The R&D Canvas: A Design Thinking Tool for the Management of R&D Projects

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Abstract: *Research and Development (R&D) projects are inherently ambitious, complex, uncertain, and risky. On the one hand, they increasingly involve diversified groups of people and entities that gather around common goals, with different objectives for each one. On the other hand, science and technology policies promoted and implemented by public entities are gaining momentum, translating into more R&D funding opportunities but also into more competition and accountability for the use of public funds. Research managers and administrators are, therefore, faced with growing challenges when coping with all these aspects and leading teams of scientists, companies, users, and other stakeholders towards successful projects. Traditional project management frameworks have been used and adapted to help the R&D project manager. However, the potential of design thinking principles and practices in this context has yet to achieve its full potential. This is quite surprising bearing in mind that both R&D projects and design thinking share a central characteristic: the key role of creativity and co-creation in assuring successful initiatives. In this paper, the rationale for a new tool for R&D management based on design thinking principles is presented. The relevant literature is reviewed, and the concepts that previous researchers have suggested are analyzed. The interplay between classical project management approaches and the creativity-driven nature of every R&D initiative is rationalized. The findings are used to develop a conceptual framework for a tool which can help research managers and administrators in facilitating the successful development of R&D initiatives. The usefulness of the R&D Canvas to the research management and administration profession is centered on its multi-purpose usability as an effective planning and communication tool that facilitates the incorporation of creativity and co-development practices in the highly heterogeneous contexts characteristic of contemporary R&D endeavors.*

Keywords: *R&D management, project management, design thinking, creativity*

Introduction

Research and Development (R&D) is a major force driving competitive advantages. This is acknowledged by many governments that have increased the level of investment in science and technology by increasingly sponsoring R&D projects. Companies carry out R&D projects, namely collaboratively with relevant stakeholders (e.g. R&D organizations), in order to develop the knowledge needed to bring new products, processes or services to the market. Public R&D tends to be different from private R&D, because the former often has low alienability and is focused on high societal gains.

By definition, R&D projects are subject to unpredictable technological, time, goal, and cost uncertainties (Kuchta & Skowron, 2015), and are characterized by irreversibility in terms of sunk costs and inappropriability (Præst Knudsen et al., 2019). Moreover, they are typically composed by non-linear processes, variable project scope (due to internal and external factors), often long-lasting project life cycles, and high odds of "failure" (Farokhad et al., 2019; Chronéer & Bergquist, 2012). Planning, resource allocation and scheduling is particularly difficult due to the constant need to cope with changes in scope and in scientific approaches (Kuchta et al., 2017; Mikulskiene, 2014). Private and public institutions have different attitudes towards driven targets, motivation, and desirable results for R&D projects (Mikulskiene, 2014). This may lead to difficulties and issues in the context of public-funded initiatives where the separation between research projects and development projects tends to disappear. This is also reflected in the terminology used by public entities. For example, currently, the European Commission area dedicated to R&D is named "research and innovation". While it is acknowledged that this may lead to greater societal appropriation of R&D results, it clearly adds complexity to managing R&D projects in this context. Thus, ideally, although some managerial differences still exist between R&D management practices in firms and in public institutions, a unified approach would be favorable for all involved parties. In this context, setting up abstract goals, having flexible planning, focusing on constraints and the context is recommended (Farokhad et al., 2019). Although phased-life cycle approaches are needed to clarify the whole process of R&D project management, non-linear management approaches should be defined to provide the chance for more creativity, flexibility in planning, iterative and incremental research stages, and improved control (Farokhad et al., 2019).

The role of research managers and administrators (RMAs) in R&D project management goes beyond administrative and financial functions and includes the provision of management services in areas such as integration management, knowledge management, human resource management, time management, communication management, and stakeholder management, to name a few. Moreover, RMAs contribute to mitigating communication and organizational culture barriers between scientific research, firms, and funding sources (public and private). Therefore, RMAs play an important role not just in the R&D proposal development (pre-award) and in the post-project technology and knowledge transfer but also in-between these two stages, i.e., during the post-award phase. In fact, Schofield (2013), in a study directed to RMAs, identified effective project management as an issue among critical success factors influencing knowledge transfer collaborations between university and industry. It was found that the project management context is particularly regarded by industrial partners, which correlates with previous findings showing that a high level of bureaucracy and inflexibility of universities is a major barrier to collaboration. Moreover, project management aspects such as flexibility and adaptation, industry early involvement in the process, past experience of partners, and effective communication, were found to be enablers for successful knowledge transfer. Conversely, process complexity, multiple stakeholders with different objectives, geographic distance, complex information flow and logistics, and time pressure, were identified as barriers.

The role of the project management office (PMO) in particular in European research consortia has been addressed by Wedekind and Philbin (2018), from the perspective of research and grant management. The authors argue that the scope change, associated with a shift from traditional academic research projects to research and innovation projects, has created the need for professional project management and has provided a productive environment for PMOs to flourish in academic settings. The specific PMO roles identified for RMAs include supportive, controlling, and directive, although at different levels depending on the grant lifecycle stage.

Formal project management approaches are relatively common in firms. Several frameworks and methodologies have been successfully adapted to R&D projects in the private sector. Conversely, in the public sector the adoption of such practices is well behind. There are several reasons for this, including the fact that for public-funded R&D in public institutions there are no incentives to ending an R&D project before time or under the contracted budget. So, researchers try to achieve the most they can within the given time period and budget. This is not the case in private firms, where strict schedule and resources monitoring and controlling mechanisms are always put in place for the sake of effectiveness. This naturally influences the R&D project management maturity between private and public entities and makes it more difficult to develop and implement unified approaches. To tackle this difficulty, shared traits of R&D projects pursued in private and public organizations have to be used as a mutual language.

Every R&D process is creative by nature. By definition, an R&D project is a path to discover the unknown and solve problems with no apparent solutions. This means there is often no prescribed route, and under these circumstances, scientists with open and creative minds are often in the best position to make breakthroughs (Sternberg, 2006). The method of scientific discovery has evolved naturally over centuries and has been refined by many great scientists and philosophers from Aristotle to Popper (Cook, 2020). It involves observation, questioning, developing hypotheses, experimenting, analysis, and to conclude/communicate. On the other hand, the creative thought process can be described by a number of frameworks, including a popular four-stage process that was first described by Graham Wallas in 1926 (Cook, 2020): preparation, incubation, illumination, and verification. The preparation phase requires sensing of a need, exploration of the problem, reading, discussing, formulating, and analyzing many possible solutions. The critical step is an incubation period, which requires the scientist to let the information gathered in the preparation phase gently ripen and come together in new ways (e.g., questioning), after which can arrive the birth of a new idea or flash of insight (i.e., hypothesis). The final step in this model of the creative process is a short, but usually rapid, period of recording, verifying, and refining the idea (e.g., experimentally). Thus, creativity-related tools and techniques are crucial in R&D project management practices. Nevertheless, its full potential is still far from being tackled. Usually, such tools and techniques are used only in the "idea generation" or "issue identification" phase that precedes the project itself. An example of a creativity-based tool for R&D project management is the Design Breakdown Structure (DBS) proposed by Diegel (2005), presented as a precursor to the traditional Work Breakdown Structure (WBS), and as allowing the idea generation process to be graphically mapped and monitored.

In face of the above, the authors propose the adoption of a new tool, based on design thinking principles, to aid the R&D project manager to focus its action in key areas while allowing the adoption of project management approaches tailored to each specific thematic area and performing organization. To this end, a literature survey is used to identify key areas that are recognized by researchers and practitioners as critical success factors and that allow to tackle the current fragilities and trends of the public-private R&D performing landscape. Next, design thinking tools are reviewed to identify concepts that could help to tackle these issues and capitalize on the creativity side of the scientific method. Finally, a new tool, the R&D Canvas, is proposed and its practical application illustrated by a case study. It is further explored how the R&D Canvas could strength R&D project management via this and supplementary design thinking-based tools, methods, and concepts such as creativity techniques, personas, and value network mapping.

The work is guided by the following overall research question: "Can design thinking tools and techniques facilitate R&D project management in contemporary research and innovation ecosystems?" To the best of our knowledge, this research question has never been addressed before by the specialized literature.

The paper is structured as follows. In the following section, the research methodology used is described. Next, the literature on project management and major specificities that characterize R&D projects are reviewed. This is followed by an introduction to design thinking, directed to its added value to R&D endeavors. Based on the analysis of the findings, the rationale for the R&D Canvas model and for each of its elements is presented, and its application to a case study is illustrated. The paper ends with the identification of major conclusions and future work.

Methodology

A heuristic framework combining a detailed literature analysis, subject matter experts consulting and use of a case study forms the basis of the research design. Findings from the literature were continuously validated through intensive interaction with practitioners as well as through observations in a case study. A qualitative case-study research approach was used, as according to Patton (2002), it is appropriate for investigating issues that are complex and difficult to quantify, as well as identifying themes, patterns, concepts and insights that are needed to understand such issues. This is used in combination with conceptual modeling and prototyping, which is consistent with design thinking principles. The research was organized into three stages (see Figure 1), accompanied by consulting of subject matter experts, namely project and research managers, and researchers:

Stage 1. Literature research / Theoretical grounding. Literature searches, selection and analysis of major papers related to the abovementioned topics were conducted. Relevant documents were searched in the Scopus database (titles, abstracts, keywords), with no temporal restrictions, and using the syntax ("project management" AND ("R&D project" OR "research and development project")). This resulted in 716 identified papers. The surveyed documents were analyzed to identify key concepts associated with the management of R&D projects. The research was carried out using a dedicated tool, VOSviewer software version 1.6.16, and its "text data mining" feature to develop a bibliometric map, to identify "clusters" of topics and their literature reference networks (Perianes-Rodriguez et al., 2016; van Eck & Waltman, 2010). This was followed by an in-depth analysis of 42 papers, covering the main "clusters", selected taking into account their relationship with the topics in each "cluster" and their connection with the extant relevant literature.

Stage 2. Prototyping of canvases. Prototyping sessions were held, with the participation of project managers, research managers, and researchers, to explore approaches to the conceptual and practical development of R&D canvases.

Stage 3. Application of results to a case study. The resulting R&D Canvas concept was applied to a case study, namely an R&D initiative concerning the valorization of residues from apple production, in the context of the circular bioeconomy concept.

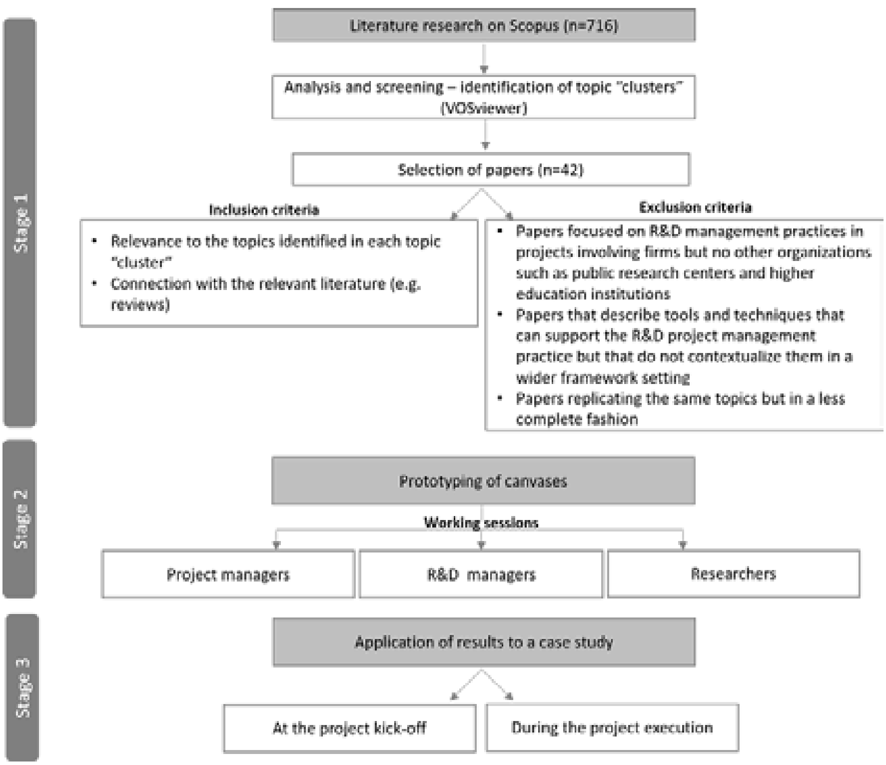

Figure 1. Methodological Procedure

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Management of R&D Projects

Projects are, by definition, unique endeavors, whose results are distinctive, oriented towards solving a problem or developing an opportunity, with specific results expected at points in time by applying certain resources and methodologies. Therefore, each project has its own specific deliverables, stakeholders, resources, and constraints. Although every project is managed, not all use project management principles (see the Heideggerian paradigm for project management [van der Hoorn & Whitty, 2015]).

The most striking feature of R&D projects is the fact that the outcomes might be very different from the initial specification but are still valuable for key stakeholders (namely firms, society, etc.). Although formality of R&D project management practices tends to increase from basic research to applied research and to development projects, managerial practices do in fact influence R&D project success (Vicente-Oliva et al., 2015). A certain level of proper planning and control through scheduling, monitoring and evaluation have been found to be among the necessary elements, which contribute to the success of new products and R&D projects (Magnaye et al., 2014).

Modern project management methodologies emerged in the late 1950s and since then several approaches, frameworks and methodologies have been developed. Generally speaking, these can be divided into three types: 1) waterfall, 2) agile, and 3) anything in between (i.e., hybrids). Waterfall approaches are characterized by well-defined, sequential phases. Agile approaches are iterative by nature. The level of ambiguity and/or risk and the level of customer involvement increases from waterfall to agile.

Hybrid approaches are increasingly common. Scrum-Stage-Gate hybrid (Cooper, 2014; Cooper & Sommer, 2020) combines scrum (agile) and stage-gate (waterfall). In order to increase the chances for such an integration to succeed, scrum should be applied as a "microplanning project management methodology", while stage-gate maintains its "macroplanning" horizon (Brandl et al., 2018). Consequently, the approach by Cooper and Sommer is divided into three different planning levels: strategical (stage-gate), tactical (integrative model) and operational (scrum). According to the authors, it "generates a healthy tension between fixed planning and iterative problem solving".

Other combinations of stage-gate and scrum are reported in the literature. For example, Binder et al. (2014) report a combination of agile methodologies with ISO 21500:2012 (a waterfall model based on PMBoK—the Project Management Body of Knowledge by the Project Management Institute). Reported benefits include meeting the financial, legal and procurement standards of large companies through its use of the ISO standard elements, while introducing the agility required to adapt to changing priorities and environments.

Albers et al. (2019) developed a method (agile systems design) that distinguishes between agile, sequential and hybrid development approaches and, depending on the development task, suggests a suitable approach. The differentiation of development tasks is based on the clustering of different types of product attributes and the associated development paths for their concretization. The work was developed in the context of the early phase of automotive development.

The bibliometric study carried out in stage 1 shows (Figure 2) that key concepts related to research on management of R&D projects can be clustered into three main areas:

Cluster 1: focused on project management methodologies and metrics (e.g., "planning", "control", "integration", "cost", "performance"), and "knowledge" (at the interface with cluster 2);

Cluster 2: focused on the R&D project itself (e.g., "technology", "solution", "program", "evaluation", the latter at the interface with clusters 1 and 3, and, thus, overlapped with metrics and risk, respectively), its "context" (e.g., "funding", "idea", "science") and "stakeholders" (e.g., "university", "government", "collaboration", "partner"); and

Cluster 3: focused on "firms" (e.g., "investment", "innovation", "market"), "risk" and "uncertainty" (e.g., "decision making", "project portfolio management", "benefit", "failure").

Thus, it can be observed that:

1) Research on the management of R&D projects is closely associated with the participation of firms as a component of their innovation strategies;

2) The key management areas most frequently cited are related to: a) the context surrounding the project (taken broadly), b) its stakeholders, c) its inherent uncertainty and risk, d) metrics/indicators, e) knowledge and f) management approaches; and

3) These key areas, and related topics, are intricately connected but in the surveyed literature there is clearly a relation between a) participation of firms and uncertainty and risk management, b) its context, stakeholders and technology drive, and c) project management methodologies, metrics and knowledge.

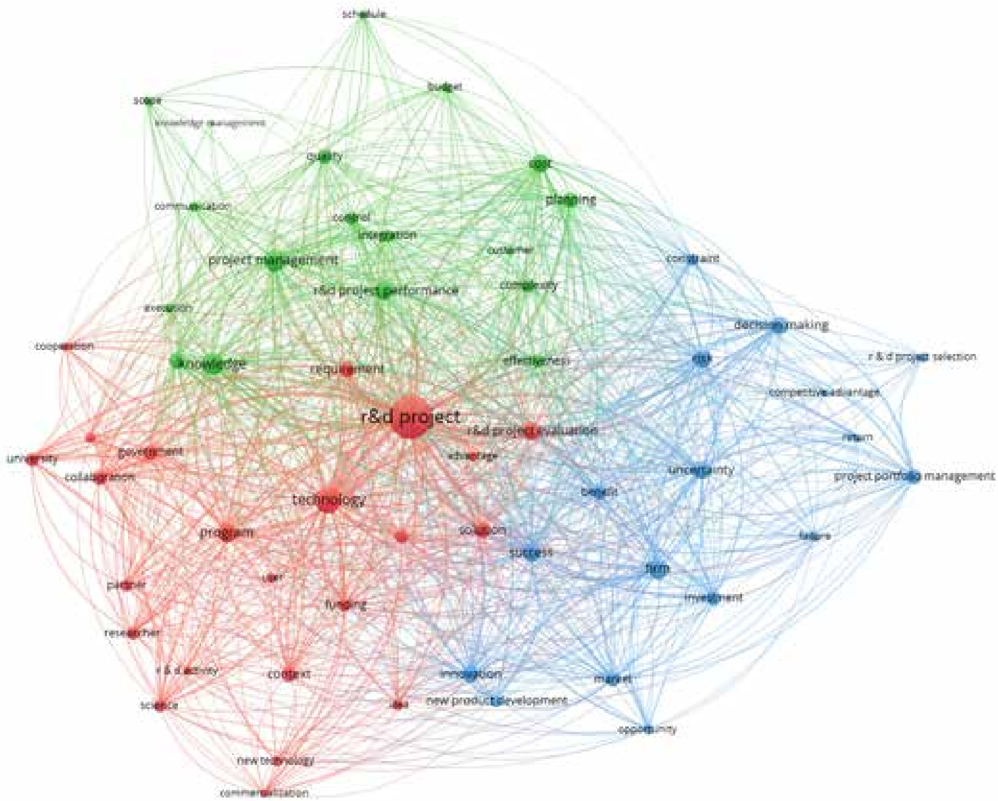

Figure 2. Bibliometric Map of the Surveyed Literature

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In the following sub-sections, we present a review of the abovementioned key areas of R&D project management. Accordingly, the following areas are addressed: 1) the context in which an R&D project is executed, 2) the influence of relevant stakeholders, 3) their risky and uncertain nature, 4) the need for performance metrics, 5) the importance of knowledge management, and 6) project management approaches.

Context

According to the project management contingency theory, management approaches should vary according to project type and contextual factors (Sauser et al., 2009; Shenhar, 2001). Recent advances include a context-specific approach that enables managers to select established project management knowledge according to changing needs along the project life cycle (Lippe & Vom Brocke, 2016). The context of a R&D project refers to the social, economic, political, scientific, technical, and environmental conditions under which it is formulated and executed. Typically, R&D projects tend to focus on scientific-technical and economic aspects, and other key areas such as political and societal development objectives are not appropriately addressed. In particular, priorities for research set by policy making bodies (often themselves research funders) and host institutions must be taken into account. If the project is not aligned with high-level priorities and strategies, the chances to be successful will be significantly reduced due to insufficient institutional support. Also, who are the key institutional stakeholders? Would they "buy" the project's main idea? How well-aligned is the project idea with existing programs or project portfolios? Are there any predictable issues regarding, for example, the negative impact of value-chain elements (such as family-owned SMEs) on specific social groups (such as handicapped citizens), or on natural ecosystems (such as protected areas)? If so, the relevant stakeholders (e.g., associations, NGOs) should be involved even before the project idea starts to gain consistency.

Every project must also consider the state of the art of the knowledge in the relevant scientific fields. Often researchers focus on scientific literature, not paying due attention to other sources such as patent and commercial databases. Not enough is known about the technology available from external sources, thereby limiting the innovative character of the project from the outset. This also has the advantage of avoiding eventual unintended intellectual property infringements.

Stakeholders

Stakeholders are persons, groups, or institutions with interest in the project. They are those who are ultimately affected, either positively or negatively by the project performance. This definition of stakeholder includes both winners and losers as well as those involved or excluded from decision making processes. Thus, R&D project management involves managing multiple stakeholders with conflicting stakes. They can cover a spectrum representing economic, environmental, and societal interests, with the potential for intense conflict between them. This includes researchers along with other categories such as policy makers, extension officers, potential end-users, relevant government and non-governmental organizations. Another important aspect that contributes to the complexity and dynamicity in managing stakeholders is their changing positions, interests, and importance over time. Topical developments in the theory and practice of stakeholder management in R&D projects include the systems approach developed by Elias (2016) to capture the conflicting positioning of multiple stakeholders.

Uncertainty and Risk

R&D projects inherently have a high level of uncertainty, as a result of only a partial knowledge of project end-products and their way of attainment being known (Biscola et al., 2017; Ernø-Kjølhede, 2000; Huljenic et al., 2005; Kuchta et al., 2017). Uncertainty may also arise from the lack of exact knowledge about costs, duration, or quality of planned activities, as a result of the usual heterogeneity in teams, or be created by a lack of clarity among the project stakeholders regarding desired outcomes.

A risk is an event characterized by some probability of occurrence and by the impact it may have on the project. Project managers tend to focus on scientific and technical risks, neglecting other potential sources that are related to context changes (e.g., a need that is no longer present), stakeholder management (e.g., someone that changes from supporting to confronting), competition risks (e.g., competitors may be the first to develop a better product/process), etc. Risk tolerance from the project's sponsor (e.g., research council, company) may vary widely, and usually is relatively low. In particular, it is difficult for some sponsors to accept that the result of a research project may be negative, but still worthwhile. Proving that something is not feasible may be as valuable as proving that it works (e.g., by saving time on more research efforts). All these factors create additional difficulties in the process of risk identification, as well as planning of risk responses and risk monitoring.

R&D Project Metrics

To evaluate the attractiveness of project proposals, or the success of ongoing or completed projects, appropriate criteria should be determined. In the absence of adequate indicators, project results cannot be measured and compared against pre-specified benchmarks making it difficult to control outcomes. When implementing performance and success evaluation systems, tangible outcomes should be considered, such as patents or publications, but also intangible/ subjective aspects such as the potential to generate future new R&D initiatives. Also, the choice of the most appropriate metrics should be based on the type of R&D, whether it is basic research, applied research, or technological development. The creation of a set of metrics to measure the effectiveness of R&D has been a major need for research managers for some time and is a particularly challenging task. The methods used range from simple screening procedures to sophisticated mathematical procedures, and are usually subdivided into the following categories: scoring models, multi-criteria decision-making models, comparative approaches, and economic models (Eilat et al., 2008).

Knowledge Management

Knowledge management is a vital issue, not only from the monitoring and controlling points of view but also from the project closure perspective, i.e., from the organizational maturity and learning points of view. Although there is always tacit knowledge hidden within project groups, knowledge should be adequately stored in documents (virtual, physical) to ensure an appropriate flow of information within and across the project and organization borders. A dynamic synthesis between tacit and explicit knowledge as a strategy of knowledge creation and adoption in each project stage is recommended (Faccin & Balestrin, 2018). On the other hand, creativity plays an essential role in the R&D process because it generates the ideas that will initiate the research activities and that will pave the way to the possible solutions. Ideas emerge at every level of the scientific process and they correspond to various challenges, such as responding to an issue, meeting a target objective, solving a problem, making use of knowledge, or understanding a phenomenon. But it is knowledge that makes it possible to put ideas to work. In addition, knowledge feeds creativity, and ideas stimulate research. Thus, the success of R&D projects relies largely on the effectiveness and efficacy with which knowledge management is implemented. Also, the use of success analysis as a framework can improve knowledge management in projects (Todorović et al., 2015).

Project Management Approaches

Currently, the dispersion and variety of project management approaches and of R&D activities poses difficulties in the selection of a management concept suitable for a particular type of R&D project. Jordan et al. (2005) showed that there are significant differences between types of projects along three dimensions: complexity of the work, size of the work, and the nature of the work. Also, other aspects such as "science vs. technology orientation of the work", "small vs. large size", and "specialized vs. complex work teams" influence the management approach. Kuchta and Skowron (2015) attempted to assign a specified management concept to a given R&D project type. The conclusion of their study is that most types of R&D projects, identified using the criterion of the degree of knowledge of their goals and methods of their implementation, should be managed by customized concepts of agile project management, when goals are known, but methods are not, or the other way around.

Design Thinking

Design is a multifaceted activity, which spans a wide variety of dimensions, from creating visual representations to conceiving, prototyping, and deploying a product or a service, to facilitating techniques such as hackathons, design jams and other similar participatory sessions that aim at directly engaging a variety of stakeholders in the design process. Design thinking is the non-linear process of inspiration (exploring opportunities), ideation (ideas creation, formulation, and validation) and implementation (the execution of an idea). It is a human-centered way of approaching innovation in R&D endeavors. It is widely acknowledged as a fundamental tool for product innovation, and it has also been identified as one of the key factors as the basis for success of technology-driven corporations.

Design thinking tools, methods, techniques, and activities such as visualization/materialization techniques can support creative processes as they help the stakeholders involved in the design process in alternating divergent and convergent thinking systematically. Rather than accept the problem as given, designers explore the problem and its context and may re-interpret or restructure the problem to reach a particular framing of the problem that suggests a route to a solution. It is thus a solution-focused thinking, distinct from the typical problem-focused strategies of scientists. It is also characterized by the use of abductive reasoning: designers infer possible solutions from the available problem information, their experience, and the use of non-deductive modes of thinking such as the use of analogies.

Another characteristic of design thinking is the co-evolution of problem and solution. Attention typically oscillates between the understanding of the problematic context and the ideas for a solution in a process of co-evolution of problem and solution. New solution ideas can lead to a deeper or alternative understanding of the problematic context, which in turn triggers more solution ideas.

The use of representations and models, such as prototypes, is closely associated with features of design thinking such as the generation and exploration of tentative solution concepts, the identification of what needs to be known about the developing concept, and the recognition of emergent features and properties within the representations.

Co-creation, closely associated with design thinking, is a well-established topic in manufacturing research. In the last two decades, there has been a wide range of publications concerning the involvement of customers in the design of end products. Recently, Cui and Wu (2016) focused on the innovation stream and proposed three forms of customer integration for co-creation: 1) customer involvement as an information source, where the designers gather input from them and apply it to develop products that meet customers' needs; 2) customer involvement as co-developers, where customers develop products together with the designers; and 3) customer involvement as innovators, where customers are allowed to design their own products, which are then adopted and offered by the firm. Prototyping is a key instrument for co-creation (Boukhris et al., 2017). It enables the creation of shared mental models between all the participants and clears misunderstandings. It creates emotions through haptic experience which has a positive impact on the group's cohesion. It helps fostering coordination between the participants.

Design thinking methods such as "persona analysis", "value network mapping" and "customer journey" are commonly used in the development of new concepts, e.g., for the development of availability-oriented business models (Kölsch et al., 2017). Personas are "clearly defined, memorable representations of users that remain conspicuous in the minds of those who design and build products". By applying the persona concept, the social role of a person in a specific context is identified. This helps the developer to gain an improved understanding of a person's behavior. With the systematic approach of a "customer journey", it is possible to reflect on the relationship between the customer and the project result. The definition of the persona is only possible after identifying the structure of an ecosystem or rather the extended value network. The "value chain analysis" adds transparency to the roles and the relations between the different stakeholders.

The "journey map" tool is yet another example of a useful design thinking tool. Aguirre et al. (2017) used it to allow stakeholders to synthesize opportunity areas grounded in a more holistic understanding of the situation at hand. It represents both the human perspective and creative dimensions to a medium extent. Basically, it asks participants to look at a very complex situation, over time, from the perspective of the persons most affected by it.

Design thinking can also play an important role in team mobilization. According to Mikulskiene (2014), in order for teams in R&D projects to be mobilized: 1) objectives need to be defined together with the team planning to work on the project, 2) it is better to ask more questions than less and to define the real problem as to what needs to be solved at a particular phase of the project, 3) the team should be inspired to produce their input at every project stage, and 4) the team´s input and feedback should be used for producing documents and to motivate people. The use of the above-described design thinking tools and techniques can be useful in this regard.

The uncertainty associated with R&D projects can be defined as a "wicked problem", which means that issues are not always obvious and explicitly known at the beginning of the process. The use of design thinking has been suggested as an appropriate framework for handling these "wicked" problems (Luotola et al., 2017). Moreover, design thinking principles can be used to connect and combine the contribution of creativity resulting from multiple stakeholders, including companies and university academics in a process in which knowledge is openly shared and transferred across each institutional boundary (Secundo et al., 2019). By stimulating the creativity of managers, scientists, engineers and designers, organizations become more flexible, agile, intuitive, imaginative, and resilient and can face the increasing complexity and turbulence of competitive environments. Moreover, creativity, that is closely related to the scientific method, emphasizes the role of interactions between stakeholders and the combination of knowledge, ideas, and information. The final result is the process of generating and applying such creative ideas in specific contexts, such as R&D activities, thereby creating meaningful and sustainable value for the project stakeholders.

In short, design thinking can be effectively deployed as an instrument to facilitate creativity, to tackle uncertainty, and to translate and process information along all the phases of the R&D project life cycle

A New Tool: The R&D Canvas

Outline

Canvases are graphical tools analogous to commonly used design thinking tools such as "personas" and "journeys". The most well-known canvas tool is the "business model canvas" (BMC), which is basically a representation of how an organization creates, delivers, and captures value from a product or service. The applicability and simplicity of the BMC has given it greater acceptance and dissemination. In the context of new product development (NPD), the business model canvas has been combined with the concept of the "technology roadmap" to provide a process integration perspective for idea or product concepts that are aligned to the current and future business needs of companies (Toro-Jarrín et al., 2016). Other uses of the canvas concept include the "creativity canvas", as a knowledge and idea management model (Hausman, 2015).

Based on the canvas as a design tool, a tool specific to R&D processes is herein proposed: the "R&D Canvas". Basically, it is a structured, hierarchical, graphically documented management tool used by the entire project team to work through the fundamental issues that must be overcome to reach the expected goals. The R&D Canvas acts a roadmap for the project and raises a shared awareness of both the issues that each team member faces, and the interconnectedness of all the issues. It forces the team to work as a coordinated, well-knit unit rather than as a team of isolated individuals. This roadmap is essential to allow the project manager to effectively manage the project. Because the R&D Canvas (Figure 3) acts as a central communication point between all project members, it helps to overcome cross-functional communication issues and allows the knowledge to flow between vastly different areas of expertise. Based on its contents and structure, when talking about the project management process, all team members are talking the same language. By using it, managers can identify areas where the available project information is sufficient and—more importantly—areas that require additional information and action.

For the R&D Canvas to be effective it must be used as a live communication tool, and much like any other project management tool, must be kept up to date and grow with the project. As it must be well documented to be truly effective, the documentation (particularly if computerized) acts as a knowledge database for future projects. When used with supplementary tools, methods, and concepts such as creativity techniques, personas, value network mapping, and in the context of collaborative project teams, the R&D Canvas gives the team the common understanding of the project that they need to achieve outcomes valuable to the key stakeholders. As illustrated below, it can be integrated with any existing project management framework or methodology.

Core to the R&D Canvas are its building blocks, which serve as a basis to describe the main areas of the developed model. Each "block" ("box") contains recommendations, which guide the users and act as inspiration for completing the information base. A typical question during its usage could be: "In what way does the project fit the current stakeholder needs?". The definition of each "box" (Figure 3) was based on the key areas for management of R&D projects identified above. In particular, the following areas and respective topics were considered:

1) Where it all starts: the "case";

2) The evolution: context, stakeholders, knowledge, risk and key indicators; and

3) The conveyance of results: milestones and deliverables.

It is the graphical and structural nature of the R&D Canvas that makes it a powerful tool, as one can almost instantly see the relationships and hierarchy between the various elements that constitute the canvas. In Figure 3 a graphical representation of the interconnectivity among the key elements of the R&D management model is presented. In the next sub-sections, the rationale of each element ("box") of the R&D Canvas is presented, and its usage instructions are described. It should be stressed that the "context", "risk", "stakeholders", "knowledge" and "key indicators" boxes are dynamic, and their content must be updated, at least, at each milestone review point.

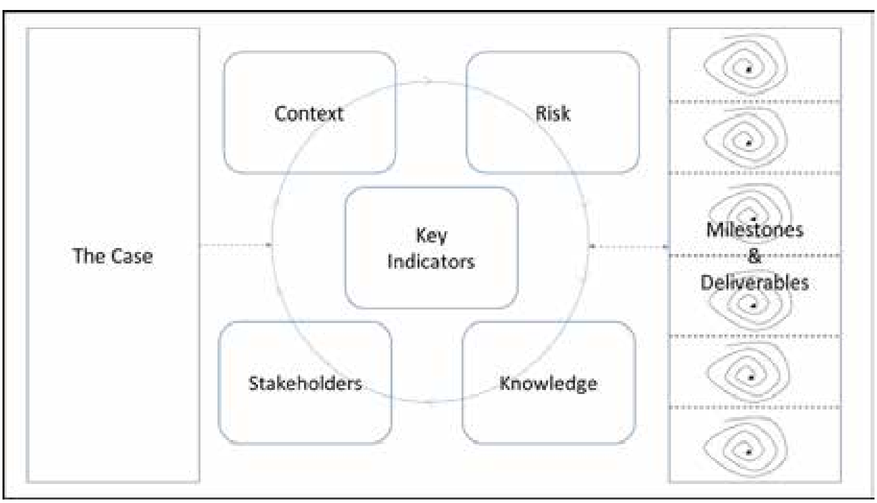

Figure 3. The R&D Canvas Concept

Click here for larger image

The Case

The "case" is a summary of the R&D project that should not change from the project idea generation phase until the post-project review. Thus, the following items should be developed with an adequate level of detail. The problems/opportunities and initial requirements must be identified, along with an outline of applicable solutions. This facilitates the definition of a coordinated set of decisions during the project planning, execution and controlling stages. Also, it is fundamental to define, in a clear way, the goals and objectives to be achieved. These should be solution-focused and not problem-focused. The project scope must be kept to the minimum level required to produce the deliverables and satisfy the stakeholders. The progressive refining of the project scope will be done during the planning of the activities needed to achieve each deliverable. The "case" should always be negotiated with key stakeholders. This part of the R&D Canvas is consistent with the Agile Principle on simplicity (the art of maximizing the amount of work not done is essential) and with common documents such as the Project Initiation Document and the Project Charter, in the PRINCE2 and PMBOK project management frameworks, respectively.

Example questions to be addressed include the following:

"What is the issue or opportunity that the project seeks to address?"

"To whom is it important and why?"

"Have you got any idea about how to tackle it?"

"So, what do you aim to achieve with this project?"

"Have the top stakeholders embraced the project idea?"

The Context

The context "box" must include dynamic user, scientific, technological, institutional and market requirements. The institutional context must include not only the alignment with the leading organization roadmap and policies, but also those of each entity when a consortium is set up to develop the project. Also, the high-level scope can provide an initial estimation of activities and resources. From this, a high-level estimation of budget and timeline can be obtained (consistent with the ISO 21500:2012 project management standard). These will contextualize the project from the resources point of view. From the scientific and technological points of view, the dynamic state of the art must be updated regularly. Social, economic, political, and environmental aspects must also be documented, as relevant.

Example questions to be addressed:

"How aligned is the project with governmental and institutional policies and priorities?"

"What do prospective end users of the project results think about it?"

"Are there any societal, political, competition-related or similar issues to be considered for the smooth running of the project?"

"What are the latest scientific and technological advances relevant to the project?"

"What are the key resources, without which the project would not be viable?"

"Are there any predetermined budget and timeline constraints?"

Stakeholders

The successful collaboration of different stakeholders to contribute to the development of novel ideas, concepts, and technologies involves information exchange and transfer. This requires the integration of diverse perspectives, experiences, competencies, and mindsets. In this "box" of the R&D Canvas, key stakeholders must be identified, and adequate management approaches must be defined. These must be reviewed regularly as stakeholders' positioning and influence change through time, thus management approaches require a balanced combination of technical, interpersonal, social and communication skills, and emotional intelligence.

This is also key to agile project management approaches where it is advocated that projects must be built around motivated individuals and with the agile principles relating to daily stakeholder cooperation and to team development (at regular intervals, the team reflects on how to become more effective, then tunes and adjusts its behavior accordingly).

According to Secundo et al. (2019), design artefacts can in fact ease the communication among stakeholders in collaborative R&D processes that often have different needs and interests, and speak different (technical) languages. Thus, the use of further design tools for stakeholder management, such as the "persona canvas", "stakeholder map" and "stakeholder canvas" is recommended. Also, design artefacts such as sketches, various visualizations (e.g., 3D renders, data visualizations, motion graphics animations and videos) and prototypes at various degrees of refinement can be used to enhance communication among various stakeholders in R&D projects.

Example questions to be addressed include the following:

"Who may influence or be influenced, positively or negatively, by the project?"

"How will their pains and gains be considered by the project?"

"Has their positioning towards the project changed since the last review?"

Knowledge

The effective acquisition and transfer of knowledge is critical to support co-creation in R&D projects, and to allow value creation from the combination of existing knowledge. This includes interactions of personnel (communication), reports, lessons learned, publications, patents, and other knowledge assets. Simplicity is nevertheless essential for communication to be understood by all parties and to avoid information overload. Thus, "flexible" information collection strategies must be formatted. When knowledge is transferred across very diverse contexts (e.g., from academia to industry), knowledge needs to be translated to still be interesting and relevant (Secundo et al., 2019). Thus, design artefacts such as prototypes and visual representations, can be useful. In this "box", the knowledge transfer principles must be outlined. This can include practices related to project meetings, information repositories, reporting, and lessons-learned collection. Mentoring and post-project reviews are recommended.

Example questions to be addressed include the following:

"Are there any information repositories being used?"

"Which team communication practices are to be used?"

"When and how are face-to-face meetings taking place?"

"Are there any templates or tools for document generation such as reports?"

"How is mentoring put into practice?"

Risks

High-level risks should be identified in the initial phases of the project and updated during the planning, execution, monitoring and controlling of each major stage (that ends with the attainment of a milestone). The categories of risks should be as varied as possible, e.g., scientific, technical, cost, schedule, resource, stakeholder, context and quality-related, commercial, etc. Also, the key assumptions should be documented and monitored regularly. Although robust project risk management (e.g., based on fuzzy inference, or using Monte-Carlo simulations) are recommended, simple tools such as a dynamic database including risk identification, qualification, quantification, and response definition, aided by a visual representation of probabilities and impacts severity, such as the probability and impact matrix recommended in the PMBOK framework, can be useful approaches.

Example questions to be addressed include the following:

"What are the main assumptions being made with regard to the various project dimensions?"

"What are the most relevant threats and opportunities for the project?"

"Has the level of probability or impact of each risk changed since the last review?"

"What are you going to do about the most relevant risks?"

Key Indicators

Key indicators are used for high-level monitoring of the project progress and success. They must be defined based on the "multiple value creation" principle, that is, value creation for the involved entities, for the project key stakeholders and for society as whole. From the progress evaluation point of view, the focus should be on the application of process metrics and lessons learned in order to quickly identify the problem areas and be able to respond promptly. Progress measurement must be linked to the activities and so each milestone represents an important point in time when key indicators are evaluated. In particular, according to the waterfall project management principles, the control of the scope should be flexible to allow for changing requirements that are supported by an impact analysis and accepted by the key stakeholders. Furthermore, and according to the agile principles, at regular intervals, the team reflects on how to become more effective, then tunes and adjusts its behavior accordingly. This calls for the adoption of adaptable indicator evaluation systems, tailored to each project, whether it be scoring models, multi-criteria decision-making models, or comparative approaches. Nevertheless, due to their "simplicity" and usefulness, namely in what concerns communicating the results to the key stakeholders, the use of "balanced scorecards" in R&D project monitoring and evaluation should be considered (see, e.g., Eilat et al., 2008).

Example questions to be addressed include the following:

"How will you measure the added value of the project for the key stakeholders?"

"And for society in general?"

"What are the baseline values for performance and results assessment?"

"What are expected target values for the key indicators?"

"How is the project performing, in relation to the baseline and to competing initiatives?"

Milestones and Deliverables

Milestones are significant events in the development of the R&D project, similar to the gates in the stage-gate model of Cooper et al. (2020). They should provide the basis for project planning (Magnaye et al., 2014). In the R&D model proposed herein, milestones define key dates at which a major revision of the project takes place. In particular, the key indicators agreed at the project onset are reviewed. Achievements and changes are controlled (in line with waterfall approaches) and adapted to the benefit of the project stakeholders (in line with agile principles). In between milestones, project development stages occur. Each has its own life cycle, including initiating, planning, executing, monitoring, controlling, and closing of project activities. The actual approaches to be used in each stage will depend on the nature and requirements of each specific project and stage. For example, a combination of waterfall and agile methodologies may be the best approach for a 3-year project with relatively low uncertainty, whereas the Scrum approach may be more adequate to a 6-month project with high uncertainty. However, a distinctive characteristic of each of these stages is that they are iterative in nature, i.e., they are spirals. This means that the abovementioned life cycle (which is basically an extended Deming Cycle) is repeated within each stage as needed to achieve a specific milestone.

The milestones must have a pre-determined schedule, to allow for periodic project assessment. Also, internal and external dependencies of each Milestone must be identified, as well as the (progressively elaborated) key activities (WBS creation) and corresponding expected outputs (deliverables). A detailed scope can be prepared for each iteration, with a corresponding analysis of the impact of changes to the high-level scope and to other project elements such as time, costs, and quality. This is in line with the agile principle that states that the highest priority should be to satisfy the customer through early and continuous delivery of valuable outputs (e.g., software, in the original Agile Manifesto). The progressive elaboration will allow for an accurate schedule and budget definition of each deliverable, to be assessed at each milestone review before the corresponding stage starts and once it finishes.

Example questions to be addressed include the following:

"Which are the milestones of the project?"

"Do they have any internal or external dependencies?"

"Are there any deliverables associated with each milestone?"

"Can you detail the work needed to achieve those deliverables?"

"Can you detail the resources needed to achieve those deliverables?"

"What are the budget and timeline associated with each deliverable?"

Case Study

The R&D Canvas tool was applied to a case study, based on an actual R&D initiative dealing with valorization of residues from apple production, in the context of the circular bioeconomy concept. Its rationale is described in detail in the next sub-section. In the next paragraphs the development of each R&D Canvas "box" is illustrated and, therefore, non-exhaustive. The usefulness of this new tool is demonstrated at two key points: at the project kick-off and during the project execution. Its usefulness at the project end is also addressed.

R&D Canvas for the Project Kick-off

At this point in time, the R&D Canvas is developed as a team effort involving the key stakeholders and led by the project manager. The use of design thinking tools (e.g., personas for stakeholder analysis), due to their co-creation basis, also facilitates team building. The team takes full ownership of the project and the project manager induces a participatory project development framework. The R&D Canvas will be available to all team members, ideally in a physical media (e.g., an A0 size paper sheet fixed on a wall). At the project kick-off, and probably during the first weeks, it is useful to include in each "box" a reference to the basic tools that will be implemented (illustrated below). Once the project is running smoothly, these can be omitted so as to not overload the canvas.

This first R&D Canvas rationale can also be used to develop a project proposal to be submitted for funding (internally or externally). The canvas contents include the major items typically requested by funding bodies. This will naturally depend on if the funding decision is internal to the lead institution or, for example, to supranational R&D funding organizations such as the European Commission. But the described benefits of its usage are also clear in this context.

For each "box" (Figure 4), the abovementioned example questions are used below to develop illustrative content. The actual "box" development must be carried out in a co-creation environment.

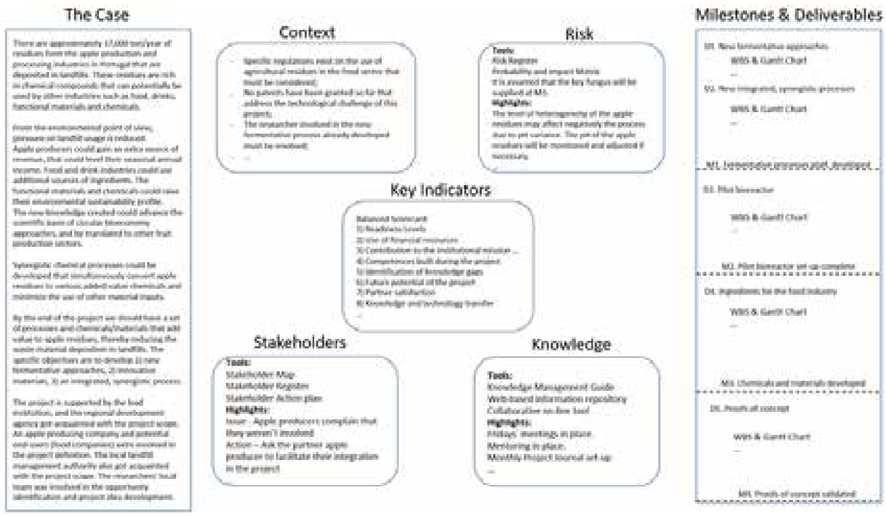

Figure 4. The R&D Canvas for the Circular Bioeconomy Case: At the Project Kick-Off

Click here for larger image

The Case

"What is the issue or opportunity that the project seeks?"

There are approximately 17,000 ton/year of residues from the apple production and processing industries in Portugal that are deposited in landfills. These residues are rich in chemical compounds that can potentially be used by other industries such as food, drinks, functional materials, and chemicals.

"To whom is it important and why?"

From the environmental point of view, pressure on landfill usage is reduced. Apple producers could gain an extra source of revenue that could level their seasonal annual income. Food and drink industries could use additional sources of ingredients. The functional materials and chemicals could raise their environmental sustainability profile. The new knowledge created could advance the scientific basis of circular bioeconomy approaches and be translated to other fruit production sectors.

"Have you got any idea about how to tackle it?"

Synergistic fermentative processes could be developed that convert apple residues to various added-value chemicals and materials and minimize the use of other material inputs.

"So, what do you aim to achieve with this project?"

By the end of the project, we should have a set of processes and chemicals/materials that add value to apple residues, thereby reducing the waste material deposition in landfills. The specific objectives are to develop: 1) new fermentative approaches, 2) innovative materials, and 3) an integrated, synergistic process.

"Have the top stakeholders embraced the project idea?"

The project is supported by the lead institution, and the regional development agency became acquainted with the project scope. An apple-producing company and potential end users (food companies) were involved in the project definition. The local landfill management authority also became acquainted with the project scope. The research team was involved in the opportunity identification and project idea development.

The Context

"How aligned is the project with governmental and institutional policies and priorities?"

The project is fully aligned with state science policies regarding circular bioeconomy. In particular, it contributes to several goals defined in the national agenda in this topic, namely the reduction of landfill occupation and the creation of new added-value chains in the food sector.

"What do prospective end-users of the project results think about it?"

Several food companies were approached and found the project results, namely new ingredients, valuable to their industrial processes, if several key specifications are met. This initial requirement list has been documented.

"Are there any societal, political, competition-related or similar issues to be considered for the smooth running of the project?"

Specific regulations exist on the use of agricultural residues in the food sector that must be considered. Fruit concentrate companies and cider producers may develop alternative uses for this residue before the project ends. The regional apple production is expected to decrease due to climate change.

"What are the latest scientific and technological advances relevant to the project?"

New fermentative process principles have been developed that may be useful. No patents have been granted so far that address the technological challenge of this project. Relevant processing equipment has been recently made available.

"What are the key resources, without which the project would not be viable?"

The project requires the existence of specific fungus material, currently not available. Also, the researcher involved in the new fermentative process must be involved.

"Are there any predetermined budget and timeline constraints?"

The budget should not exceed 150,000 euros as this is the budget limit for the typical call for proposals by the national science agency that could support the project. For the same reason, bearing in mind the competitiveness of the food ingredients market, the project timeframe should not be greater than two years. A preliminary estimate, based on previous data related to "analogous" activities allows one to predict a total budget of 125,000 euros and a development time of two years. The latter estimate has a high degree of uncertainty.

Stakeholders

"Who may influence or be influenced, positively or negatively, by the project?"

A stakeholder map has been developed that resulted in the project stakeholder register.

"How will their pains and gains be considered by the project?"

A Stakeholder Action Plan has been developed. It details the issues and corresponding actions to be performed. Highlights: Issue - Apple producers complain that they were not involved; Action - Ask the partner apple producer to facilitate the integration of other companies in the project.

"Has their positioning towards the project changed since the last review?"

The Stakeholder Register details the dynamics of stakeholder towards the projects. Highlight: cider producers now see the project as an opportunity to their businesses.

Knowledge

"Are there any information repositories being used?"

All the bibliographic sources and data arising from the project is stored at the web-based information repository, in accordance with the Project Knowledge Management Guide.

"What are the team communication practices to be used?"

Collaborative online tools are used in day-to-day communications. However, face-to-face meetings are preferable.

"When and how are face-to-face meetings taking place?"

Face-to-face meetings occur ad-hoc, outside the R&D center facilities, and gathering the key stakeholders relevant to the topics to be discussed.

"Are there any templates or tools for documents generation such as reports?"

The online reporting system must be used, following the procedure set in the Knowledge Management Guide.

"How is mentoring put into practice?"

Each junior team member is allocated a more experienced colleague as a mentor in the context of the project.

Risks

"What are the main assumptions being made with regard to the various project dimensions?"

It is assumed that the project will not last longer than two years. Also, it is assumed that the needed fungus will be supplied during the first three months of the project execution.

"What are the most relevant threats and opportunities for the project?"

The threats and opportunities have been recorded using the Risk Register. Highlights: the level of heterogeneity of the apple residues may negatively affect the process due to pH variance; the fermentative process may be tolerant to cellulose contents and, thus, be used with other fruits.

"Has the level of probability or impact of each risk changed since the last review?"

The Probability and Impact Matrix is updated weekly.

"What are you going to do about the most relevant risks?"

The risks action plan is documented in the Risk Register. Highlights: the pH of the apple residues will be monitored and adjusted if necessary.

Key Indicators

"How will you measure the added value of the project for the key stakeholders?"

A balanced scorecard has been developed, considering the interests of each key stakeholder. The following areas have been identified: 1) Readiness Levels (technology, innovation, societal and impact); 2) use of financial resources; 3) contribution to the institutional mission, objectives, and strategic vision; 4) competences built during the project; 5) identification of knowledge gaps; 6) future potential of the project; 7) partner satisfaction; and 8) knowledge and technology transfer.

"And for society in general?"

Using the Societal Readiness Level concept.

"What are the baseline values for performance and results assessment?"

Included in the developed balanced scorecard.

"What are expected target values for the key indicators?"

Included in the developed balanced scorecard.

Milestones and Deliverables

"Which are the milestones of the project?"

M1. Fermentative processes platform developed (month 6)

M2. Pilot bioreactor set-up complete (month 12)

M3. Chemicals and materials developed (month 18)

M4. Proofs-of-concept validated (month 24)

"Do they have any internal or external dependencies?"

M4 depends on M3. M2 depends on performance of supplier.

"Are there any deliverables associated with each milestone?"

For M1: D1. New fermentative approaches; D2. New integrated, synergistic processes

For M2: D3. Pilot bioreactor

For M3: D4. Ingredients for the food industry

For M4: D5. Proofs-of-concept

"Can you detail the work needed to achieve those deliverables?"

A high-level WBS has been developed for each deliverable.

"Can you detail the resources needed to achieve those deliverables?"

A preliminary Resource Breakdown Structure has been developed for each deliverable.

"What are the budget and timeline associated with each deliverable?"

A Gantt Chart was developed. The estimated budget for each deliverable has been documented and is as follows: D1 – 50,000 euros; D2 – 5,000 euros; D3 – 50,000 euros; D4 – 10,000 euros; and D5 – 5,000 euros.

R&D Canvas During the Project Execution

Once the project is running, the R&D Canvas (Figure 5) is updated accordingly and used 1) to keep the team aligned, 2) to provide a snapshot of the project status, and 3) as a high-level planning tool. The "box" describing "the case" is the only one that does not change. Its aim is to keep the team focused on the origin and reason of being of the project. Mention to project tools is removed as the team ought to be fully acquainted with these by now. It can be useful to use a "traffic light" or similar system to visually identify points needing attention. The work to be developed to achieve each deliverable is outlined by the corresponding team. For budget and schedule monitoring and controlling purposes, the high-level information is presented in a WBS and a Gantt Chart. But the actual management methodology to be used by each team may differ from one deliverable to another. For example, a deliverable consisting of a firmware component may be developed using Scrum principles, and a deliverable relating to a complex hardware component may use a hybrid agile-waterfall methodology. Naturally, this approach has to be adapted to each project uncertainty and complexity. Nevertheless, the R&D Canvas provides a management model that can fit whatever project management methodology(ies) is(are) considered adequate by the project team.

An example, non-exhaustive R&D Canvas is presented in Figure 5 for the case study. It reflects the following issues: 1) the pH of the apple residues does not vary significantly; 2) apple producers are not actively involved in the project; 3) the weekly project status meetings were changed to Wednesdays following a suggestion by the team; 4) the Project Journal (a one-page summary focused on the balanced scorecard in use) is now issued weekly; and 5) experiments at the lab are going well (milestone M1 was already achieved and the project reviewed by then), but the key fungus material was not delivered at month 3 as promised by the supplier.

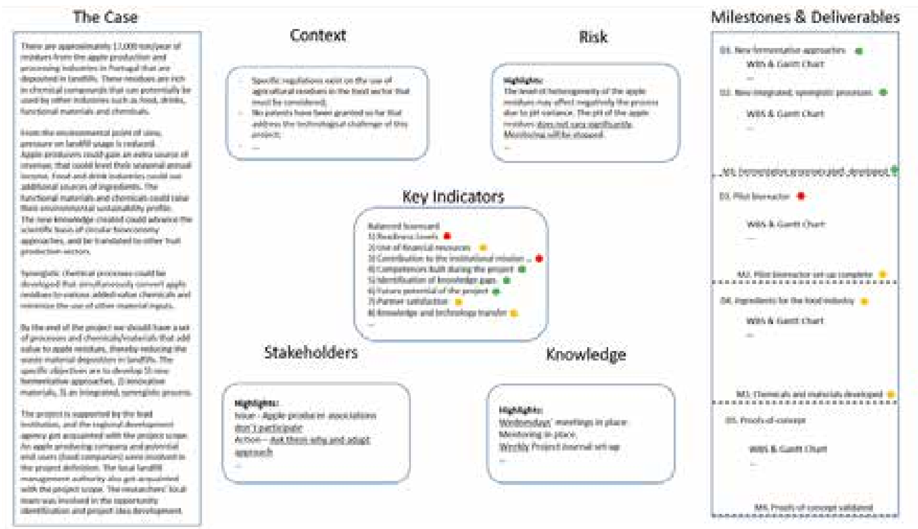

Figure 5. The R&D Canvas for the Circular Bioeconomy Case Study: During the Project Execution

Click here for larger image

R&D Canvas at the Project Closing

Once the project has ended, the dynamic R&D Canvas is used as a lessons-learned tool. The analysis of the project evolution, as documented in the canvas, facilitates the collection of practices, knowledge and results that could benefit future projects. Thus, this information should be gathered using the R&D Canvas boxes relating to context, risk, stakeholders, and knowledge. This document should be considered during the use of the R&D Canvas for the development of new initiatives.

Implications for Research Administrators

RMAs develop a varied portfolio of roles, including project proposal development, knowledge and technology transfer (Schofield, 2013) and, increasingly, tasks and responsibilities framed in project management offices (Wedekind & Philbin, 2018). In this context, the R&D Canvas is proposed as a valuable multi-purpose tool to be used by RMAs: a) when intervening in the project/proposal delineation phase, due to its creativity-driven and co-creation nature; b) in the project kick-off as a team building tool; c) during project execution, as it facilitates the controlling and directive roles increasingly played by RMAs in the context of PMOs; d) for knowledge and technology transfer processes that can benefit from its structured knowledge collection feature, and e) during project closing, as a lessons-learned tool that contributes to continuous organizational improvement and maturity. In a nutshell, the R&D Canvas is suggested as a versatile tool that RMAs can use to improve their job efficacy and effectiveness.

Conclusions

Research and development activities are of paramount importance as driving forces bringing about societal advantages in the broadest sense possible. This is reflected in the increasing volume of public funds being allocated to multi-stakeholder initiatives, often focused on mission-oriented programs. R&D projects are characterized by non-linear processes and subjected to unpredictable technological, outcomes, schedule, and budget uncertainties. Several frameworks and methodologies have been adapted to R&D projects, with a certain degree of success. However, it is widely recognized that these hardly incorporate the intrinsic creativity and co-creation nature of contemporary R&D projects. In this context, the usefulness of design thinking tools and techniques was reviewed.

Based on a systematic literature review it was found that major R&D project development areas identified as key by the scientific literature and by practitioners are: the "case" support, the context description, the risk, stakeholders and knowledge management, the use of key indicators, and the use of adequately formulated and managed deliverables and milestones.

Following these findings, a new approach to the design and management of R&D endeavors, based on design thinking principles is proposed. A "canvas" concept was developed to account efficiently for the mentioned dimensions. Major advantages of the R&D Canvas include its graphic nature, its usefulness during all the phases of project management, and its usability in combination with formal project management approaches. As a visualization technique, based on solution-focused thinking, it facilitates stakeholders involved in the project design and management process in alternating divergent and convergent thinking systematically. This is particularly important in R&D projects due to the key influence that uncertainty and creativity play in this specific type of project. Also, the R&D Canvas acts as a knowledge database for future initiatives. Its usefulness is demonstrated at the project definition, kick-off, running and post-end evaluation and follow-up.

Research management and administration would benefit from the use of new tool from varied perspectives, ranging from the project proposal definition and grant application to the project execution and post-project knowledge transfer processes. It can be used as an effective planning and communication tool, that helps to incorporate creativity and co-development practices in the highly heterogeneous settings that characterize contemporary R&D endeavors.

Further field studies may now apply the R&D Canvas model in practice, alongside—or replacing—more "conventional" tools, and assess its effectiveness and the gaps to be addressed.

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