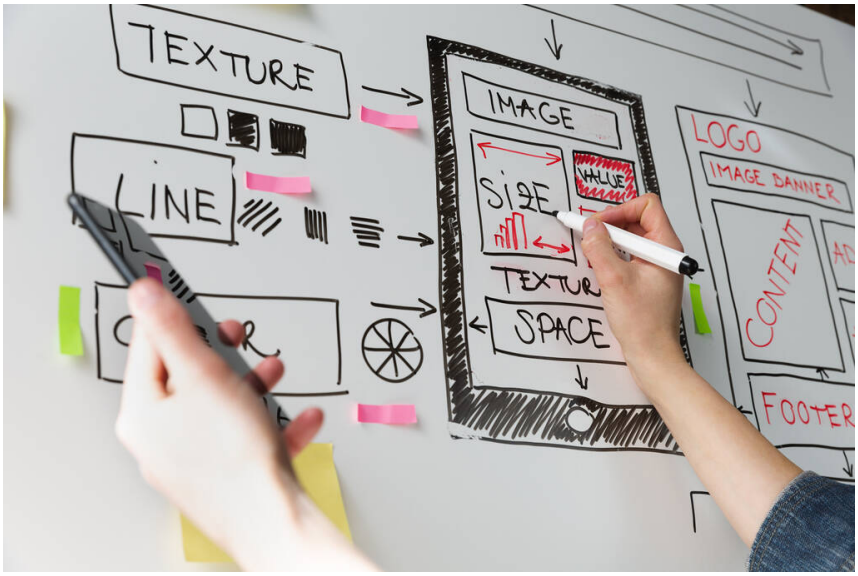


Figure 5.13: Example of interface sketching in paper.

Applicability & Supporting Tools

This type of collaborative event resembles the idea generation activities mentioned in Section 5.3.6 but introduces the concept of sketching, making it a more effective option for solutions that may benefit from visual support. Compared to solely focusing on mining ideas, this implies an overhead, leading to fewer ideas being proposed in a similar period of time. However, even though quality is not the ultimate target of these events, they still allow exploring ideas in more detail through sketching, while also contributing to a better understanding of them. That said, for problems that appear to have relatively predictable solutions and whenever digging slightly deeper than simply throwing up ideas is desirable, carrying out events based on this methodology can be of immense benefit. These should be ideally scheduled and listed in the innovation platform, as well as reference the respective problems they aim to address.

5.3.8 Options Pipeline

Rationale

Making choices is a recurrent need in open innovation and has been previously mentioned as an important step in some practices recommended by the Mobius framework, such as Design Sprint (c.f. Section 5.3.5) and Design Studio (c.f. Section 5.3.7). For these reasons, it is fundamental to have methods to prioritize options in a quick and agile way – a premise on which the ICE Scoring Model is based.

Background

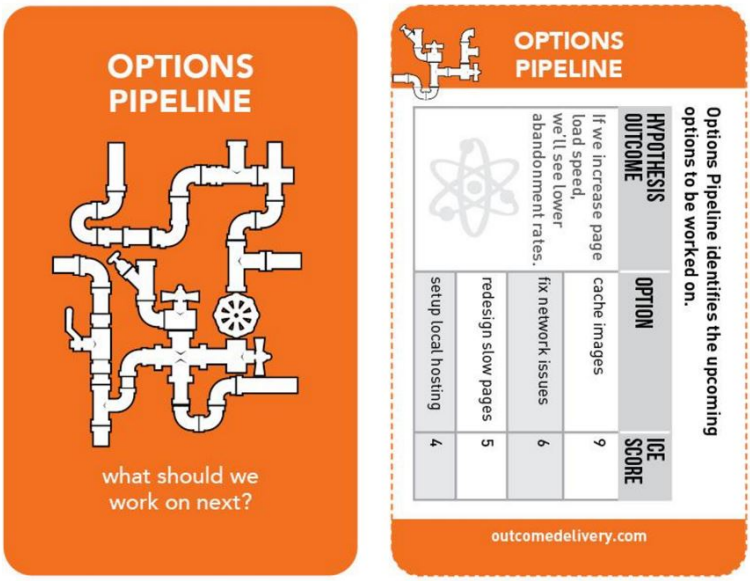


Figure 5.14: Options pipeline – Mobius trigger card [3].

The ICE score is a way to prioritize features or options among others, including Weighted Scoring, Weighed Shortest Job First, and Opportunity Scoring [74]. The ICE acronym stands for Impact, Confidence, and Ease, which are the three levers of this feature evaluation method [54].

Impact refers to the impact that a given feature has on satisfying the needs of the target audience, whereas Confidence is the measure that indicates the degree of certainty that the estimated impact will indeed happen [74, 54]. As for Ease, it describes the amount of work or effort that will be required to launch the feature [74, 54].

Each of these factors is graded on a scale of 1-10, and the overall feature worthiness (i.e., the so-called ICE score) is calculated by multiplying the points assigned to each one, thus following the following formula [74, 54]:

ICE Score = Impact * Confidence * Ease

Idea	Impact [0-10]	Confidence [0-10]	Ease [0-10]	ICE Score [I x C x E]
Community tab	7	2	8	112
Update submit flow	5	5	3	75
Add PayPal billing	8	1	5	40
Double opt-in	1	4	3	12

Figure 5.15: Examples of ideas prioritization according to the ICE score [28].

Applicability & Supporting Tools

The methodology proposed for City Catalyst involves exploring options and eventually prioritizing them, as is the case with strategies covered in previous sections, such as design sprints, generating ideas, and design studio. When it comes to making cities smarter, all the three components of the ICE score are relevant and should be considered.

Thus, whenever it is necessary to decide which solutions to explore further or implement, each of those should be rated from 1 to 10 with regards to impact, confidence, and ease. The available options are then prioritized according to the product of these three values. When multiple participators vote and the average rating is considered, the options must have a comparable number of votes. Ideally, each participant should rate every option under consideration, otherwise results may become harder to analyze.

5.3.9 Learning Early and Often

Rationale

Handling risk is a critical aspect of innovation, as some ideas have as much potential as uncertainty associated. Investing grandly in something that has barely been explored can have catastrophic effects on the management of resources available for innovation processes. Ergo, a more conservative approach is desirable until sufficient learning is captured.

Background

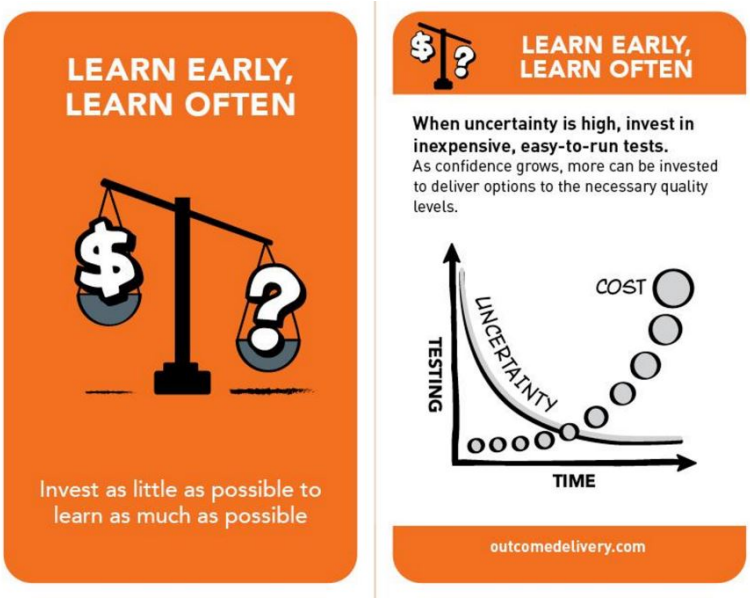


Figure 5.16: Learn early, learn often – Mobius trigger card [3].

The earlier stages of open innovation adventures are particularly characterized by uncertainty and lack of confidence [77]. Over time, as experiments are conducted and lessons are learned, uncertainty tends to decrease exponentially [2]. For this reason, it is fundamental to start learning early and often, as it is the most direct way to gain confidence in the products or services being developed or explored [77].

The thought process for investment should be coherent with the degree of confidence, i.e., the values spent should be inversely proportional to the amount of uncertainty, as illustrated in Figure 5.16. In other words, it might be reasonable to start with a small initial investment, use it to learn as much as possible, and at some point in time, make a follow-on investment [77].

Applicability & Supporting Tools

The City Catalyst project should promote initiatives that maximize learnings with available resources as a way to reduce risk on investment (e.g. Design Studio events, as covered in Section

5.3.7). The Confidence component of the ICE score can be adopted as a criteria to allocate resources.

After an idea or rather a solution proposal is refined through collective feedback and experiments, the degree of perceived confidence and ease may change, so the innovation platform should allow them to be updated.

5.3.10 Minimum Viable Product

Rationale

Once a problem is appropriately framed, broadly understood, and option pivoting activities have taken place, it is time to deliver value.

In spite of all the efforts made to understand the various facets of the problem and make the best choices, which allow reducing the risk of building the wrong product[2], building the product right remains a challenge.

In addition, time to market can be crucial, and waiting until a feature-rich product is built can sometimes mean losing opportunities. Hence, starting with a Minimum Viable Product should be highly considered.

Background

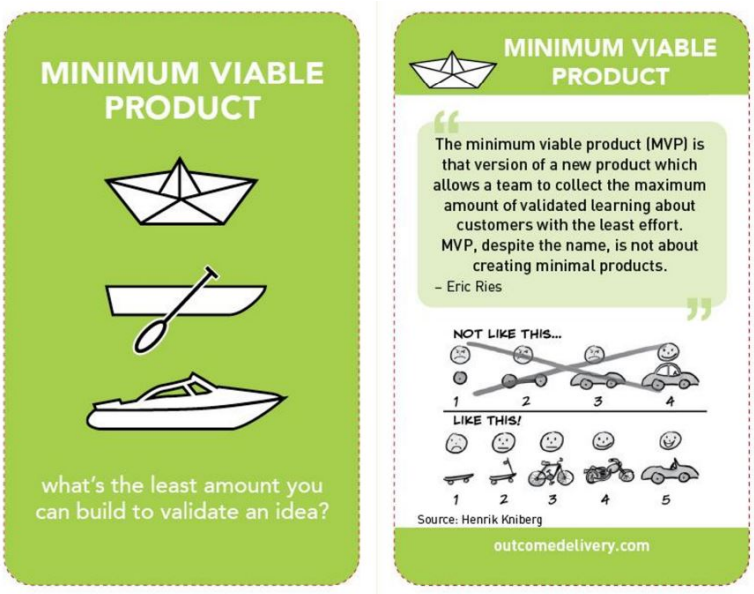


Figure 5.17: Minimum Viable Product – Mobius trigger card [3].

Known as one of the most important Lean Startup techniques (c.f. Section 2.3.5), a Minimum Viable Product (MVP) is described as a version of a new product that allows a team to collect the maximum amount of validated learning about customers with the least effort [58].

[2]We refer to "wrong products" as artifacts that are not aligned with the needs of the target audience. In contrast, we consider that a product is "built wrong" when it is not built according to its specification.

Contrary to what the name suggests, this technique is not about creating minimal products, as an MVP must be complete enough to demonstrate the value it brings to the user [58, 48]. Only then is it possible to conduct trustworthy experiments to understand the value of a product and its growth hypothesis [48].

The choice of which features to incorporate into an MVP should have into consideration what needs to be proved (or disproved) to reduce risk [44]. At the same time, the overall feature-set should bring in useful functionality even if limited in order to fulfill the "basic narrative", i.e., the core purpose of the product [44].

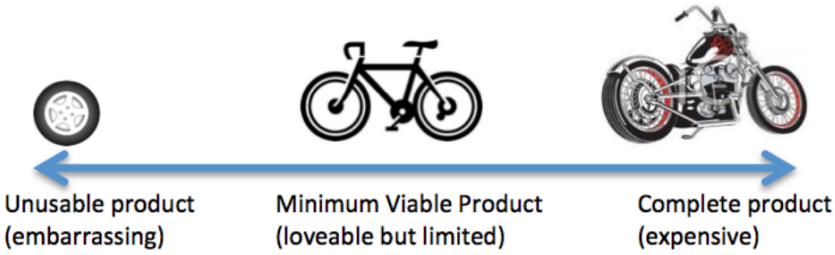


Figure 5.18: Illustration of a poorly vs well conceived MVP [44].

Henrik uses this famous example [44]: if developing a car is our ultimate goal, a good example of an MVP would be a bicycle (c.f. Figure 5.18). While it does not offer the same levels of comfort or speed, it is a means of transportation that one can use and will be a huge improvement compared to walking. On the other hand, releasing isolated parts of the intended product, such as a wheel in this example, will not cause any enthusiasm or allow testing anything [44]. That is because, even though the car wheels can be an essential component of the final result, they are not meaningful when alone.

Applicability & Supporting Tools

Given the need to implement the most promising solutions while managing risk and iteratively delivering value, this methodology appears to be the perfect fit for the deliver phase kick-off. By building a Minimum Viable Product for the solutions with the highest ICE score, it is possible to see how they work in practice and thus test assumptions on their most core aspects. This is closely aligned with the principle of learning often and early (c.f. Section 5.3.9) and therefore brings more confidence regarding the tested solutions and willingness to invest.

This "minimal" version of a product or service should loyally represent its essence so that it is possible to collect reliable feedback once it is tested in the field. If the feedback is positive, that is a good indicator that developing the full solution is worthwhile – even if a few refinements are required – and, consequently, further resources should be allocated to the current option. On the other hand, if the results fall behind expectations, the innovation process should take a step back, going from the deliver phase to the options pivoting phase, where available options should be re-prioritized based on the collected learnings.

5.3.11 Retrospective

Rationale

The Agile development of products and services implies continuous improvement in the way that teams work, not just from the perspective of internal efficiency but also to ensure that the products and services are built according to expectations. In this sense, teams may benefit from periodically stopping to discuss the positives and the negatives of the processes followed and progress made, thereby seeking improvement for the subsequent iterations.

Background

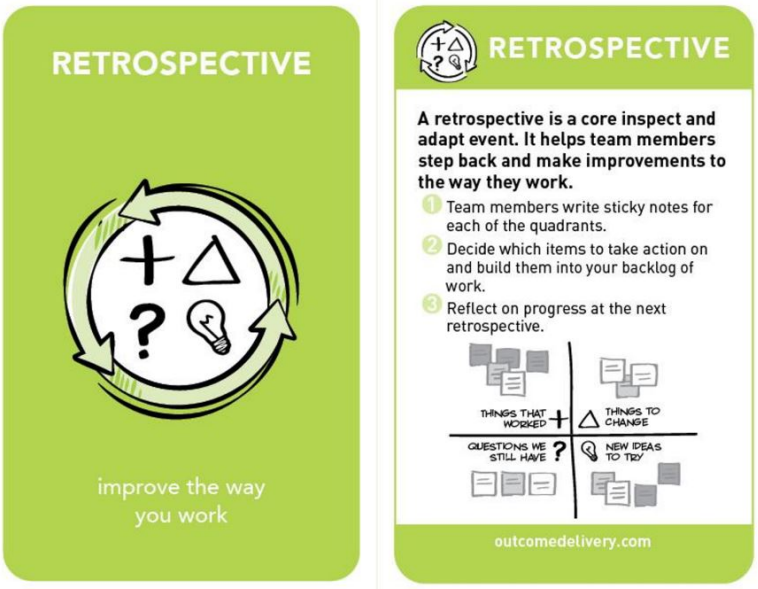


Figure 5.19: Retrospective – Mobius trigger card [3].

The Agile development methodologies, such as Scrum, introduced the notion of short development cycles, also known as sprints [66]. One primary goal of the Scrum development process is to improve the quality, effectiveness, and team productivity from sprint to sprint, hence why team meetings are held at the end of each cycle [27]. These are called retrospective sessions [27].

Retrospective sessions can be held either face-to-face or online, but some anonymity is preferred [27]. Without it, some team members might not feel comfortable and avoid or hesitate to provide genuine feedback, as it may come across as disturbing [27]. Besides, retrospectives can be time-consuming when they are seen as mere group conversations, and no protocol is followed [27].

The retrospective model proposed by the Scrum methodology aims to lessen these issues and thus maximize the potential of these sessions [27]. Essentially, each topic raised during the meeting should be presented in the form of a sticky note, which should fall into one of the following four categories [27, 2]:

- **Things that worked** – Elements that worked well during the last sprint and should remain in the future.
- **Things to change** – Helpful changes that could improve the following sprints. The most impactful candidate improvements should, inclusively, be the target of immediate action in the next sprint.
- **Pending questions** – Questions or issues that have not been addressed yet and may become obstacles in a closer or further away future.
- **New ideas to try** – Suggestions on what could be implemented to improve processes within the team.

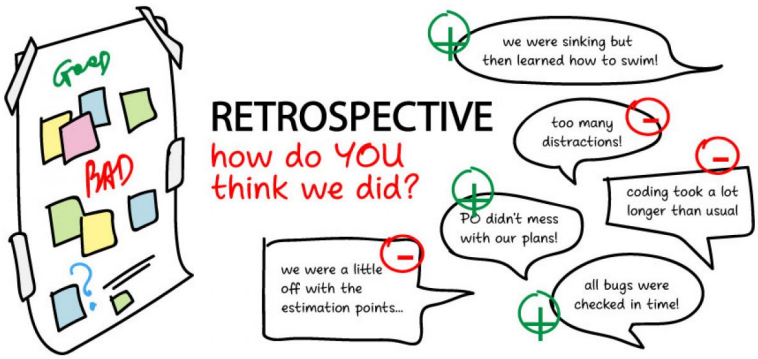


Figure 5.20: Example of retrospective notes [7].

In face-to-face retrospective sessions, these sticky notes can be physically posted on a board, divided into four sections as described above.

Applicability & Supporting Tools

Retrospectives should take place at the end of every development cycle in the City Catalyst projects. Increasing agility in the development of solutions entails not only the validation of the latter but also the improvement of collaboration forms to move ideas faster and increase trust at the development team level. We suggest the retrospective model proposed by the Scrum methodology to be adopted with enough flexibility to allow both open and anonymous feedback.

The feedback should come in the form of notes falling in one of the four categories explored above – things that worked, things to change, pending questions, or new ideas to try. Feedback the two former categories, together with progress made, may be published in the innovation platform, as long as it is not related to the internal functioning of the team.

In addition to providing new feedback, the retrospective exercise should include room to discuss points of improvement mentioned in previous weeks, so as to evaluate if they are being or have been addressed.

5.3.12 Quick Win

Rationale

Some of the problems the City Catalyst proposes to address may involve relatively complex solutions. While creating complete solutions is excellent and ultimately necessary to solve a problem, setting it as the initial goal can turn out to be demotivating. In the worst case, projects can be abandoned halfway through due to the lack of visible progress compared to the efforts applied. On the other hand, progressing with little effort and cost while still observing meaningful impact is way more appealing.

Background

Figure 5.21: Quick win – Mobius trigger card [3].

A quick win refers to a rapid improvement in a short period of time, being one of the fundamental goals of Lean Tools – procedures that allow organizations to obtain benefits and eliminate processes that are not valuable [61]. In other words, this philosophy aims for simple yet visible improvement with immediate benefit and low cost [64] (c.f. Figure 5.22).

Even though obtaining quick gains is tempting alone, they should ideally promote long-term benefits, such as acquiring marketing or technical know-how and adapting to collaborative and dynamic processes [64].

Moreover, it is important to highlight the role of people when it comes to ideating and achieving quick wins [64]. If they are aggressive to one another and unreceptive to criticism, chances of success are low. Other major pitfalls include obsession with details, jumping to conclusions early, and micromanaging [64].

On the other hand, factors such as proper credit recognition, collective ownership, and end-to-end vision can stimulate quick wins [64]. The more a learning mindset is adopted and the former

Figure 5.22: Relationship between impact and effort implicit in quick wins [64].

factors are fostered, the higher the chance of delivering quick value to the target audience and, consequently, the higher the motivation and focus of the people working on it [64, 2].

Applicability & Supporting Tools

The "Quick Win" mindset should be visible in any phase of the innovation processes carried out by the City Catalyst project, but especially during the deliver phase. Obtaining quick gains with little effort can be particularly helpful in overcoming complex and demotivating deadlock situations, which may include, for example, lack of resources or undesirable external dependencies.

In addition, this philosophy should be adopted as a criterion for choosing initial features for the Minimum Viable Product in order to maximize its potential, as covered in Section 5.3.10. During subsequent sprints, "Quick Wins" may likewise serve as a basis for feature prioritization.

5.4 Summary

In this chapter, we introduced a toolkit for improving innovation processes in cities. This toolkit is rooted in the Mobius framework, approaching techniques that cover the different phases of an innovation process. Considering our target context, we have selected just a few of these suggested practices and built on them in order to better satisfy the specific needs of the City Catalyst project, including its innovation platform. In this sense, we performed further research to strengthen the knowledge about the proposed techniques, provided guidelines on how they should be used, and bridged some of these practices with features that the innovation platform should support.

Chapter 6

Results

The primary aim of this chapter is to document the experiments and inquiries that were carried out in order to validate our suggested approach.

6.1 Introduction

When it comes to concrete products or artifacts, it is relatively simple to establish metrics to assess if and to what degree they fulfill their intended purposes. In contrast, evaluating a methodology of this nature has higher inherent subjectivity, which also justifies our choice for the qualitative method (c.f. Section 4).

This way, we reached the conclusion that the most effective and reliable form to test the proposed methodology would be to exercise it and assess factors that go hand in hand with the requirements defined in Section 3.4. Having this in mind, we idealized two different ways to validate our work.

6.2 Workshop

We had initially planned to host a workshop to raise awareness of the importance of agile methodologies in accelerating open innovation processes and, above all, obtain validation of the methods developed for City Catalyst.

Our initial plan was to contact local councils in an attempt to collect real challenges and approach one of them during the workshop session. However, considering time restrictions, we realized this would be unfeasible. Instead, we decided to search for problems that affect the majority of cities and thereby find a hypothetical challenge. In addition, since we deemed audience engagement extremely important, the proposed challenge should be able to motivate the participants and stimulate their creativity. With these criteria in mind, we ended up presenting the following problem statement:

> "Mobility is necessary to ensure access for all to work, education, basic services and product, leisure and health facilities and to friends and family. Local authorities are

> currently faced with numerous challenges linked to transport patterns such as congestion, insecurity, air and noise pollution and increasing difficulty to ensure mobility for the most vulnerable populations and cover the rising cost of public transport infrastructure investment and management. Urban transport and particularly urban freight and private cars are estimated to account for around one quarter of CO2 emissions in Europe. A low carbon, efficient and inclusive mobility strategy providing attractive, cost-effective and accessible alternative mobility solutions is essential for quality of life and air, economic appeal as well as for social cohesion, reduction in infrastructure budgets over the long term and climate mitigation." [4]

This event had a planned duration of 90 minutes and its agenda would include:

- Opening, introduction and presentation of the agenda;
- Contextualization of Agile values and their importance within the project;
- Brief presentation of the methodology designed for City Catalyst;
- Presentation and implementation of the proposed activity;
- Gathering feedback from participants on the effectiveness of the activity and satisfaction in relation to the results obtained;
- Wrap-up and closing comments.

Unfortunately, it was not possible to schedule this event with a reasonable number of attendees. However, for future reference, we still opted to document it.

6.3 Survey

The survey methodology consists of gathering information from a sample of entities to build statistics [31]. We conducted a survey to obtain a qualitative and theoretical assessment of our solution. In the following sections, we will present all the details regarding the questionnaire, which may also be found entirely in Appendix A.2.

6.3.1 Target audience

Our solution, despite applying to the broader context of open innovation processes in cities, had a strong emphasis on the specific needs of the City Catalyst project. Thus, we believe that a more credible and rigorous validation involves collecting feedback directly from the project's stakeholders.

However, we did not impose any restrictions regarding the technical knowledge of the respondents. Although we are interested in expert assessment, we also wanted to understand the view of contributors that are not necessarily experienced with Agile development. Our proposed

methodology targets multiple agents of the Quadruple Helix Model; hence we need to test if it is lightweight and easy-to-understand enough to be adopted by people with different backgrounds and experiences.

6.3.2 Structure

The survey was divided into the following 6 sections:

- **Participant's profile** – Basic assessment of the participant's knowledge about Agile methodologies.
- **The Mobius framework** – Questions regarding the suitability of the Mobius framework for open innovation processes in cities.
- **Recognition & Discovery in Innovation Processes** – Questions to assess the perceived importance of discovery in innovation processes and key aspects inherent to the proposed methodology.
- **Ideation & Prioritization in Innovation Processes** – Questions to assess the effectiveness of the idea gathering and prioritization strategies.
- **Product Development** in Innovation Processes – Questions regarding Agile product development techniques.
- **Final remarks** – Wrap-up questions to understand if the requirements initially defined for the methodology are in accordance with the techniques suggested.

It is worth noting that, despite not explicitly mentioned above, all the questions addressed in the survey were answered in light of the City Catalyst context, which we made sure to emphasize in every section.

6.3.3 Limitations

In spite of our attempt to conduct an accurate survey, we recognize that some factors may have influenced the outcomes of the questionnaire, the main one being the number of respondents. Only 8 responses were collected, which invalidates a sustained statistical analysis. We strongly believe that a higher number of replies would increase confidence in our work. Likewise, the distribution of participants when it comes to their technical background and length of involvement in the project contributed to scrambling the results, even though we collected this information by the volunteer will of the respondents.

Besides, the structure and the items of the survey can be viewed skeptically for two main reasons. Firstly, the former may have been excessively oriented to our approach, in the sense that we sought validation of our work but very few questions established a relationship between our methodology and alternative ones. Secondly, regardless of our attempt to focus on the key

aspects of this work, it is questionable whether the array of questions raised in the survey is wide enough to assess the methodology representatively. These possible threats to validity are a trade-off that emerged from our attempt to prevent the questionnaire from overwhelming the participants, especially considering the diversity of the target audience.

6.3.4 Results & Findings

Participant's profile

The majority of stakeholders who answered the survey (5 in 8) have been involved in the City Catalyst project for over a year, indicating that our sample mainly consists of people well versed with the project structure and objectives.

When asked to self-assess their knowledge about innovation in a 1-5 scale, we observed the distribution in Figure 6.1, revealing that our sample is familiarized with innovation processes. To our delight, a fair percentage of participants also seems to have at least hands-on knowledge of Agile methodologies, with an average self-assessment of 3 using the same scale. Additionally, it was interesting to note that a considerable proportion of respondents have heard of the following Agile frameworks: Scrum (8 in 8), Hackathon (5 in 8), Kanban (5 in 8), Design Thinking (3 in 8), Lean Startup (2 in 8), Mobius (2 in 8), and Extreme Programming (1 in 8).

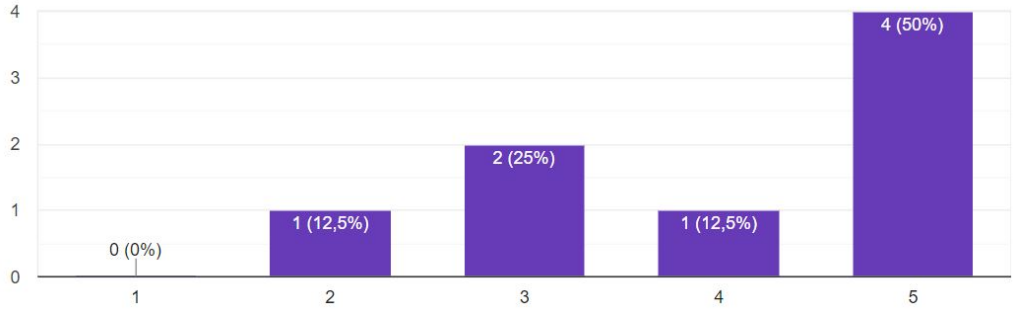


Figure 6.1: Knowledge of innovation of our sample – survey results.

Last, five of the candidates admit to having previously worked on a project where the lack of agility (i.e., lack of short feedback loops or excess of bureaucracy) negatively affected or delayed the outcomes.

The Mobius framework

Generally, the participants are confident about the structure of the Mobius loop being adequate for open innovation processes, both generally and when applied to the reality of smart cities (with average Likert[1] ratings of 4.4 and 4.1, respectively). Likewise, they confirmed that framing and

[1] According to the Likert scale, participants are asked to show their level of agreement (from strongly disagree to strongly agree) given a real or hypothetical situation under study [42]. Within the scope of results interpretation, we are considering the following classifications and values:

- 1 – Strongly Disagree;

refining problems and ideas before moving them to an implementation stage are of extreme importance, with 6 in 8 participants strongly agreeing upon this statement. The need for agility to ensure that products and services are built right was also firmly acknowledged by seven participants. Last, the majority of respondents (5 in 8) agree or strongly agree that the transition between these phases should happen iteratively rather than necessarily sequentially.

Overall, we perceived an excellent adhesion to the Mobius framework, which is a strong indicator that the project stakeholders understand and acknowledge the benefits of increasing agility in the different segments of the innovation life cycle.

Recognition & Discovery in Innovation Processes

When framing a problem, most participants believe that a description, context, causes, impact, and intended outcomes are relevant aspects (c.f. Figure 6.2), which is aligned with the problem framing methodology proposed for City Catalyst. Nevertheless, it should be noted that the description and outcomes were identified as the most critical aspects considering all the answers.

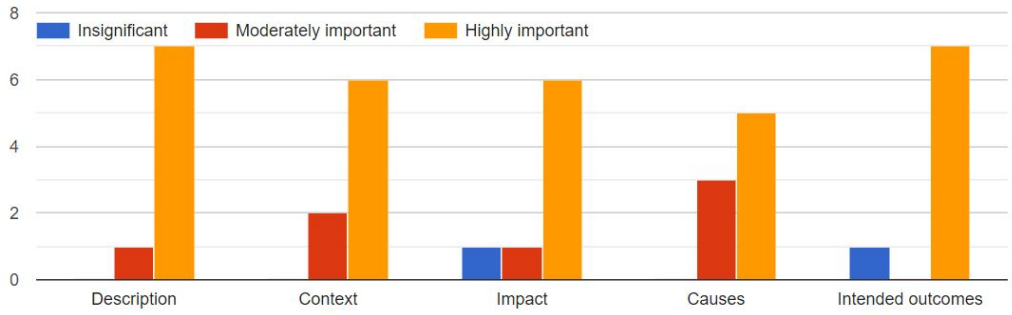


Figure 6.2: Level of importance attributed to the aspects that are included in the problem definition – survey results.

Regarding the assumption that promoting open innovation events to gather ideas or solve problems is not viable without framing a problem accordingly, 4 of the respondents expressed agreement, which further stresses the relevance of this phase. Notwithstanding, we noticed some uncertainty in the answers, with three participants being neutral about this statement and another one completely disagreeing with it. A possible interpretation is that our assumption is too pragmatic and, sometimes, gathering ideas to a precariously framed problem can actually work out and perhaps help define it better.

As for the impact tracking, "metrics" was deemed the most critical variable, followed by "methods" and "baseline", both still coming with considerable relevance (c.f. Figure 6.3). This

- 2 – Disagree;
- 3 – Neutral;
- 4 – Agree;
- 5 – Strongly Agree.

demonstrates that our impact tracking strategy was generally validated by the survey. At the same time, the particular emphasis on metrics indicates that future research should focus on this point.

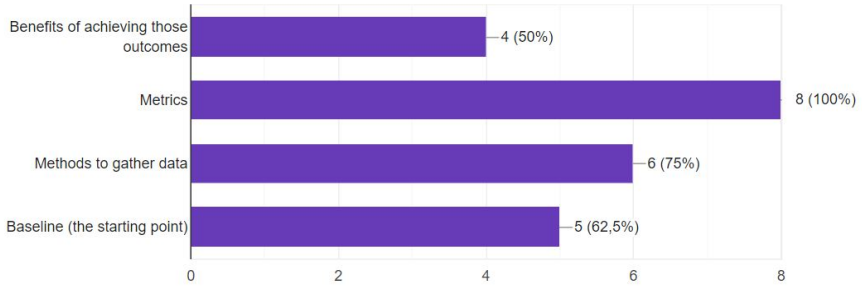


Figure 6.3: Relevance of the variables to take into account to track impact (number of votes per aspect on the vertical axis) – survey results.

Last, the majority of respondents are in favor of conducting field surveys of citizens affected by a given problem to help understand the target problems with more clarity and address potential doubts or difficulties when framing a challenge. The average Likert rating of this statement was 4.4 out of 5, thus supporting the proposed Guerilla Research technique.

Ideation & Prioritization in Innovation Processes

Firstly, we wanted to assess if the guidelines proposed for generating ideas presented by Mobius – and corroborated in our approach – are acknowledged by the survey respondents. We listed those and asked the participants to select the relevant ones, resulting in the statistics presented in Figure 6.4. The premise that ideas should not be filtered was unanimously validated, whereas seven respondents agreed that critical thinking should be restrained during the process. On the other hand, four respondents believe that building on other ideas is valuable, while three of them claim that ideas should flow without being self-edited. Surprisingly, only two participants saw benefit in representing ideas visually. Although we did not interview the surveyed people to understand their point of view, we assume that the receptivity to some of the underrated guidelines would have been greater if the participants had the chance to experience them in practice.

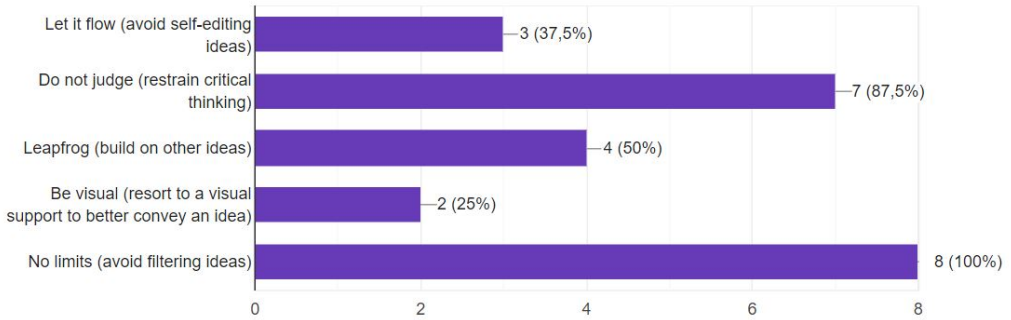


Figure 6.4: Relevance of the guidelines proposed for brainstorming activities – survey results.

When it comes to Design Sprints, the participants agree (with an average Likert classification of 4.1) that these processes can help answer critical questions and convert ideas into testable hypotheses and increase confidence in them. Similar results were seen regarding Design Studios, where participants agree that such type of event can effectively yield structured solutions to a problem.

With regard to prioritizing options, we asked the participants about the relevance of each of the ICE score factors. Participants notably focused on Impact (8 votes), followed by Ease (6 votes) and Confidence (4 votes). Nevertheless, six of them agree that the ICE score as a whole is a reasonable approach to assess and prioritize available options before moving on to the implementation phase.

We end this section of the survey with two questions about risk in innovation. Every participant agreed that risk is indeed a critical aspect of innovation. Likewise, they support our approach to coping with uncertainty, emphasizing that collecting learnings and increasing confidence should be prioritized over large upfront investment.

Product Development in Innovation Processes

The Minimum Viable Product methodology was acknowledged by six respondents (five of which firmly acknowledged) as being a good way to gain validated learnings with little effort before the full implementation of a product. Moreover, all the respondents state that a successful validation of a minimal yet representative version of a product increases confidence in resource allocation.

The Quick Win philosophy also received positive feedback, with the majority of participants strongly agreeing that seeking simple gains that can be delivered quickly is crucial to keep people motivated and focused. To further validate our beliefs about concrete application scenarios, we also asked if this technique would possibly apply or contribute to:

- Overcoming complex/demotivating deadlock situations;
- Prioritizing features of a product or service;
- Deciding which features should integrate an MVP (Minimum Viable Product);
- Learning more about a problem;
- Preventing projects from being abandoned.

The results, fully detailed in Figure 6.5, highlight the importance of seeking quick gains in the presence of complex deadlock situations. A fair proportion of participants also selected the prioritization of features as a good application scenario for this method. In contrast, only three participants identified this mindset as suitable for learning more about a problem and preventing projects from being abandoned.

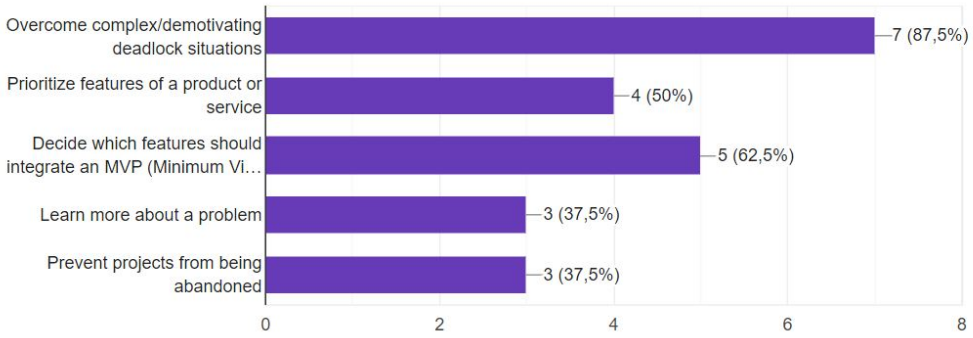


Figure 6.5: Scenarios in which the "Quick Win" method can be applied – survey results.

The last questions of this segment of the questionnaire are related to retrospectives within development teams. Firstly, we could observe that the respondents generally agree about the need to reflect on each sprint before moving to the next one. Furthermore, the majority of respondents validate the reflection points proposed in our technique, with a greater emphasis given to "things that worked" and "things to change", as shown in table 6.6.

Figure 6.6: Points to discuss in retrospective events – survey results.

Still on the topic of retrospectives, every participant believes that the ability to provide anonymous feedback is essential to guarantee that all the members of a team feel comfortable and will not hesitate to provide their genuine feedback, which validates our suggestions in this regard. On the other hand, the overwhelming majority of participants are in favor of the outputs of the retrospective exercises (excluding feedback related to the team's internal functioning) being shared with all the actors of the open innovation cycle.

Final remarks

The final section of the survey includes a few wrap-up items to assess if the overall approach meets the requirements initially established. We present these in Table 6.1, as well as their respective responses.

Table 6.1: Average Likert rating of the assumptions made with regards to our approach.

Assumption	**Average rating**
This approach contemplates the need for the participation of the various agents of the quadruple helix.	Agree (3.75)
This approach allows for the efficient use of resources.	Agree (4.25)
This approach allows capturing valuable ideas.	Strongly Agree (4.5)
This approach increases learnability of the problems addressed, contributing not only to immediate solutions but also to build a solid knowledge base that may come in handy to solve other problems in the future.	Agree (4.25)
This approach includes effective means to objectively assess an innovation outcome.	Agree (4.25)

Based on these results, we conclude that our approach stood out for the capturing of valuable ideas, in addition to being competent in increasing learnability, assessing innovation outcomes, and efficiently using resources. While good feedback was provided in relation to meeting the needs of the quadruple helix, it is the aspect that less convinced the participants.

Last, we could not miss the opportunity to analyze the results from the perspective of expert assessment, i.e., considering only the answers of the participants that self-rated their innovation or Agile knowledge as 5 out of 5. Such analysis resulted in even more solid results, as demonstrated in Table 6.2.

Table 6.2: Average Likert rating of the assumptions made with regards to our approach (considering the subsamples of innovation and Agile experts).

Assumption	**Average rating of Innovation experts (4)**	**Average rating of Agile experts (1)**
This approach contemplates the need for the participation of the various agents of the quadruple helix.	Agree (4.25)	Agree (4)
This approach allows for the efficient use of resources.	Agree (4.25)	Agree (4)
This approach allows capturing valuable ideas.	Strongly Agree (4.5)	Strongly Agree (5)
This approach increases learnability of the problems addressed, contributing not only to immediate solutions but also to build a solid knowledge base that may come in handy to solve other problems in the future.	Strongly Agree (4.5)	Strongly Agree (5)
This approach includes effective means to objectively assess an innovation outcome.	Strongly Agree (4.5)	Strongly Agree (5)

6.4 Summary

We aimed to validate this work through two different yet complementary processes. Unfortunately, the workshop that we proposed with a view to a practical validation did not take place due to lack of available participants. Nevertheless, we carried out with a comprehensive survey, which was designed to be accessible even without any prior knowledge of our methodology. Overall, the collected feedback suggests that our Mobius-based approach for open innovation in cities has the potential to produce promising results, although it was possible to find areas for improvement. Furthermore, despite their small size, the subsamples of innovation and Agile experts working in the City Catalyst project underpinned the validity of our work.

Chapter 7

Conclusions

This final chapter recaps the work developed for this dissertation and addresses to which extent the initially established goals were accomplished. Besides, it also includes some notes regarding what and how future work could be conducted.

7.1 Contributions

The primary objective of this dissertation was to increase the agility of open innovation processes in smart cities, especially within the context and needs of the City Catalyst project. In order to achieve this goal, we firstly performed a literature review on the themes of open innovation, co-creation, agile frameworks, and innovation processes.

After providing a solid background on these topics, we introduced the Mobius framework and highlighted its potential to address all the important phases of an innovation process, unlike other well-known agile frameworks that were also covered. This helped us understand that the applicability of agile methodologies should not be limited to the delivery of artifacts. Instead, earlier steps of an innovation life cycle are likewise prone to benefit from increased agility, without which a wrong product or service may ultimately be built. When this reality is transposed to the context of cities, it can be discouraging and threaten the objective of maximizing the well-being of citizens with the scarce resources available.

Having recognized the importance of framing the challenges and making decisions before jumping to the implementation of solutions, we performed more profound research to determine which practices were more relevant and how they could be implemented in the context of open innovation for smart cities. Furthermore, we suggested ways to integrate this methodology with the innovation platform being developed in parallel for City Catalyst.

In order to validate our developed work, we prepared a questionnaire to assess the suitability of Mobius for open innovation and the worthiness of specific practices that were proposed. In general, we collected excellent feedback, despite based on a small sample size. The results clearly demonstrated that people-focused and results-focused approaches are recognized as a necessity to enhance the success of open innovation projects.

In summary, all the desired objectives of this dissertation were successfully met. We were able to build a methodology based on Mobius tailored to the specific needs of open innovation initiatives in cities. Moreover, we demonstrated that the application of agile methodologies in the early phases of an innovation process is feasible and is key to reaching the intended outcomes.

7.2 Future research

Although we accomplished the proposed objectives for this dissertation and believe to have provided a solid contribute to City Catalyst, this research work could be improved or extended in a few ways.

First and most important, we wish that a more profound validation of the developed methodology had taken place. We were able to validate our work by carrying out a survey of project members, but it would be desirable to put into practice at least some of the proposed techniques. A more credible and accurate validation would involve monitoring an entire lifestyle of at least one innovation process; or, even better, multiple innovation processes, involving challenges and solutions of different natures. This would allow to assess the methodology in a greater variety of scenarios and increase confidence on the same. Additionally, exercising the methodology would provide the opportunity to collect further feedback and work out and polish the methodology details.

Another possible way to give continuity to this work would be to explore a higher number of Mobius trigger cards, since we decided to only focus on the highest priority ones. In order to complement our approach, it might be valuable to also look into some of the practices classified as "should-have" or even "could-have". This is especially true in relation to the deliver phase, where several Agile development frameworks could have been explored and possibly adapted to the urban environment and the Quadruple Helix Model.

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Appendix A

Validation

A.1 Complete questionnaire

A.1.1 Participant's profile

Table A.1: Questions of the Section 0 — Participant's profile.

ID	Question	Response options
1	How long have you been involved with the City Catalys projectt?	• I'm not involved in the project (1) • < 1 month (2) • 1 - 6 months (3) • 6 - 12 months (4) • > 1 year (5)
2	How do you self-assess your knowledge about innovation?	Likert scale (1 - 5)
3	How do you self-assess your knowledge of Agile methodologies?	Likert scale (1 - 5)
4	Which of the following Agile frameworks have you heard of?	Scrum (1); Lean Startup (2); Design Thinking (3); Hackathon (4); Kanban (5); Extreme Programming (6); Mobius (7).
5	I have worked on at least one project where the lack of agility (i.e., lack of short feedback loops or excess of bureaucracy) negatively affected or delayed the final outcome.	Likert scale (1 - 5)

A.1.2 The Mobius framework

Table A.2: Questions of the Section 1 — The Mobius framework.

ID	Question	Response options
6	According to Mobius, an innovation process can be split into 3 phases: discover (defining a candidate problem), ideate (generation and discussion of ideas), and deliver (implementation of the solution). Do you agree with this structure?	Likert scale (1 - 5)
7	The previously mentioned structure still applies when it comes to Open Innovation processes in smart cities.	Likert scale (1 - 5)
8	An initial investment in understanding the problem before jumping to ideas and implementation thereof can save resources that could otherwise be wasted in undesired outcomes.	Likert scale (1 - 5)
9	It is relevant to frame and refine ideas before moving them to an implementation stage.	Likert scale (1 - 5)
10	The Agile development of solutions, including moments of reflection and validation, is bound to ensure that products or services are built right.	Likert scale (1 - 5)
11	The transition between phases of an innovation process in Mobius should happen iteratively rather than sequential (e.g., if the ideation phase exposes the absence of important details in the problem definition, it is desirable to explore the problem further instead of moving forward).	Likert scale (1 - 5)

A.1.3 Recognition & Discovery in Innovation Processes

Table A.3: Questions of the Section 2 — Recognition & Discovery in Innovation Processes.

ID	Question	Response options
12	How important are each of the following aspects when it comes to understanding a problem? • Description (a) • Context (b) • Impact (c) • causes (d) • Intended outcomes (e)	• Insignificant (I) • Moderately important (MI) • Highly important (HI)
13	It is **not** viable to promote open innovation events to gather ideas or solve problems before they are framed according to the "highly important" points.	Likert scale (1 - 5)
14	When it comes to tracking the impact of desired outcomes, what is important to consider or establish?	Benefits of achieving those outcomes (1); Metrics (2); Methods to gather data (3); Baseline (4); Other (5).
15	Conducting field surveys of citizens affected by a given problem can help understand the target problems with more clarity and address potential doubts or difficulties when framing a challenge.	Likert scale (1 - 5)

A.1.4 Ideation & Prioritization in Innovation Processes

Table A.4: Questions of the Section 3 — Ideation & Prioritization in Innovation Processes.

ID	Question	Response options
16	Which of the following guidelines are relevant for brainstorming events.	Let it flow (avoid self-editing ideas) (1); Do not judge (restrain critical thinking) (2); Leapfrog (build on other ideas) (3); Be visual (resort to a visual support to better convey an idea) (4); No limits (avoid filtering ideas) (5).
17	Design Sprint (a five-day process for answering critical questions through design, prototyping and validating ideas) can help convert ideas into testable hypotheses and increase confidence in them.	Likert scale (1 - 5)
18	Design Studio (an event where a problem is framed and the participants sketch possible solutions in a short time, provide feedback regarding other ideas, and converge on a solution at the end) can result into a well structured option to solve a problem.	Likert scale (1 - 5)
19	Which criteria do you believe should be used when prioritizing options?	Impact (I); Confidence (C); Ease of implementation (E).
20	The ICE score is a reasonable approach to assess and prioritize available options before moving on to the implementation phase.	Likert scale (1 - 5)
21	Do you believe that handling risk is a critical aspect of innovation?	• Yes • No
22	An effective way to cope with uncertainty in innovation is to start with limited investment and strengthen it as confidence and learning are captured.	Likert scale (1 - 5)

A.1.5 Product Development in Innovation Processes

Table A.5: Questions of the Section 4 — Product Development in Innovation Processes.

ID	Question	Response options
23	It is convenient to build a Minimum Viable Product (a simpler version of the product that allows a team to collect validated learnings with little effort) before trying to implement a complete solution.	Likert scale (1 - 5)
24	Knowing that a minimal version of a product (although representative of its purpose) has been successfully tested and validated in the field increases confidence in resource allocation...	Minimally — Drastically (1 - 5)
25	Seeking simple gains that can be delivered quickly is crutial to keep people motivated and focused.	Likert scale (1 - 5)
26	The "Quick Win" phylosophy presented in the previous question can be applied to:	Overcome complex/demotivating deadlock situations (1); Prioritize features of a product or service (2); Decide which features should integrate a Minimum Viable Product (3); Learn more about a problem (4); Prevent projects from being abandoned (5).
27	It is desirable for the development teams to reflect about each sprint (short development cycle) before moving to the next one.	Likert scale (1 - 5)
28	What should be discussed in a retrospective event?	Things that worked (1); Things to change (2); Pending questions (3); New Ideas to try (4).
29	Some members of the team might not feel comfortable and hesitate to provide genuine inputs when anonymous feedback is not an option.	Likert scale (1 - 5)
30	The outputs of the retrospective exercises (excluding feedback related to the team's internal functioning) should be shared with all the actors of the open innovation cycle.	• Yes • No

A.1.6 Final remarks

Table A.6: Questions of the Section 5 — Final remarks.

ID	Question	Response options
31	This approach contemplates the need for the participation of the various agents of the quadruple helix.	Likert scale (1 - 5)
32	This approach allows for the efficient use of resources.	Likert scale (1 - 5)
33	This approach allows capturing valuable ideas.	Likert scale (1 - 5)
34	This approach increases learnability of the problems addressed, contributing not only to immediate solutions but also to build a solid knowledge base that may come in handy to solve other problems in the future.	Likert scale (1 - 5)
35	This approach includes effective means to objectively assess an innovation outcome.	Likert scale (1 - 5)
36	Additional remarks — Feel free to provide further feedback or improvement suggestions.	Free text

A.2 Results of the questionnaire

Table A.7: Survey answers for all items.

Item	**Resp. 1**	**Resp. 2**	**Resp. 3**	**Resp. 4**	**Resp. 5**	**Resp. 6**	**Resp. 7**	**Resp. 8**
1	5	5	5	5	1	3	4	5
2	3	5	3	5	4	2	5	5
3	3	3	3	3	2	3	5	2
4	1, 4, 6	1, 5	1, 2, 3, 4, 7	1, 2, 5, 7	1, 3, 4, 5	1, 4, 5	1, 3, 4, 5	1
5	4	2	4	5	4	3	2	4
6	4	5	4	5	4	4	5	4
7	3	3	4	5	5	4	5	4
8	4	5	5	5	5	5	5	4
9	4	4	5	5	5	5	5	5
10	5	5	5	5	5	3	5	5
11	3	5	5	5	4	3	5	3
12 a)	HI	HI	HI	HI	HI	MI	HI	HI
12 b)	HI	HI	MI	HI	HI	MI	HI	HI
12 c)	I	HI	HI	HI	HI	HI	MI	HI
12 d)	MI	HI	MI	HI	HI	HI	MI	HI
12 e)	HI	HI	HI	HI	HI	I	HI	HI
13	4	1	4	4	3	4	3	3
14	2, 3	1, 2, 3	2, 3	1, 2, 4	1, 2, 4	2, 3, 4	1, 2, 3, 4	2, 3, 4
15	4	5	3	5	4	4	5	5
16	1, 2, 5	5	2, 5	2, 3, 5	2, 3, 5	1, 2, 3, 4, 5	1, 2, 3, 5	2, 4, 5
17	3	5	4	4	5	3	5	4
18	4	5	4	4	4	2	5	4

19	I	I, E	I	I, C, E	I, C, E	I, C, E	I, C, E	I, E
20	4	4	3	4	4	3	5	4
21	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
22	4	5	3	5	4	4	5	4
23	1	5	5	5	4	5	5	3
24	5	5	5	4	4	5	5	5
25	4	5	5	5	4	5	5	4
26	1, 4	1, 3	1, 5	1, 2, 5	1, 2, 3	1, 2, 3, 5	1, 2, 3, 4	3, 4
27	3	4	3	5	5	4	5	4
28	1, 2, 3	1, 2, 4	1, 2, 3, 4	1, 2, 3, 4	1, 2, 3, 4	1, 2	1, 2, 3, 4	1, 2, 3, 4
29	4	4	4	5	4	4	4	4
30	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
31	4	5	3	5	3	3	4	3
32	4	5	5	5	5	3	4	3
33	5	5	5	5	5	3	5	3
34	4	5	5	5	4	3	5	3
35	4	5	5	5	4	3	5	3
36	-	-	-	-	-	-	-	-