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Project management for scientific research

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Thesis abstract

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Contemporary scientific research is often realized through research, development, and innovation projects and is usually driven by project funding from academic and industrial ties. Consequently, a need arises to deploy project management for managing scientific research. In this context, this thesis aims to construct an optimal project management framework for scientific research and develop guiding project management models for scientific research projects. To attain these objectives, quantitative and qualitative research are performed, and a small university research unit is chosen for the study.

To construct an optimal project management framework, the research life cycle of a scientific research project and the project life cycle of a generic project are compared to choose suitable frameworks for each life cycle phase from the existing literature through a systematic literature review. Once the framework is constructed, its relevance in scientific research is justified in terms of the collective opinion of the research unit under study. To deduce this collective opinion, quantitative research is performed by conducting an online survey and statistically analysing the survey responses. The quantitative study revealed that the chosen research unit collectively prefers project ideation using blue ocean and lean strategies, project management using hybrid (waterfall and agile) methods, and transformational project leadership.

Based on the findings mentioned above, project management models are developed for scientific research projects through qualitative research. By conducting action research within the chosen research unit and employing qualitative content analysis on the action responses, guiding models are developed for project strategy (blue ocean and lean), project leadership (transformational 6-L), and project management (lean-hybrid). The qualitative study revealed that the project strategy model ensures value innovation, cost minimization, and flow of created values. The project leadership model promotes emotional intelligence, commitment to people, and a growth mindset. The project management model secures values, minimizes waste, and mitigates the volatility of scientific research. To afford adaptability, the high-level project tasks that require more planning are performed using the waterfall method, while the low-level project tasks that require more agility are conducted in an agile way. Collectively, the guiding models provide key information on how to implement project management in scientific research.

[1] Keywords: Blue ocean strategy, lean principles, waterfall method, agile method, transformational leadership

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1 INTRODUCTION

Science, as a discipline, has always been the main driving force behind the development of human civilization. From the invention of fire, wheels, and electricity to today's artificial intelligence (AI)-based systems, our scientific pursuits have yielded the greatest leap in human history by inventing advanced technologies. We enjoy an abundance of such technologies (e.g., electronic gadgets, telecommunication, internet, appliances, etc.) in our daily lives, and modern society immensely depends on scientific technology for food, medicines, and transportation, to name a few. Eventually, the practice of science, i.e., scientific research, has always been and will be an integral part of human history.

Like human evolution, scientific research has evolved through time. At first, scientific research was very *individualistic*. Pioneers in science, such as Galileo Galilei (1564–1642), Isaac Newton (1642–1727), or Charles Darwin (1809–1882), practiced scientific research as individuals and purely for the pursuit of knowledge (Crowther, 1995). After that, during the twentieth century (1901–2000), due to World War I and II, scientific research became national interest and *institutionalized*. To develop weapons, communication systems, transportation, and warfare technologies, various research institutions were formed in many countries, and scientists were hired as employees. The MIT Radiation Laboratory (1940) and the Manhattan Project (1942–1946) are notable examples of such state-owned initiatives (Maas & Hooijmaijers, 2009).

After World War II, scientific research became more and more institutional. During the second and third eras of globalization (1960–2000), the world witnessed a paradigm shift in scientific practices when scientific research became *entrepreneurial*. Scientists, instead of being limited to universities, research institutions, or big organizations, started to form small companies and sell their inventions to make a business out of them. By following in the footsteps of great inventors like Thomas Alva Edison (1847–1921), such entrepreneurial scientific research gave birth to some extremely successful companies like Intel (1968), Microsoft (1975), and Nokia Bell Labs (1984), to name a few (Sethi, 2016). Even nowadays, scientists becoming successful entrepreneurs is not a far-fetched idea anymore. Obtaining a patent for the invention is a rising trend among scientists. The synergy between academic institutions and industrial research at an organizational level is a common trend now. Eventually, *academic entrepreneurship* became popular among scientists (Marcolongo, 2017). For example, Carolyn Bertozzi, a 2022 Nobel Prize winner in chemistry, is working as a professor at Stanford University and leading multiple biotechnology startups simultaneously (Mullard, 2020). So is Edward Hæggström in

Finland, who is a professor at the University of Helsinki and the CEO of a pharmaceutical start-up, Nanoform (Nanoform, n.d.). It is also very common nowadays that scientists are taking on the roles of executives, e.g., chief scientific officer (CSO) or chief technology officer (CTO), where, besides scientific expertise, having managerial skills is paramount (Marcolongo, 2017).

As scientific research became more and more *institutionalized* and *entrepreneurial*, it also became more and more *project-based* (Wingate, 2014). Contemporary scientific research is often realized in the form of research, development, and innovation (RDI) projects having an end-product as a project deliverable (e.g., the COVID-19 vaccine). For example, the VTT Technical Research Centre of Finland performs project-based scientific research where all their RDI activities are implemented as projects covering both academic and industrial interests (VTT Technical Research Centre of Finland, n.d.). Global research institutes are predominantly project-based organizations such as NASA (USA), CNRS (France), and Max Planck Society (Germany), to name a few. Similarly, university research and academic entrepreneurship are intrinsically project-based and driven by project funding (Badiru, 2022). Consequently, employing project management processes for conducting and managing scientific research projects becomes pivotal in modern science and technology practices. Inevitably, having project management skills becomes a prerequisite for scientists working in academic and industrial research (Kennett, 2014).

Project management is a developed branch of business management practices, and there is a rich body of knowledge prescribed by international bodies such as the Project Management Institute (PMI) and the International Project Management Association (IPMA), to name a few (Artto et al., 2011). The term *project* here can be understood as a sequence of specific tasks and activities leading to desirable outcomes or deliverables. Any project must be executed with a fixed budget (cost), within a fixed time period (schedule), and for a fixed scope (set of tasks to attain the goals) (Kerzner, 2022). In scientific and technological research, the RDI project goals and deliverables often lead towards the development of a new product (e.g., the COVID-19 vaccine) or the implementation of a new system (e.g., a renewable power station or the Hubble Space Telescope). Since all projects (whether they are scientific research projects or not) go through multiple phases during the project lifecycle, optimal execution of each phase is essential for project success (Artto et al., 2011). Project management provides a set of approaches, tools, and techniques to optimally realize such manoeuvres in order to attain the desired goals (Kerzner, 2022).

Although the relevance of project management is apparent in the context of scientific research, scientists often lack project management skills in practice. To develop the project management competence of scientists as a mandatory *soft skill*, universities and research institutions are currently including project management trainings (courses, workshops, certification, etc.) in their curriculum and human resource development programs (Badiru et al., 2018). Similarly, when hiring researchers, universities, research institutions, and industry are now more and more looking for talents who have project management skills and experiences along with job-specific technical, scientific, and research skills (Harpum, 2011).

Considering the complexity and uncertainty associated with scientific research projects, utilizing the existing project management standards is crucial for optimal RDI activities (Payne et al., 2011). In this regard, this thesis aims to find answers to two research questions:

RQ1: What is the optimal project management framework for scientific research projects?

RQ2: How to develop such a framework for scientific RDI projects?

To address these research questions by anchoring them into a real-life scenario, a small academic research unit comprised of 20 researchers is chosen, which is also the workplace of the author. To find answers for RQ1, existing project management frameworks are explored via a literature review, and their relevance in managing scientific research is evaluated through quantitative research (surveys and statistical analysis). Based on the findings, the optimal project management framework for scientific research is proposed. To find answers for RQ2, a project management model is developed via qualitative research (action research and qualitative data analysis) for the chosen research unit for a generic RDI project. Therefore, this thesis provides key information on *how to implement project management in scientific research*, which is useful for RDI management in university research, in academic entrepreneurship, and in innovation-based small and medium enterprises (SMEs) or startups.

This thesis starts with a brief literature review of the existing project management frameworks in Chapter 2, followed by a brief description of the research methods in Chapter 3. The research findings are presented as well as discussed in Chapter 4 and concluded in Chapter 5. The thesis ends with a list of cited references in the bibliography section.

2 THEORETICAL FRAMEWORK

As already mentioned in Chapter 1, project management is a developed field of business management that consists of various strategies, methodologies, models, and techniques (Kerzner, 2022). In this regard, this chapter describes the theoretical framework of the thesis, followed by brief descriptions of the theories included in the framework.

2.1 Literature review

Literature review can be employed as a research methodology to build a theoretical framework (Snyder, 2019). Considering the abundance of existing project management literature, one needs to choose a certain approach to conduct the literature review. In this thesis, a *systematic and research question specific* literature review (Snyder, 2019) has been performed to keep the scope lean.

In RQ1, the aim is to find an optimal project management framework for scientific research projects. To do so, at first, the life cycle of a scientific research project (the research life cycle) is compared with the life cycle of a generic project (the project life cycle). Then, suitable theories are chosen for each phase of the research life cycle.

As shown in Figure 1, a project life cycle has five main phases, covering specific tasks allocated to each phase (Project Management Institute, 2021). The phases are –

i. **Initiating:** defining a new project or a new extension of an existing project, appointing project manager, and assessing/defining project scope/goals.

ii. **Planning:** forming project scope/objectives concretely, defining meeting conditions of project objectives, defining project workflow (stage gate model, work breakdown structure, Gantt chart, activity networks, critical path, etc.), allocating resources, and forming risk/change management procedures.

iii. **Executing:** completing defined work packages, managing project teams, keeping project within predefined cost-timeframe-scope, managing stakeholders, and maintaining project workflow.

iv. **Monitoring & Controlling:** tracking-reviewing-regulating project progress as well as mitigating challenges created on the way, measuring project execution against project plan/goals, and reviewing cost-time-scope parameters.

v. **Closing:** evaluating project completion as per allocated time/cost, performing closing procedures, project retrospective (lessons learned), project delivery, and formal closure.

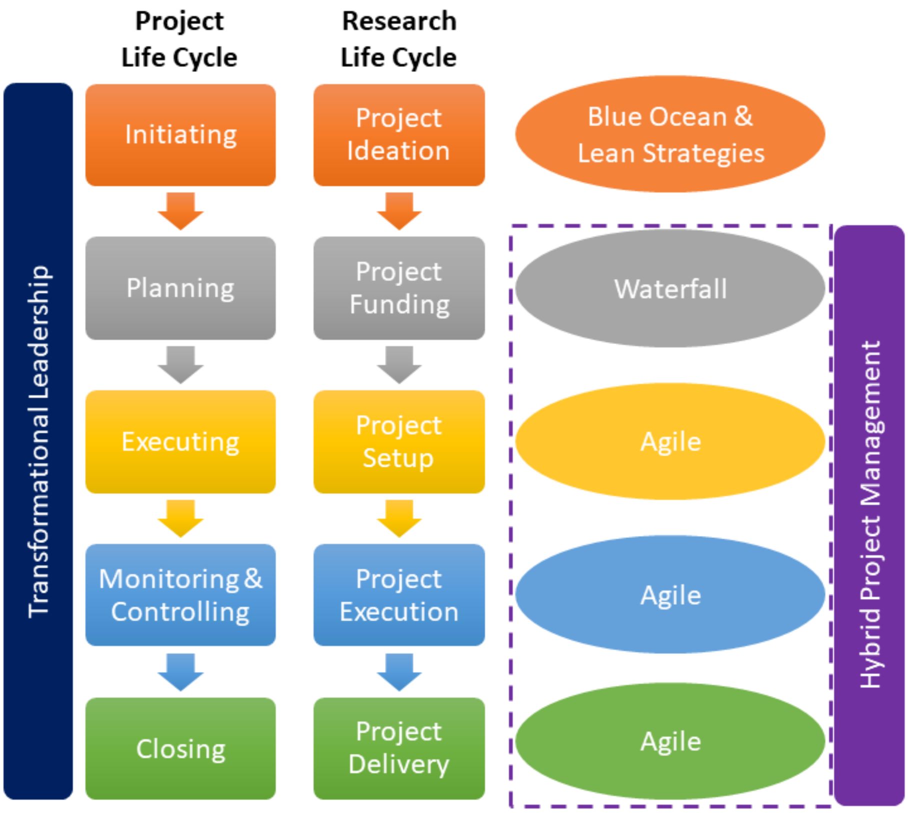

Figure 1. Theoretical frameworks for different phases of project and research life cycles.

Now, if we look at the life cycle of a scientific research project (Boué et al., 2018), as also shown in Figure 1, we again see five main phases in the research life cycle, which are more or less similar to the aforementioned phases of the project life cycle. The main phases of the research life cycle (Boué et al., 2018) are –

i. **Project Ideation:** forming the project idea and feasibility study.

ii. **Project Funding:** preparing detailed project proposal (project plan, project charters, cost model, project description, etc.) and obtaining funding through grant application processes.

iii. **Project Setup:** research design (forming collaborations, technology transfer, shared infrastructure, etc.), experimental design (building laboratory, buying equipment, etc.), building protocols (material safety and lab safety guidelines, hazardous waste management plan, etc.), and building research team (hirings).

iv. **Project Execution:** performing research (experiments, computations, etc.), collecting and analysing data, synthesizing results, preparing end-product (prototyping), and preparing manuscripts for publications, patents, or further grant applications.

v. **Project delivery:** delivering the end-product as per the project proposal, delivering data repository, project review and closure.

It is apparent from Figure 1 that *initiating* and *project ideation* phases are analogous, where project scope and goals are starting to form. These are the phases where strategic project management comes into play. The literature review revealed that blue ocean strategy (Kim & Mauborgne, 2015) and lean strategy (Arthur, 2010) frameworks can be used at *project ideation* phase to create a unique strategic positioning of the project. Such unique value creation will give the project a competitive advantage in grant applications to secure funding.

The *planning* and *project funding* phases are also analogous, where the project description and workflow are planned at a granular level. The literature review revealed that employing a traditional project management model, i.e., the waterfall method (Wysocki, 2019), at *project funding* phase is essential. The waterfall method provides clear structure, commits to an end goal at the beginning, and transfers information efficiently (Wysocki, 2019). Therefore, using the waterfall approach, a stable and well-structured project proposal can be formed, which will again give the project a competitive advantage in grant applications to secure funding.

It is worth noting here that *executing* and *monitoring & controlling* are not necessarily sequential phases but are often parallel in practice. In a broad sense, *executing* and *monitoring & controlling* together form the *operational* phase of a project. Similarly, *project setup* and *project execution* phases can be parallel and together form the *operational* phase where the actual research happens. The literature review revealed that implementing an adaptive project management model, i.e., the agile method (Wysocki, 2019), at *project setup* and *project execution* phases is crucial since a significant number of complexities and uncertainties are always associated with scientific research projects. The agile method emphasizes collaboration between self-organizing teams, adapts to change, and responds agilely to uncertainties (Wysocki, 2019). Therefore, the agile method can sustain flexibility and offer an iterative approach during the volatile *operational* phase of research.

The *closing* and *project delivery* phases are equivalent, where the project earns closure by delivering the end-product as promised in the project proposal. In a scientific research project, the end-product can be an invention (e.g., the COVID-19 vaccine) or a new system (e.g., a renewable power station or the Hubble Space Telescope). The literature review revealed that the agile method is also useful for the project delivery phase since, in scientific research, delivering the end-product is often iterative and incremental, which is exactly how the agile method works (Wysocki, 2019).

Scientific research projects cannot be fully managed via the waterfall method since conducting research requires flexibility and adaptability. Scientific research, fundamentally, is an iterative trial-and-error approach that is very agile in nature. On the other hand, scientific research projects cannot be fully managed via the agile method either since the overall project structure needs to be well-structured and stable to navigate the project in the right direction. Therefore, a hybrid project management method blending waterfall and agile approaches (Dionisio, 2022) is the best way to run a scientific research project.

No project can succeed without a good leader. That's why project leadership is an essential element of project management (Turner & Müller, 2005). The literature review revealed that transformational leadership (Ali et al., 2021) suits best in leading scientific research projects since transformational leaders act as coaches and mentors for their subordinates. In science, leaders are usually professors or senior scientists who have a pedagogical commitment towards junior early-stage researchers. Therefore, transformational leadership should be practiced while leading scientific research projects.

In summary, the systematic literature review recommends that scientific research projects should be ideated with the help of blue ocean and lean strategies, conducted (planning to closure) using a hybrid (waterfall and agile) project management method, and orchestrated by a transformational leader. These theoretical models and methods are briefly explained in the subsequent sections.

2.2 Strategic project management

Strategic project management ensures clear alignment of the project strategy with the project goals, unique value creation, efficient decision-making, better communication, the removal of redundancies, and consistent performance as well as growth over time (Kodukula, 2014). Among many other strategic approaches, blue ocean strategy (Kim & Mauborgne, 2015) and lean principles (Arthur, 2010) are relevant to the scientific research project. These strategic methods are briefly discussed in the following subsections.

2.2.1 Blue ocean strategy

If we look at the known market space around us, we see constant competition between organizations (not only companies but also academic universities and research institutes) over the existing market demand. Everyone is trying to outperform others by capturing a major portion of the existing market, whether it is a new product (e.g., a smartphone, a car, etc.) or a research grant. This is the *red ocean*, where competition is considered the only key to success and industry boundaries, such as market demands, are considered fixed (Kim & Mauborgne, 2017).

The blue ocean strategy offers a pathway to create a *blue ocean*, i.e., an unexplored potential market space where no contest or competition exists yet. The idea is to make the competition irrelevant by creating new market demands while minimizing costs. When the existing industry is competitive and limited to certain market boundaries, i.e., an ever-contesting red ocean, the blue ocean strategy focuses on reshaping the market structure via value innovation (Kim & Mauborgne, 2015).

The basic framework of the blue ocean strategy can be understood from Figure 2. In Figure 2(a), the term *value* can be considered as existing market demands, i.e., elements the market is offering to the buyers right now, and the term *cost* here means the cost related to that. The blue ocean strategy is all about creating new market demands (by raising value) while minimizing costs via value innovation (Kim & Mauborgne, 2017). As we see in Figure 2(a), the *value innovation* is residing in a zone where the cost is minimum while the value is raised. To uplift *value*, the blue ocean strategy raises and creates elements that the industry or existing market has never offered. To minimize *cost*, the blue ocean strategy eliminates and reduces the factors an industry or the known market competes on (Kim & Mauborgne, 2015).

To create a new value curve (value innovation), as we see in Figure 2(b), blue ocean strategy (Kim & Mauborgne, 2017) –

i. **Raise:** the factors that should be raised well above the industry's standard.

ii. **Create:** the factors that are never offered by the industry and should be created.

iii. **Reduce:** the factors that should be reduced well below the industry's standard.

iv. **Eliminate:** the factors that the industry has long competed on and should be eliminated.

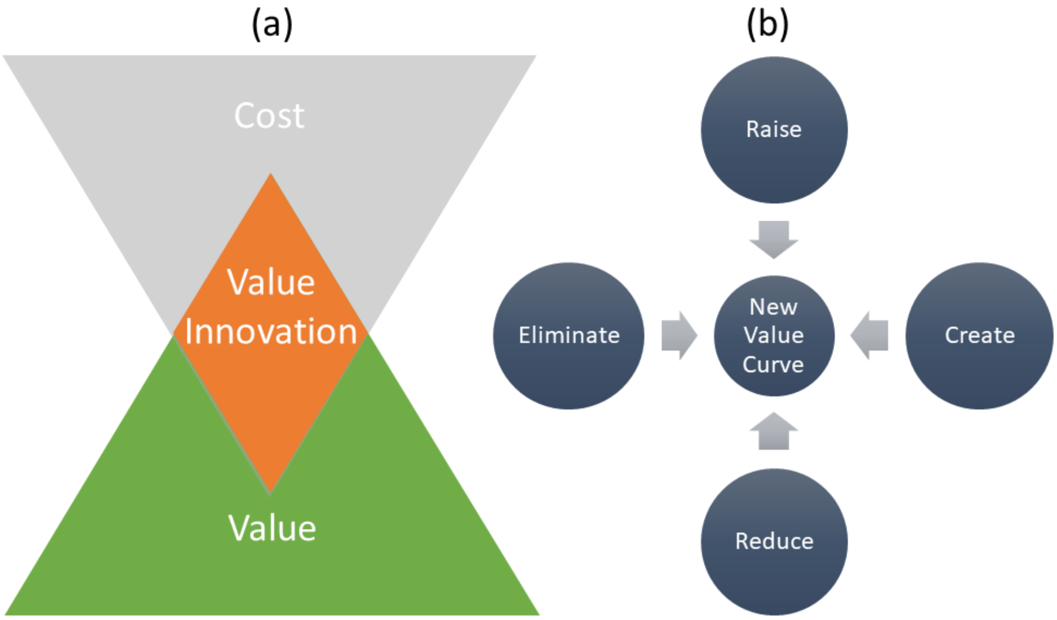

Figure 2. (a) Value innovation and (b) four actions framework of blue ocean strategy.

In scientific research, research groups are fighting for lucrative RDI grants and funding in the existing academic *red ocean*. If a project proposal can promise project goals and end-products that are never raised or offered by the research community, moreover, as low-cost solutions, then the *blue ocean* can be created, and more likely, the project will succeed in obtaining funding.

2.2.2 Lean strategy

Scientific research projects are often funded by the public sector, and hence, it's the taxpayer's money. Even when such projects are funded by industry (e.g., RDI activities), the money comes from the national or even global economy. Therefore, project operations should minimize *waste* during project execution to avoid suboptimal usage of resources. Here, *waste* not only refers to money but also time and human resources.

Lean strategy (Olesen et al., 2015) can be used to minimize such *waste* while the project is running if the lean principles are integrated properly with the project ideation and planning. Lean principles aim to eliminate *waste* and, thereby, improve project operations. Originally developed for the automotive manufacturing industry, lean strategies are nowadays also used in the process industry, in health care, in public services, and in product development.

According to lean principles, *waste* is any kind of expense of time, cost, or effort (human resource) that does not add any value to the project. Lean strategy optimizes each phase of the project in such a way that *waste* will be eliminated (or at least minimized) during the project process steps. Consequently, at each project phase, only the true value will be added (Olesen et al., 2015).

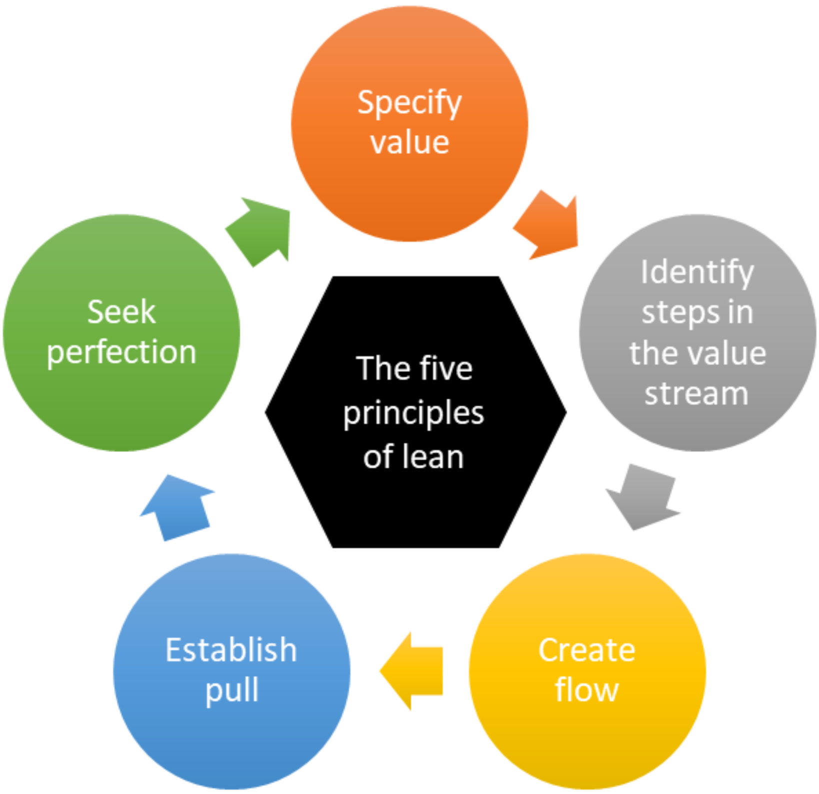

Figure 3. Principles of lean strategy.

Lean strategy consists of five principles of lean (Olesen et al., 2015), as shown in Figure 3. The principles are –

i. **Specify value:** specify value from the perspective of the end user or from the point of view of project delivery. In other words, identify and create project steps that add value to the project.

ii. **Identify steps in the value stream:** identify the project steps that add value to the project and aid project success. Also, identify the project steps that do not add any value to the project and result in waste. Then, eliminate the non-value-adding project steps whenever possible so that a value stream can be formed based only on the value-creating steps.

iii. **Create flow:** design a tight chain of value-creating steps to ensure smooth flow of the project operations towards the project goal.

iv. **Establish pull:** after creating the flow, value should be pulled from the next upstream activity. In other words, resources (time, money, and human effort) will only be used when needed. So, there will be no waste of resources.

v. **Seek perfection:** a continuous rectification of the project process chain (steps i to iv) until the project runs with zero waste.

Since lean strategy aims to eliminate non-value-adding elements from the project operation, like blue ocean strategy, it can also minimize the overall cost of the project. Considering the volatile nature of scientific research, conducting research in a lean way not only improves resource management and value innovation but also the productivity of the project team.

2.3 Project management methodologies

Project management methods are widely used to manage projects from the project initiation phase to project closure (Kerzner, 2022). Project management methods can be linear and sequential, such as the waterfall method, or iterative and cyclic, such as the agile method (Wysocki, 2019). It can also be a combination of both, such as the hybrid project management method (Dionisio, 2022). In the following subsections, these methods are discussed briefly.

2.3.1 Waterfall method

The waterfall method is a linear project management life cycle model and the oldest project management method in use. The method is named *waterfall* due to its sequential nature, which resembles the one-directional water flow in a real waterfall. Just like the real water flow in the falls, in the waterfall method, returning to the previous phases is not possible except by starting over from the beginning again. For predictable and repeating projects (e.g., construction), the waterfall method is usually preferred due to its simplicity (Wysocki, 2019).

The basic characteristics of the waterfall method (Wysocki, 2019) are –

i. **Sequential structure:** this method breaks down the project operations into sequential stages where flow is allowed only in a forward direction. Therefore, moving to the next stage is only possible after the current phase is completed. Eventually, completed stages cannot be revisited, and no change is allowed in the sequential workflow once the project is started. To make changes, the project needs to start over from the beginning.

ii. **Minimal end-user involvement:** this method gathers the end-user's requirements in detail at the beginning of the project. After that, when the project is running, the end-users will only be communicated with during the project delivery phase. Therefore, end-users do not have the possibility to modify their requirements during project operation.

iii. **Robust documentation**: this method meticulously gathers all the requirements and provides detailed project documentation covering the whole project life cycle. Therefore, information and knowledge at each project phase are precisely recorded and stored.

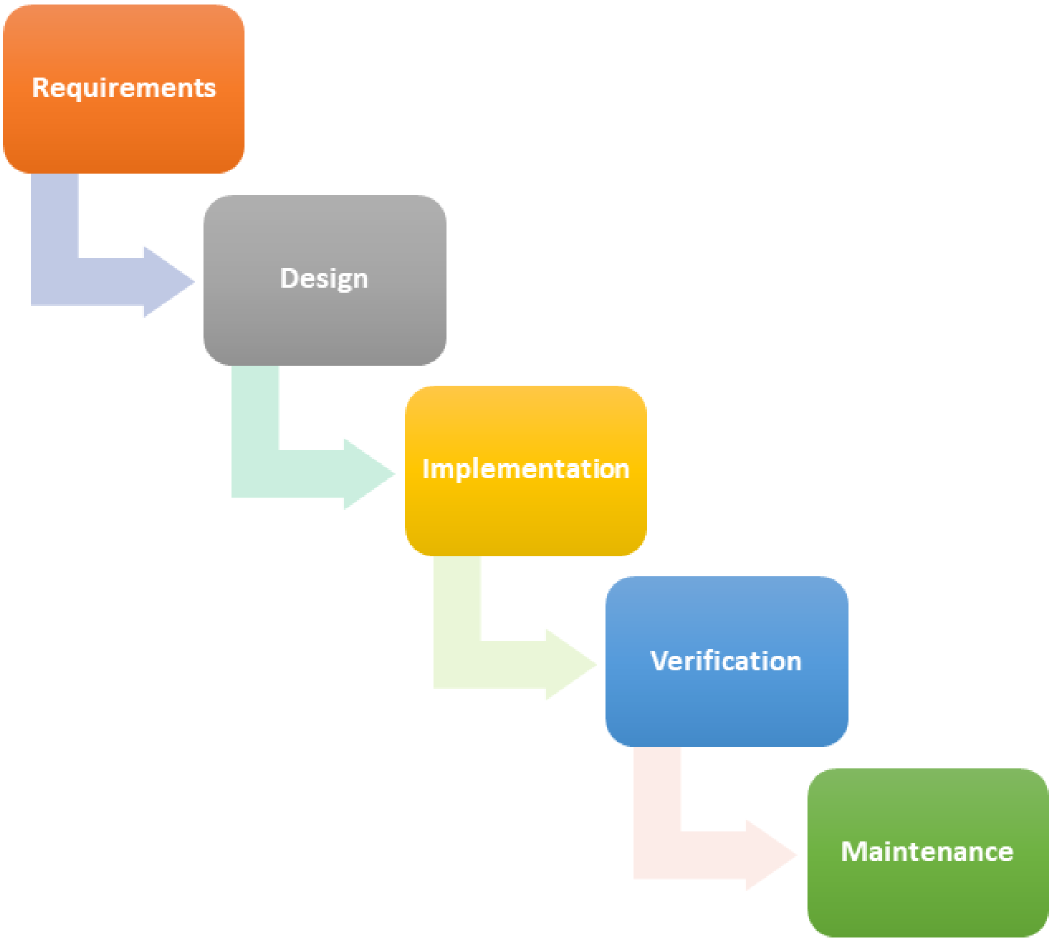

Figure 4. Main phases of waterfall method.

The waterfall method has five main phases in its simplest form, as depicted in Figure 4. These phases are strictly chronological and have their own fixed timeframe, requirements, and objectives. The main phases of the waterfall method (Wysocki, 2019) are –

i. **Requirements:** this phase includes gathering requirements from end-users, extensive documentation of the project, detailed project planning, and in-depth communication with end-users.

ii. **Design:** also known as *analysis*, this phase includes a review of the gathered requirements, the development of project design, the identification of the work path that leads to project delivery, and the detailed specification of actual work packages meeting the requirements. In project design, first the solutions meeting project objectives are designed at a logical level (theoretical and high-level design). Then, the implementation of the solutions is designed in more concrete terms at a physical level (on-ground and low-level design).

iii. **Implementation:** this phase includes actual project actions and operations (e.g., construction, coding, etc.), i.e., practical implementation of the design. Based on the documentation of previous phases, project deliverables are produced as per the planned work packages.

iv. **Verification:** this phase includes testing and verification of requirements to ensure that they are met. The deliverables are rigorously scrutinized for quality assurance. Any major issue causing failure to meet the quality standard will force the project to go back to phase one.

v. **Maintenance:** this phase starts after project delivery, where the maintenance team will help the end-users employ the deliverables in practice. This phase can be long-term (continuous support) or short-term until the end-users are fully satisfied.

In any scientific research project, the documentation of knowledge is extremely important. Therefore, robust documentation of the waterfall method can be useful. However, the strict sequential structure of the waterfall method provides little possibility to modify the requirements during project operation. This is a problem in scientific research since research projects are always evolving and very volatile in nature.

2.3.2 Agile method

The agile method is an iterative project management life cycle model and is heavily used in software development projects. In the agile method, certain processes are repeated in each cycle or iteration to incrementally attain the project deliverables. Therefore, after each cycle or iteration, intermediate versions of the project output are generated and revised as the end-user requirements change. The agile method includes different adaptive approaches such as *scrum*, *kanban*, and *scrumban*, to name a few. These agile frameworks are members of the so-called *agile family* and are often known as agile variants (Wysocki, 2019). In this thesis, only the *agile scrum* framework is considered for scientific research projects.

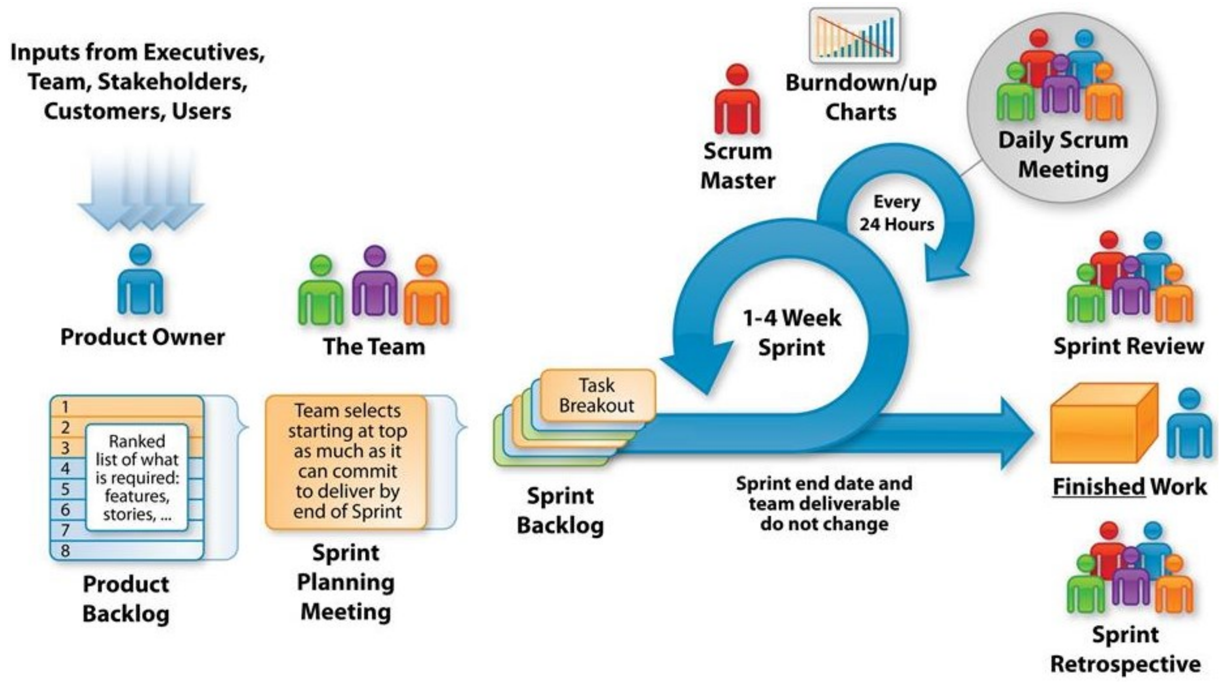

Figure 5. Agile scrum framework.

The basic workflow of the *agile scrum* framework (Wysocki, 2019), as illustrated in Figure 5 (Source: Yelkar, n.d.), has several steps. The steps are –

i. First, the *product owner* represents the end-users, defines the project output with the requirements in detail, and decides the date of the project delivery. The *product owner* also sets the acceptance criteria for the project output, i.e., the quality standards.

ii. Then, after collecting all the requirements from the end-users and key stakeholders, the *product owner* prioritizes and ranks the requirements in the *product backlog*.

iii. After that, the project company breaks down the whole project operation into a series of smaller cycles known as *sprints*, which are typically 1-4 weeks long. The project teams are also broken down into smaller *scrum teams* (5-9 members), which are cross-functional and collaborative in nature.

iv. Then, the *scrum team* selects the most prioritized requirements from the *product backlog* and creates a *sprint backlog* during the *sprint planning* meeting. The *scrum team* will only work on the *sprint backlog* during the *sprint* and will produce an intermediate version of the project output.

v. During the *sprint*, the *scrum master* leads the *scrum team* and monitors a *burndown chart*. The *burndown chart* progressively depicts how far the total tasks in the *sprint backlog* have already been achieved and how much is left. Therefore, at the beginning of the *sprint*, the *burndown chart* should be at its maximum, while it should be at its minimum when the *sprint* is over. The *scrum team* meets every morning in a *daily scrum* meeting (daily stand-ups) to discuss what work has been done, what work will be done, what the problems are, and how to resolve them.

vi. After the *sprint*, an intermediate or partial version of the project output is generated. The *scrum team*, *scrum master*, *product owner*, end-users, and key stakeholders together inspect and review the sprint output as per the acceptance criteria in *sprint review*.

vii. After that, the *scrum master* and the *scrum team* together assess their performance and productivity in terms of what went well and what could be improved in the *sprint retrospective* through open discussions. The idea is to resolve the issues causing ineffectiveness and adapt accordingly so that the team can be more efficient and effective.

viii. After that, based on the assessment, feedback, discussions, and change requests noted during the *sprint review*, the *product owner* updates or refines the *product backlog*.

ix. Then, the project operation enters the next *sprint*, and steps iv to viii are repeated.

x. Each *sprint* will produce the project output part by part, leading to the final project delivery after a certain number of *sprints*, which varies from project to project.

The *agile scrum* method maintains a flexible structure where the end-user requirements can be refined or changed after each *sprint* during project operation. Moreover, the feedback loop after each sprint retrospective leads to the refinement of the product backlog, making the project progress a continuously evolving and improving process (Wysocki, 2019). Therefore, the agile method can be extremely useful for scientific research projects since scientific research, fundamentally, is an iterative trial-and-error approach that seeks continuous improvement and evolves based on the lessons learned.

2.3.3 Hybrid method

Projects can often be too complex to manage only through the waterfall method or the agile method. In those cases, a hybrid project management approach is used by combining waterfall and agile methods. Such a synergy brings the best from the two methods and overcomes the drawbacks of the individual methods (Reiff & Schlegel, 2022).

Hybrid project management is a relatively new project management method and has recently become a popular choice for technology-based projects (Copola Azenha et al., 2020). Hybrid methods are not always a combination of waterfall and agile methods. They can also be a blend of different project management methods (Reiff & Schlegel, 2022). In this thesis, however, only the *waterfall-agile* hybrid project management method is considered.

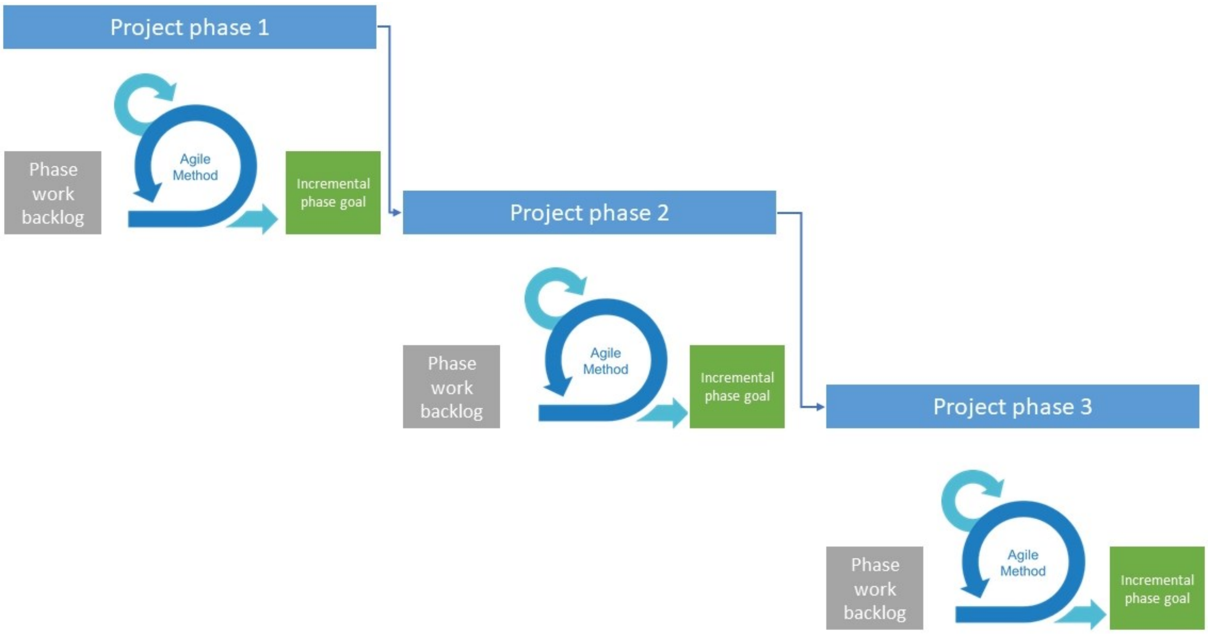

Figure 6. Waterfall-agile hybrid project management method.

In the *waterfall-agile* hybrid method, the *waterfall* method is used to plan the high-level project phases, while the *agile* method is employed to execute the low-level project phases. In other words, the exterior structure of the project, i.e., the main phases, maintains a *waterfall* framework, while the interior structure, i.e., each phase, is executed in an *agile* way (Dionisio, 2022). As illustrated in Figure 6 (Source: Vasiliauskas, 2023), the *waterfall* style is employed at the high-level project phases for project planning to decide the high-level deadlines, deliverables, milestones, and stage-gates, while in each phase, the project tasks are executed in an *agile* way, i.e., through *sprints*. Eventually, each *sprint* starts with a phase work backlog and delivers the phase goals incrementally (Dionisio, 2022).

The *waterfall-agile* hybrid method provides a robust top-level structure for the project using *waterfall* and allows adaptivity in actual bottom-level project operation through *agile* (Dionisio, 2022). Such an approach can greatly help in managing scientific research projects. On one hand, by employing *waterfall*, the overall project structure can be maintained as well-structured and stable to navigate the project in the right direction. On the other hand, by utilizing *agile*, the volatile nature of scientific research can be handled well.

2.4 Transformational leadership in projects

Leadership plays a key role in project success (Turner & Müller, 2005). Therefore, choosing the right leadership style is crucial for smooth project execution (Ali et al., 2021). Leadership style in projects can be

i. **Transactional:** In this leadership style, the leader is only interested in task completion. Transactional leaders do not invest time and effort to motivate or mentor their subordinates. They only reward or punish the followers based on their performance (Martinez & Leija, 2023).

ii. **Transformational:** In this leadership style, the leader acts as a coach or mentor for the subordinates. Transformational leaders motivate their subordinates to grow and align their motivation towards the project goals (Bass & Riggio, 2006).

iii. **Servant:** In this leadership style, the leader believes in a servant mindset and commits to the stewardship of subordinates (Martinez & Leija, 2023).

In hybrid project management, the role of the leader is very demanding. On one hand, the leader is required to efficiently coordinate the top-level project phases as an executive. On the other hand, the leader needs team management skills to steer the bottom-level sprints by leading the scrum masters, scrum teams, and the sprint retrospective (Dionisio, 2022). Considering the complex nature of the hybrid project management method, it is very hard for a transactional leader to sustain the motivation, productivity, and change-readiness of the project teams since a transactional leadership style is purely task-oriented and indifferent to people (Martinez & Leija, 2023). Only a people-oriented and emotionally intelligent leader can efficiently orchestrate such a complex project environment (Dionisio, 2022), and hence, a transformational leadership style is more suitable for complex projects (Ali et al., 2021).

One might argue that servant leadership is also suitable for projects since, like transformational leadership, it is also people-oriented and motivating (Andersen, 2018). However, servant leadership differs from transformational leadership in terms of the focus of the leader (Gregory Stone et al., 2004). In transformational leadership, the leader primarily focuses on the project goals. To ensure project success, a transformational leader motivates, aligns, and mentors the project workers towards those goals. Therefore, people-oriented engagement is the secondary focus to meet the primary focus, i.e., project success. In other words, in transformational leadership, projects come first, and then come the project workers (Bass & Riggio, 2006). On the contrary, servant leaders primarily focus on the subordinates and have low affinity for the project. In simple terms, in servant leadership, project workers come first, and then come the project goals or success (Gregory Stone et al., 2004). Only a people-oriented leader, who primarily focuses on project success and ensures that by polarizing the project workers towards the project objectives, can ace in a complex project environment. Eventually, transformational leadership is a relatively more secure choice for complex projects compared to servant leadership.

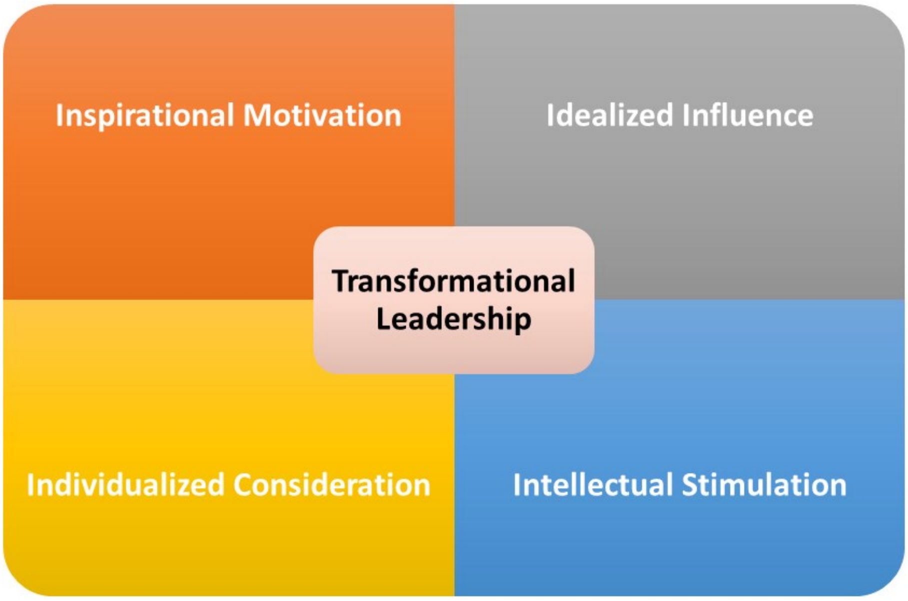

Figure 7. Main elements of transformational leadership.

Simply put, transformational leadership is a better choice for leading complex projects (such as scientific research projects) since it is neither merely task-oriented (transactional) nor losing focus from the project (servant). The key components of transformational leadership (Bass & Riggio, 2006), as shown in Figure 7, are –

i. **Inspirational motivation:** transformational leaders should have a clear vision about the project goals and the ability to clearly show that to the project workers. Such leaders should be able to induce motivation in their followers so that they attain those goals passionately.

ii. **Idealized influence:** transformational leaders should become a role model for their subordinates. By taking the right actions and by living as an example, such leaders should instill a high level of trust and respect in their followers towards the leader.

iii. **Intellectual stimulation:** transformational leaders should appreciate creativity, innovation, and a growth mindset in the work culture. Such leaders should build a work atmosphere where learning new things, exploring new ways of solving problems beyond the comfort zone, and perceiving challenges as opportunities are always encouraged.

iv. **Individualized consideration:** transformational leaders should support, coach, mentor, and encourage followers at an individual level. Through open communication and emotional intelligence, such leaders should create a safe space for the subordinates where project workers feel free to share ideas and be seen, heard, and recognized.

In scientific research projects, project leaders are usually professors or senior scientists who have a pedagogical commitment towards the project workers, i.e., junior or early-stage researchers. Leading projects in science is often academic supervision too. Therefore, transformational leadership should be practiced when leading scientific research projects.

Chapter summery

This chapter presented the theoretical framework of the thesis obtained via a systematic literature review, followed by brief explanations of the underlying theories included in that framework. According to the presented framework, scientific research projects should be ideated using blue ocean and lean strategies, conducted (from planning to closure) using a hybrid (waterfall and agile) project management method, and orchestrated by a transformational leader.

3 RESEARCH METHODS

In this chapter, the research methods used in this thesis are briefly presented. The chapter starts by explaining the research framework of the thesis, followed by brief descriptions of the research methods used in this thesis.

3.1 Research framework

The research framework of the thesis employs quantitative and qualitative research methods to address the research questions RQ1 and RQ2. As shown in Figure 8 and as per the research framework –

i. First, a systematic literature review has been performed to construct a theoretical framework for project management in scientific research projects. The details of the systematic literature review process and the theoretical framework depicted in Figure 1 are already discussed in Chapter 2.

ii. Then, the suitability of the theoretical framework is tested via quantitative research. A survey has been conducted to collect the opinions of the people under study on the proposed theoretical framework, and statistical analysis is performed on the survey data to reveal the underlying consensus. Therefore, at this stage, RQ1 is answered by finding the optimal project management framework for scientific research projects and by justifying it based on the opinions of the scientific community under study.

iii. After that, based on the findings of RQ1 (optimal framework), a project management model is developed for the research unit under study through qualitative research. Action research is employed to realize the development process, while qualitative data analysis (QDA) is utilized to analyse the qualitative data generated during the action research. At the end of this phase, RQ2 is answered by developing a project management model for scientific research projects customized for the research unit under study.

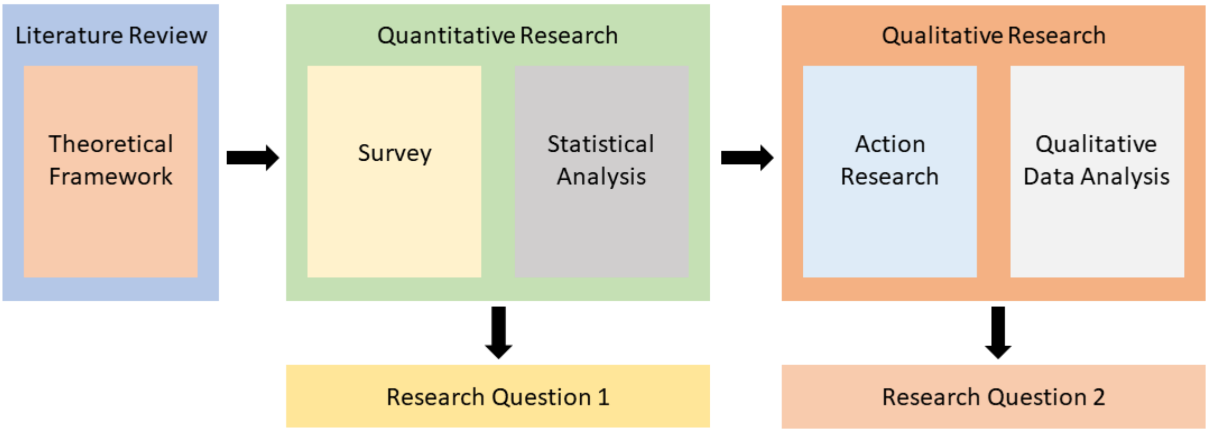

Figure 8. Research framework.

3.2 Quantitative research

In quantitative research, a survey is used to collect the data, while statistical methods are employed to analyse the collected data.

3.2.1 Survey

A survey is a research tool often used in quantitative research to collect information from the people under study through questionnaires. Surveys are widely used to gather information in many research fields, such as social science, marketing, health, politics, and psychology, to name a few (Rea & Parker, 2014). In survey research, the basic steps are –

i. **Define the survey population and sample:** before performing the survey, the researcher should define the survey participants. The *population* should be the target population relevant to the research question, and the *sample* should be a clear subset of that *population*. Since conducting a survey on the entire *population* is often not possible, surveys are usually conducted on a *sample* that is representative of the *population*. The *sample* is obtained through *sampling*, i.e., the method of selecting a subset from a much larger community, and it can be probabilistic (random) or non-probabilistic (selective) in nature. For the chosen *sample*, the total number of survey participants is the *sample size* (Rea & Parker, 2014). In this thesis, the *population* is scientific researchers, and the *sample* is the researchers of a chosen research unit. The *sample* is obtained through *convenience sampling* since the survey participants are workmates of the author selected based on accessibility and availability. The *sample size*, i.e., the total number of researchers working in that research unit, is 20.

ii. **Define survey type:** surveys can be done in the form of *questionnaires*, where the participants respond to a set of questions, or in the form of *interviews*, where the participants are interviewed, and their responses are recorded (Rea & Parker, 2014). In this thesis, the survey is conducted in the form of a *questionnaire*.

iii. **Design survey questions:** survey questions can be *open-ended* or *closed-ended*. In *open-ended* questions, the participants respond in their own words, and the survey responses are free-form answers. In *closed-ended* questions, the participants chose their answers from a predetermined set of answers. For example, when multiple answers are provided as options (yes/no, agree/somewhat agree/disagree, etc.), the participants select one option from those (Rea & Parker, 2014). In this thesis, the survey consists of *closed-ended* questions with a predetermined set of answers.

iv. **Distribute the survey:** surveys can be conducted online, via mail, or in person (Rea & Parker, 2014). In this thesis, the survey is conducted online using *Google Forms*. The online link to the survey is distributed to the participants via email.

v. **Analyze survey responses:** in quantitative research, survey responses are analyzed using statistical methods (Rea & Parker, 2014). In this thesis, *descriptive statistics* is used to analyze the survey data. This is discussed in detail in the subsequent section.

In this thesis, fortunately, the response rate of the survey is 100%, i.e., all 20 researchers working in the chosen research unit responded to the survey.

3.2.2 Statistical analysis

In quantitative research, survey responses are often converted to numbers for data analysis. Such conversion can be based on the Likert scale (e.g., $agree = 2$, $somewhat\ agree = 1$, and $disagree = 0$) or a binary scale (e.g., $yes = 1$ and $no = 0$), to name a few. The conversion yields *survey data* for statistical analysis (Rea & Parker, 2014).

Statistical analysis can be *descriptive*, *inferential*, or a combination of both. In this thesis, only *descriptive statistics* is used to analyze the *survey data*. In *descriptive statistics*, the main characteristics of the *survey data* are described (Levine et al., 2019) in terms of –

i. **Central tendencies:** mean, median, and mode.

ii. **Variation:** range, standard deviation, and variance.

iii. **Shape:** skewness and kurtosis.

iv. **Accuracy:** standard error and confidence level/interval.

In this thesis, the *descriptive* statistical parameters evaluated from the *survey data* are –

i. **Mean:** For a survey dataset $[x_1, x_2, \dots, x_j, \dots, x_N]$, where $j = 1,2,3, \dots, N$ and N is the *sample size*, mean ($\bar{x}$) is mathematically defined as $\bar{x} = \left(\sum_{j=1}^{N} x_j\right)/N$, and it represents the average of the dataset (Levine et al., 2019).

ii. **Median:** For a survey dataset $[x_1, x_2, \dots, x_j, \dots, x_N]$, which is sorted in an ascending order with rank $j = 1,2,3, \dots, N$ (N is the *sample size*), median is mathematically defined as the data x_m having rank $m = (N+1)/2$, and it represents the middle value of the dataset (Levine et al., 2019).

iii. **Mode:** In a survey dataset, mode is the most frequently appearing value (Levine et al., 2019). For example, in a binary scaled survey dataset [1, 0, 1, 0, 1, 0, 1, 1, 1], mode is 1 since it appeared most frequently.

iv. **Range**: For a survey dataset $X = [x_1, x_2, \dots, x_j, \dots, x_N]$, where $j = 1,2,3, \dots, N$ and N is the *sample size*, range is mathematically defined as $range = X_{max} - X_{min}$, and it represents the difference between the largest value and the smallest value present in the dataset (Levine et al., 2019).

v. **Standard deviation:** For a survey dataset $[x_1, x_2, \dots, x_j, \dots, x_N]$, where $j = 1,2,3, \dots, N$, $\bar{x}$ is the mean, and N is the *sample size*, standard deviation (σ) is mathematically defined as $\sigma = \sqrt{\left\{\sum_{j=1}^{N}\left(x_j - \bar{x}\right)^2\right\}/(N-1)}$, and it represents the dispersion of the dataset with respect to the mean (Levine et al., 2019).

vi. **Variance:** For a survey dataset $[x_1, x_2, \ldots, x_j, \ldots, x_N]$, where $j = 1,2,3, \ldots, N$, $\bar{x}$ is the mean, N is the *sample size*, and σ is the standard deviation, variance (V) is mathematically defined as $V = \sigma^2$, and it represents the spread or variability present in the dataset with respect to the mean (Levine et al., 2019).

vii. **Skewness:** In a survey dataset, the distribution of data can be symmetric or asymmetric around the mean, and its shape can be measured via skewness. For a survey dataset, if $mean < median$, then the distribution is left-skewed (asymmetry in left side of mean). If $mean > median$, then the distribution is right-skewed (asymmetry in right side of mean), while for $mean = median$, the skewness is zero (symmetric around mean). Therefore, skewness represents the degree of symmetry present in the distribution of data (Levine et al., 2019).

viii. **Kurtosis:** In a survey dataset, the shape of the distribution of data can further be measured via kurtosis. In the case of normal distribution, $kurtosis = 0$ and the distribution resembles a bell shape curve. When $kurtosis > 0$ (leptokurtic), the distribution curve is sharper than the normal distribution. When $kurtosis < 0$ (platykurtic), the distribution curve is flatter than the normal distribution. Therefore, kurtosis represents the degree of sharpness present in the distribution of data (Levine et al., 2019).

ix. **Standard error:** For a survey dataset $[x_1, x_2, \ldots, x_j, \ldots, x_N]$, where $j = 1,2,3, \ldots, N$, $\bar{x}$ is the mean, N is the *sample size*, and σ is the standard deviation, standard error (SE) is mathematically defined as $SE = \sigma/\sqrt{N}$, and it is a measure of accuracy. In other words, standard error tells how much a *sample statistic* might vary from a *population statistic* (Levine et al., 2019).

x. **Confidence level and interval:** For a survey dataset, confidence level is the probability of getting the same results for a *sample statistic* if the survey is conducted again with the same *sampling*. The confidence interval (CI) is an expected interval, and at a presumed confidence level, the results for a *sample statistic* will reside within that interval if the survey is conducted again with the same *sampling*. For a survey dataset $[x_1, x_2, \ldots, x_j, \ldots, x_N]$, where $j = 1,2,3, \ldots, N$, $\bar{x}$ is the mean, N is the *sample size*, σ is the standard deviation, and z is the confidence coefficient for a presumed confidence level, confidence interval (CI) is mathematically defined as $CI = \bar{x} \pm z(\sigma/\sqrt{N})$. When calculating CI, presuming a 95% confidence level ($z = 1.96$) is the common practice. Therefore, confidence level and interval are measures of accuracy, and they represent the level of confidence associated with the *survey data* (Levine et al., 2019).

It is worth highlighting here that in this thesis, the survey participants are chosen via *convenient sampling*, and the *sample size* of the survey is very small ($N = 20$). Consequently, the survey is prone to statistical bias, and the *sample* might not represent the *population* accurately (Rea & Parker, 2014). That is why, in this thesis, only *descriptive statistics* is used to analyze the *survey data*, and any advanced statistical analysis (e.g., *inferential statistics*) is avoided. Therefore, the quantitative data analysis in this thesis is limited to *descriptive statistics*, not to avoid mathematical complexity or rigor but to omit any spurious statistical outcomes. Since the research questions are customized for a chosen research unit and the whole unit responded to the survey, *descriptive statistics* is enough to conclude the collective mindset of the chosen research unit with adequate accuracy.

3.3 Qualitative research

In qualitative research, action research is used to realize RQ2, while qualitative data analysis (QDA) is utilized to analyse the qualitative data generated during the action research.

3.3.1 Action research

Action research is a qualitative method where a given problem is investigated and solved simultaneously through iterations, i.e., action research cycles. In each action cycle, the researcher conducts research and acts concurrently to reach a solution to the given problem via incremental understanding and improvements (Eriksson & Kovalainen, 2008).

Action research is highly interactive in nature, and it involves systematic inquiries and reflections. In action research, when a researcher approaches a given problem related to a group of people, the people under study become participants in the action research and act as co-researchers by sharing their experiences and reflections. The action researcher prioritizes and utilizes these reflections to solve the given problem. Since the people for whom the solution is sought are directly involved in the problem-solving process, action research is often used to bridge the gap between theory (e.g., a proposed model) and practice (practical implementation of that model) (Cornish et al., 2023).

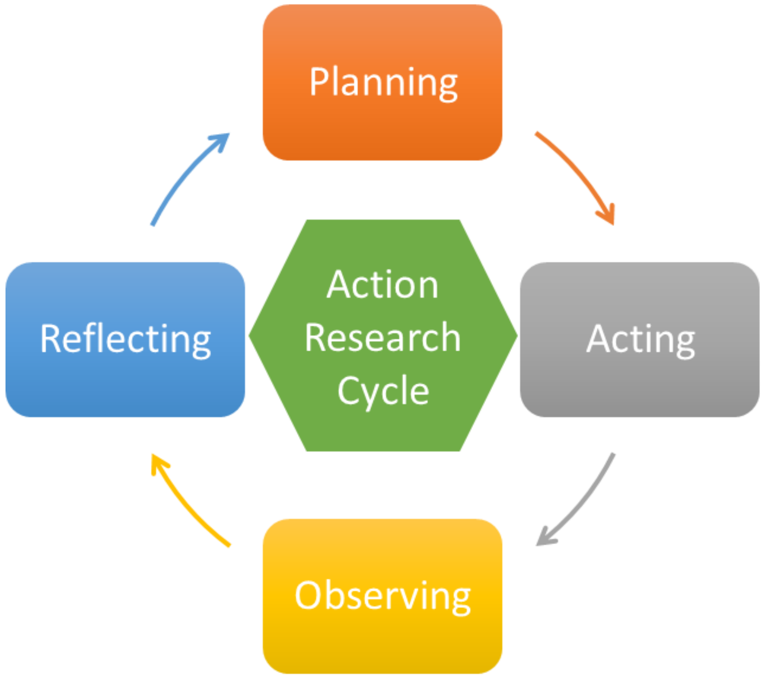

Figure 9. Stages of action research process.

To understand how action research works in practice, let's consider that the given problem is *what could be the best online teaching process in the classroom*. Action research will happen through multiple iterated feedback cycles, i.e., action research cycles, where each cycle contains a sequence of actions (*planning* → *acting* → *observing* → *reflecting*) (Cornish et al., 2023), as shown in Figure 9. To find a solution for the given problem –

i. **Planning:** the action researcher performs a preliminary diagnosis of the problem first and *plans* a list of digital teaching tools as well as a teaching process that could be tested in the classroom.

ii. **Acting:** then, the action researcher *acts* by implementing the proposed teaching process and by using those digital teaching tools in the classroom.

iii. **Observing:** while the teaching process and those digital teaching tools are in use, the action researcher *observes* how the teachings and studies are going.

iv. **Reflecting:** after that, the action researcher collects reflection on this issue from the people under study (educators and students) and *reflects* after analyzing the collected information. The action researcher *plans* a revised solution, i.e., an improved version of the teaching process along with an updated list of digital teaching tools for testing, and initiates the next action research cycle by repeating steps i to iv. The iteration of action cycles will not stop until the optimal solution is found.

In this whole action study, i.e., starting from the *planning* phase of the first action cycle to the last phase of the last action cycle, where the optimal teaching model is already found, students and educators are the participants as well as strong collaborators in the action research by providing critical reflections and insights. The action researcher and the participants together focus on solving the problem (the development of an optimal online teaching process) systematically by compiling learnings (critical reflections and retrospectives) in the *reflecting* phase, revising the existing process based on the lessons learned in the *planning* phase of the next action cycle, implementing the revisions in the *acting* phase, and studying the change or effects in the *observing* phase (Coghlan & Shani, 2018).

Due to its highly adaptive nature and ability to tailor the solution to individual needs, action research is often used in organizations to figure out an immediate, approachable, and actionable path to resolve any issue (Shani & Coghlan, 2019). On one hand, in project management, action research is very effective for implementing change and improving quality (Coghlan et al., 2022). On the other hand, action research brings potential benefits to RDI management (Ollila & Yström, 2020). Therefore, action research can easily be exploited as a method to develop project management models for scientific research.

In this thesis, action research is used to develop a project management model for a chosen research unit. The given problem is – *what could be the optimal project management model for RDI projects*. An action group is formed by building a focus group (Morgan, 1997) consisting of 6 members of the chosen research unit who are the participants of the action research. The action group includes 2 top-level, 2 mid-level, and 2 low-level scientists and, hence, covers the whole project hierarchy. A project management model for a generic RDI project is developed through three action cycles (three months), where each action research cycle lasts one month. The critical reflections and retrospectives are collected through focus group discussions and analysed via qualitative data analysis (QDA).

3.3.2 Qualitative data analysis (QDA)

Unlike quantitative research (survey and statistical analysis), where research data is purely numerical, action research is a qualitative research method and generates *qualitative data*, i.e., non-numerical data such as texts, videos, audios, photos, etc. These *qualitative data* are collected during action research and analyzed to decipher the reflections of the people under study, to gain insights, and to create new knowledge (Schreier, 2012).

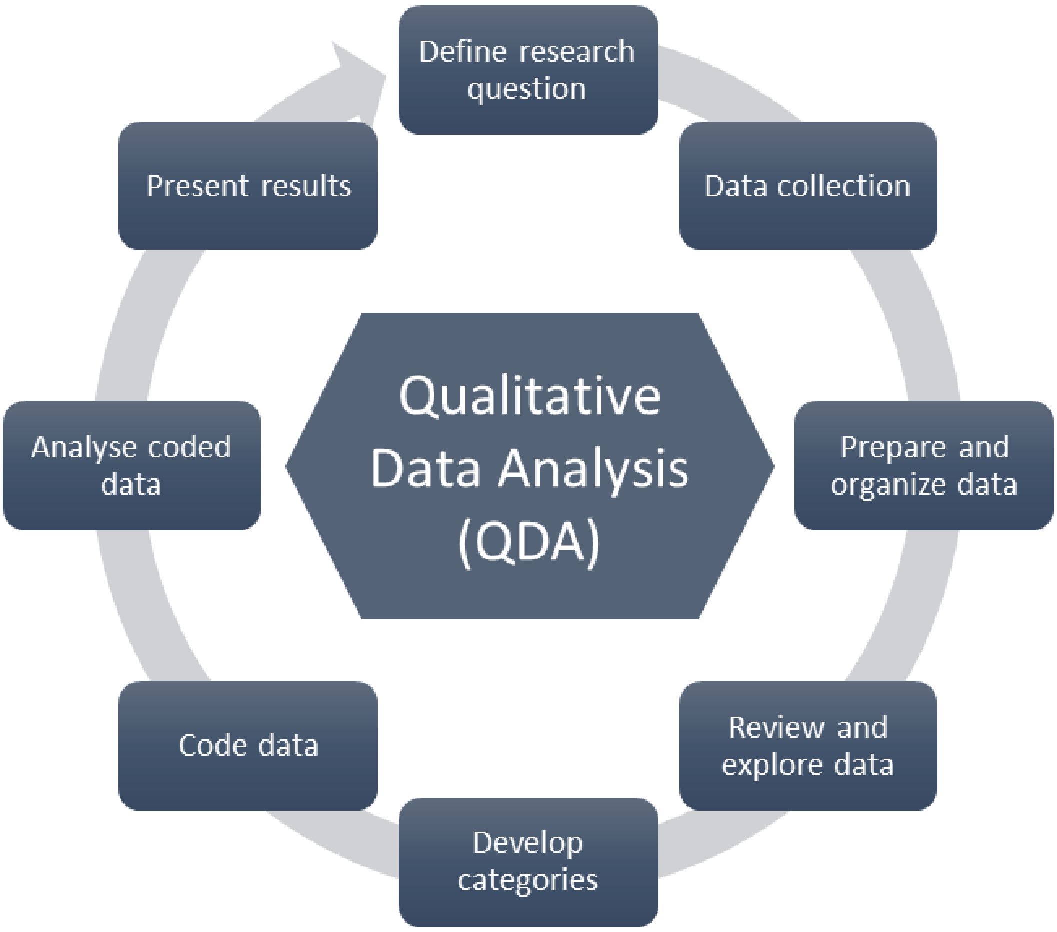

Figure 10. Basic steps of qualitative data analysis (QDA).

The basic steps of qualitative data analysis (QDA), as depicted in Figure 10, are –

i. **Define research question:** in QDA, the foremost step is defining the research question concretely (Kuckartz & Rädiker, 2023). In this thesis, that is RQ2, i.e., a project management model for a generic RDI project.

ii. **Data collection:** next step is data collection, where the action researcher decides the type of data to be collected as well as the means of collection and collects the data

(Kuckartz & Rädiker, 2023). In this thesis, critical reflections and retrospectives are collected during action cycles through focus group discussions, and hence, the collected *qualitative data* is textual contents (meeting memos, feedback forms, focus group discussion notes, etc.).

iii. **Prepare and organize data:** after collecting the raw data, the action researcher organizes the data in a structural manner and prepares it for analysis (Kuckartz & Rädiker, 2023). In this thesis, this step is done by merging all *qualitative data* (textual contents) collected from different sources (meeting memos, feedback forms, focus group discussion notes, etc.) into a single data file for each action cycle.

iv. **Review and explore data:** when the collected data is organized, the action researcher reviews the data to explore patterns, themes, categories, relationships, and repeated ideas. This is a prerequisite before performing any actual QDA technique (Kuckartz & Rädiker, 2023). In this thesis, this step is done for each action cycle.

v. **Develop categories:** after reviewing the data, the action researcher develops categories based on the explored themes and segments the data into categories (Kuckartz & Rädiker, 2023). In this thesis, the action research data is categorized as per the elements of project and research life cycle phases (see Figure 1).

vi. **Code data:** when the data is categorized, the action researcher codes the data for QDA. The term *coding* here means tagging or labeling data based on topics or theme elements (Kuckartz & Rädiker, 2023). In this thesis, the coding is done by going through each focus group participant's responses and tagging those responses as per the elements of the theoretical framework (e.g., leadership, sprint, project plan, etc.).

vii. **Analyze coded data:** after coding the data, the action researcher analyzes the coded data by identifying recurring or overarching themes, linking codes, and thereby constructing a holistic and cohesive map of the issue (Kuckartz & Rädiker, 2023). In this thesis, the coded data is analyzed using *content analysis* (Bengtsson, 2016), where patterns are extracted from textual contents as per the coding system (Zelčāne & Pipere, 2023).

viii. **Present results:** this is the last step where the action researcher summarizes the findings, draws conclusions, and presents the results to the participants of the action research (Kuckartz & Rädiker, 2023). At this stage, based on the reflection of the action group on the results, the next action cycle starts by redefining the research question and following steps i to viii again, as shown in Figure 10. In this thesis, this step is done for each action cycle, i.e., monthly.

3.4 Research tools

In this thesis, *Google Forms* and *Microsoft 365* package (provided by SeAMK) are used as research tools. The online survey is prepared and conducted using *Google Forms*. The thesis and the action research documents are prepared using *Word*, while all the figures are prepared using *PowerPoint*. The quantitative and qualitative data analysis is performed in *Excel*, and the associated plots are prepared using *Excel*.

Chapter summery

This chapter presented the research framework of the thesis and briefly discussed the research methods included in that framework. As per the research framework, RQ1 is addressed by constructing a theoretical framework for project management in scientific research projects through a systematic literature review and by justifying it based on the opinions of the scientific community under study via quantitative research (surveys and statistical analysis). Based on the findings of RQ1, RQ2 is addressed by developing a project management model for scientific research projects customized for the research unit under study through qualitative research (action research and QDA). The fine details of the research work and the research results are presented and discussed in detail in the next chapter.

4 RESEARCH RESULTS AND DISCUSSIONS

In business research, the common practice is to use quantitative and qualitative methods to solve the research questions (Bryman & Bell, 2011), and the methods used in this thesis are discussed in the previous chapter. This chapter presents and discusses the research results.

4.1 Quantitative research results

In this thesis, the quantitative research aims to find the answer for RQ1, i.e., to derive an optimal project management framework for scientific RDI projects. Such a framework (Figure 1) is constructed via a literature review (Chapter 2), and an online survey has been conducted via *Google Forms* to collect the opinions of the people under study (Rea & Parker, 2014) on the proposed theoretical framework. After that, statistical analysis is performed on the survey data in *Excel* (Schmuller, 2022) to reveal the underlying consensus.

Before presenting the questions and results of the survey, it is important to highlight here that the survey participants only agreed to respond to the survey anonymously. Therefore, it is not possible to categorize the survey responses as per the hierarchy of the chosen research unit. In other words, due to the anonymity of responses, it is impossible to determine, e.g., the opinions of the top-level members and how they differ from the opinions of the mid-level or low-level members. Nevertheless, the collective mindset of the chosen research unit and, hence, the underlying consensus are revealed through quantitative research.

The survey consists of 10 questions covering different themes and subthemes of the proposed framework (Figure 1). The main themes and the associated research results are discussed in the following subsections.

4.1.1 Project mindset

To incorporate project management into the work culture of a research unit, one first needs to evaluate the *project mindset* of the members of that chosen unit, i.e., their cognitive readiness towards project management (Belack et al., 2019). In simple terms, how do the members of that chosen unit feel about integrating project management into their work practices? Are they willing to accept it as a positive change or reluctant to adopt it? Do they think it is important for project success or not?

The first two survey questions (Q1 and Q2) reported in Table 1 are used to assess the *project mindset* in terms of collected opinions on project competence (Q1) and the effectiveness of project protocols (Q2). The predetermined sets of answers for Q1 and Q2 are also reported in Table 1, along with the associated Likert scale coding.

Table 1. Survey questions on project mindset.

Question number	**Sub-theme**	**Survey question**	**Possible responses (Likert scale coding)**
Q1	Project management competence	In addition to being experts in science and technology, do you think that it is important for scientists to have project management skills?	Not important (0) Somewhat important (1) Very important (2)
Q2	Project management protocol	Enabling project management protocols will boost the productivity and performance of the team members as individuals and as a team.	Strongly agree (2) Agree (1) Neutral (0) Disagree (-1) Strongly disagree (-2)

As one can see from Table 1, based on the responses of Q1, we can figure out whether the members of the chosen research unit think it is important to have project management competence or not. Their confidence in project management protocols or systems can be evaluated from the responses in Q2. Together, responses to Q1 and Q2 reflect how project management is perceived or viewed among the members of the chosen research unit.

Statistical analysis in *Excel* (Schmuller, 2022) on the survey data related to Q1 and Q2 is performed in terms of *distribution* of data and *mode* of data. The *distribution* provides a map of the collective opinion, while the *mode* reflects the most popular choice (Schwabish, 2023). As reported in Figure 11(a), 50% of people think having project management competence is somewhat important, while the rest 50% think it is very important. However, no one thinks it is not important. When it comes to integrating project management protocols into work practices, as reported in Figure 11(b), 45% of people believe that it can enhance work efficiency, 40% strongly believe the same, and only 15% think it has no such effect. However, no one thinks that it will have any adverse effects.

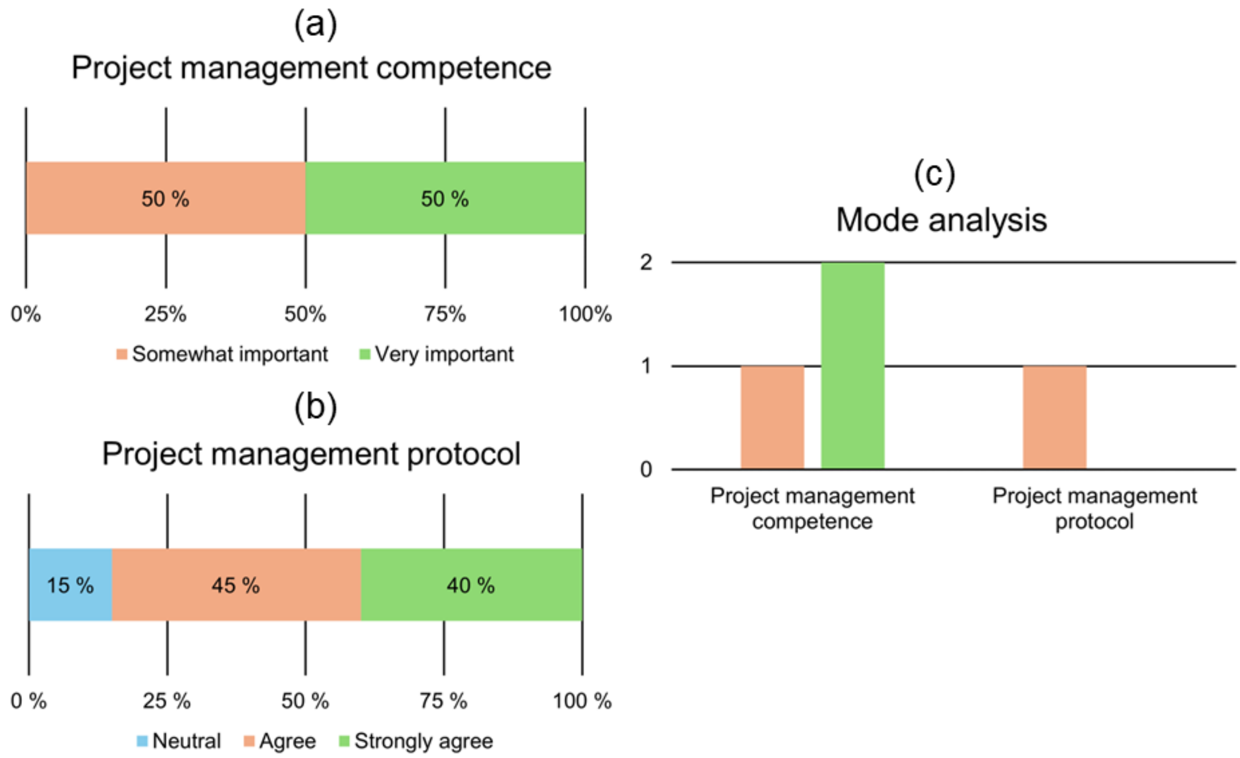

Figure 11. Distribution of survey responses on (a) project management competence and (b) project management protocol. (c) Mode analysis of survey responses.

Now, let us look at the mode of the survey responses, i.e., the most popular choice. As shown in Figure 11(c), for Q1, we got two modes: 2 (very important) and 1 (somewhat important), while for Q2, the mode is 1 (agree). Therefore, we can conclude that the research unit collectively holds an overall positive attitude towards project management and is cognitively ready to integrate it into their work practices.

4.1.2 Project leadership

In project management, the role of a project leader is very demanding, starting from developing the project strategy to drawing the project closure (Burke & Barron, 2014). Therefore, optimizing the project leadership style is essential for project success (Jonasson & Ingason, 2018). In this regard, the next two survey questions (Q3 and Q4) are used to determine what kind of *project leadership* is preferred among the people under study. The assessment is done in terms of collected opinions on leadership style (Q3) and managerial style (Q4). The survey questions Q3 and Q4, along with their predetermined sets of answers, are reported in Table 2.

Table 2. Survey questions on project leadership.

Question number	Sub-theme	Survey question	Possible responses
Q3	Leadership style	What kind of leadership style do you think best suits scientific research projects?	Transactional: just cares about whether the assigned tasks are done or not to ensure project success. Transformational: more like a coach or mentor, always motivating and guiding to ensure project success. Servant: believes in serving people more than the project's success.
Q4	Managerial style	What kind of leader do you think best suits scientific research projects?	cares more about employees' happiness than their productivity. cares more about employees' productivity than their happiness. prefers a trade-off between the happiness and productivity of employees.

As one can see from Table 2, based on the responses in Q3, we can figure out what kind of leadership style is preferred among the people under study. The preferred managerial style can be evaluated from the responses in Q4. Together, responses to Q3 and Q4 reflect how project leadership is perceived or viewed among the members of the chosen research unit.

Statistical analysis of the survey data related to Q3 reveals that the whole research unit collectively (100%) prefers a transformational leader, as one can see in Figure 12(a). When it comes to managerial style (Q4), as reported in Figures 12(b) and 12(c), 95% of people like a leader who prefers a trade-off (middle of the road) between the happiness and productivity of employees, and only 5% choose a leader who prioritizes employees' happiness (country club).

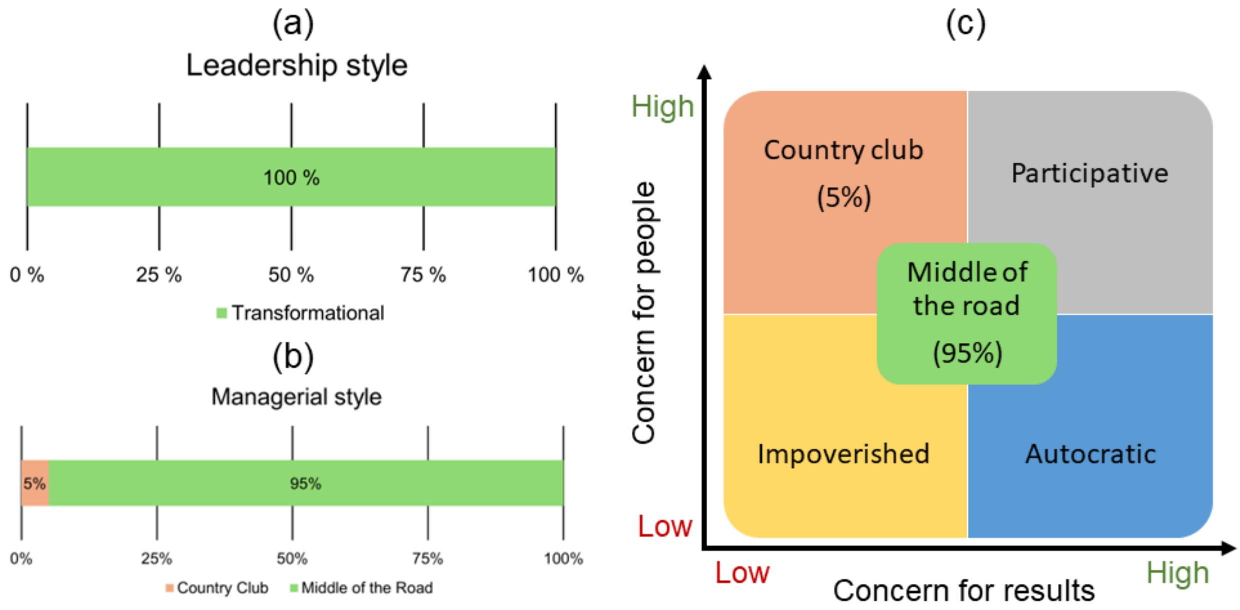

Figure 12. Distribution of survey responses on (a) leadership style and (b) managerial style. (c) Managerial grid model of leadership.

To understand the managerial style of a leader more clearly, one should consider the managerial grid model of leadership (Roy, 2019), as depicted in Figure 12(c). In the managerial grid model, five kinds of leadership styles are defined depending on the leader's concern for people (subordinates) and results (meeting goals). In *country club* leadership style, the leaders are usually overly friendly and keep the subordinates happy. However, they fail to prioritize meeting goals and boosting team productivity. In simple words, a *country club* leader cares more about employees' happiness than their productivity. In *impoverished* leadership style, the leaders neither make the subordinates happy nor prioritize meeting goals and boosting team productivity. In other words, *impoverished* leaders only care about them while ignoring employees' happiness and productivity (i.e., the worst-case scenario). The *autocratic* leadership style is transactional leadership, where the leader only cares about employees' productivity, i.e., whether the task is accomplished or not, and is indifferent to their happiness. The *participative* leadership style is the best-case scenario where the leaders can enhance both the happiness and productivity of their employees, while in *middle-of-the-road* leadership, the leader prefers a trade-off between the happiness and productivity of employees (Roy, 2019).

Now, if we look at the possible responses to Q4, as reported in Table 2, we can see that the given options are *country club*, *autocratic*, and *middle-of-the-road* leadership. During survey design, *impoverished* and *participative* leadership styles are excluded since they are extreme scenarios and rare in practice. As we see in Figures 12(b) and 12(c), 95% of people prefer *middle-of-the-road* leadership, and only 5% prefer a *country club* leader.

Transformational leaders neither prioritize employees' productivity over happiness (autocratic or transactional) nor the other way around (country club or servant). In that sense, the *middle-of-the-road* style is well aligned with transformational leadership. Therefore, we can conclude from Figure 12 that the research unit predominantly prefers a transformational leader who maintains a middle-of-the-road trade-off between the happiness and productivity of employees to ensure project success.

4.1.3 Project strategy

In project management, an optimal project strategy is crucial to ensure clear alignment of project goals, unique value creation, and the removal of redundancies. During project ideation and planning, forming a good project strategy secures a favourable strategic positioning of the project (Kodukula, 2014). As already discussed in Chapter 2, the blue ocean strategy aids in unique value creation while minimizing cost (Kim & Mauborgne, 2015), and lean principles warrant the removal of redundancies (Arthur, 2010). In this regard, the next survey question (Q5) reported in Table 3 is used to evaluate what the members of the chosen research unit think about integrating blue ocean and lean into *project strategy*. Do they think it is important or not? The assessment is done in terms of collected opinions on *project strategy* (Q5), and Table 3 reports the predetermined set of answers for Q5 along with the associated Likert scale coding.

Table 3. Survey questions on project strategy.

Question number	Sub-theme	Survey question	Possible responses (Likert scale coding)
Q5	Blue ocean Lean	The blue ocean strategy enhances project value while minimizing project cost. Lean principles minimize the waste of time and resources during project operation. In a research project, do you think that it is important to integrate the blue ocean and lean into the project strategy?	Not important (0) Somewhat important (1) Very important (2)

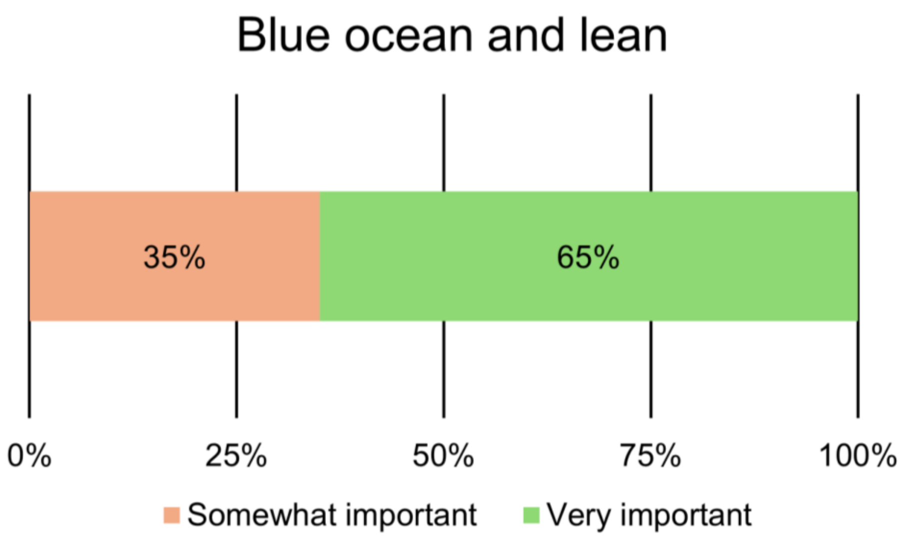

Figure 13. Distribution of survey responses on project strategy.

Statistical analysis of the survey data related to Q5 reported in Figure 13 reveals that 35% of people think integrating blue ocean and lean into project strategy is somewhat important, while the rest 65% think it is very important. As per the survey responses to Q5, the mode (most popular choice) is 2 (very important), and no one thinks blue ocean or lean are not important. Therefore, we can conclude that the research unit collectively holds an overall positive attitude towards integrating blue ocean and lean principles into project strategy as well as into their work practices.

4.1.4 Project management

As already discussed in Chapter 2, project management for scientific RDI projects requires a hybrid approach, i.e., the *waterfall-agile* hybrid method. In such a hybrid scheme, *waterfall* is used to plan the high-level project phases, while *agile* is employed to execute the low-level project phases. In other words, the exterior structure of the project, i.e., the main phases, maintains a *waterfall* framework, while the interior structure, i.e., each phase, is executed in an *agile* way (Dionisio, 2022). In this regard, the rest of the five survey questions (Q6 to Q10) are used to evaluate the necessity of *waterfall* and *agile* methods in scientific RDI projects in terms of collected opinions. The survey questions from Q6 to Q10 focus on different elements of *waterfall* and *agile* methods, such as

- ✓ Q6: Project planning and documentation in the *waterfall* method.
- ✓ Q7: Flexibility of the *agile* method.

- ✓ Q8: Collaborative and cross-functional teamwork in *scrum*.
- ✓ Q9: Project visualization.
- ✓ Q10: Project key performance indicator (KPI).

The survey questions (Q6 to Q10), their predetermined sets of answers, and the associated Likert scale coding are reported in Table 4 and Table 5.

Table 4. Survey questions on waterfall and agile project management.

Question number	Sub-theme	Survey question	Possible responses (Likert scale coding)
Q6	Waterfall	The waterfall method provides a well-defined project structure, rigorous project documentation, and meticulous project planning. Do you think it is important to use the waterfall method in managing scientific research projects?	Not important (0) Somewhat important (1) Very important (2)
Q7	Agile	Scientific research projects are full of risk and uncertainty and often evolve over time. How important is choosing the agile (iterative, flexible, and adaptive) method for managing such unpredictable projects?	
Q8	Scrum	The scrum approach suggests project execution by forming small, cross-functional, and self-organized teams. When a scientific research project is ongoing, how important are continuous collaboration, cooperation, and communication among research groups and members?	

Table 5. Survey questions on project visualization and KPI.

Question number	Sub-theme	Survey question	Possible responses (Likert scale coding)
Q9	Project visualization	Project visualization helps with project control and monitoring. How important is it to visualize the progress status of a scientific research project using some dashboards during the project lifecycle?	Not important (0) Somewhat important (1) Very important (2)
Q10	Project KPI	In industry, key performance indicators (KPIs) are widely used to judge the performance or success of a project. In your opinion, what could be the best KPI for scientific research projects?	How many papers have been published in high-impact journals? Is innovation patented or not? Growth of scientific knowledge. Whether the proposed project goals are achieved or not.

As one can see from Table 4, based on the responses of Q6, Q7, and Q8, we can figure out the relevance of the waterfall and agile methods in scientific RDI projects from the viewpoint of the members of the chosen research unit. Do they think it is important to employ waterfall and agile processes for managing scientific RDI projects or not? Their perspective on project control and monitoring (visualization and KPI) can be evaluated from the responses of Q9 and Q10 (Table 5). Together, the responses to the survey questions reported in Table 4 and Table 5 reflect what the members of the chosen research unit think about managing a scientific research project in practice, starting from planning and documentation to defining a closure based on a predefined KPI.

Statistical analysis of the survey data related to Table 4 in terms of *distribution* and *mode* is reported in Figure 14. From Figure 14(a), it is clear that 90% of people think it is very important to employ waterfall and scrum in managing scientific RDI projects, while the rest 10% think it is somewhat important. However, no one thinks it is not important. When it comes to deploying agile for the same, as reported in Figure 14(a), 45% of people think it is very important, while the rest 55% think it is somewhat important. Again, no one thinks it is not important.

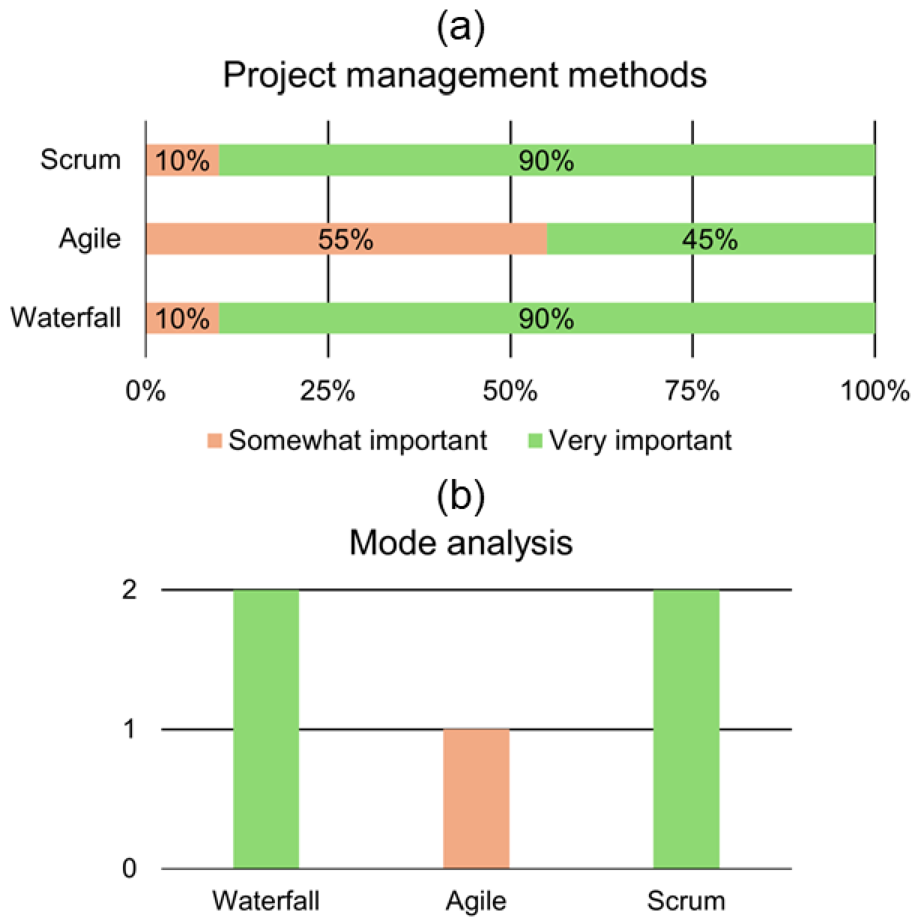

Figure 14. (a) Distribution of survey responses on project management methods. (b) Mode analysis of survey responses.

Now, let us look at the mode of the survey responses, i.e., the most popular choice. As shown in Figure 14(b), for waterfall (Q6) and scrum (Q8), the mode is 2 (very important), while for agile (Q7), the mode is 1 (somewhat important). Therefore, we can conclude that the research unit collectively holds an overall positive attitude towards waterfall and agile project management methods. However, considering their mixed biases towards both methods, a *waterfall-agile* hybrid approach will be an optimal trade-off when it comes to managing scientific RDI projects.

No matter which project management method we choose to implement, i.e., whether it is waterfall, agile, or a hybrid of them, project control and monitoring are essential for project success. Project control and monitoring are often realized through project visualization with the help of project dashboards and by tracking the project KPI. Project KPI also often helps to determine the criteria for project closure (Kerzner, 2023). Therefore, survey responses related to Table 5 (Q9 and Q10) are worth exploring.

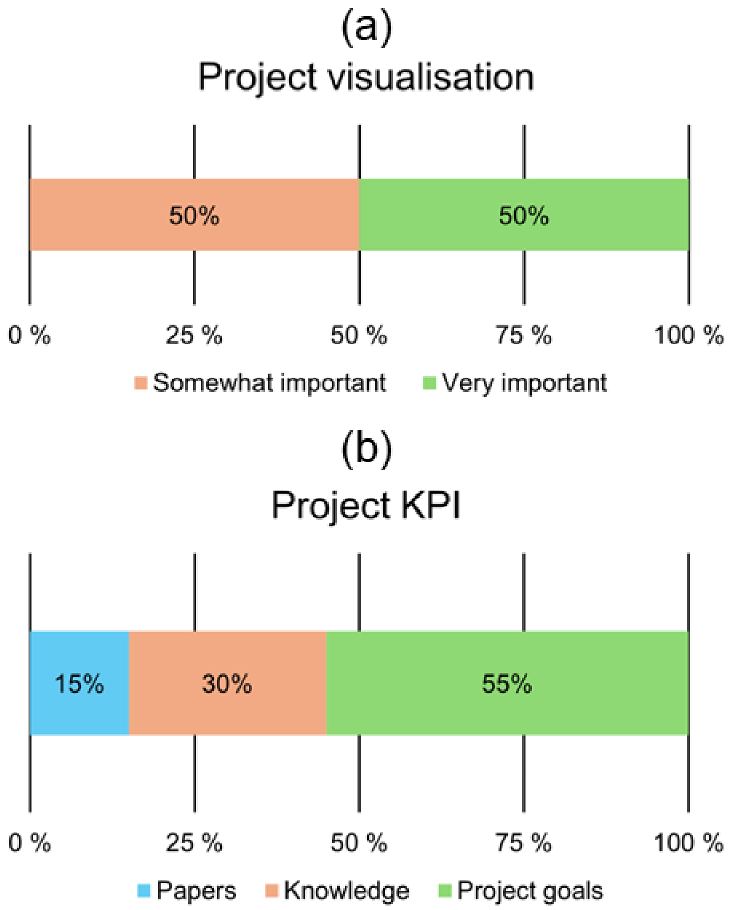

Figure 15. Distribution of survey responses on (a) project visualization and (b) project KPI.

Statistical analysis of the survey data related to Q9 reported in Figure 15(a) reveals that 50% of people think project visualization is somewhat important, while the rest 50% think it is very important. However, no one thinks it is not important. Therefore, we can infer that the research unit is willing to maintain a project dashboard in their work practices.

Defining project KPIs and project success is elusive for scientific research projects (Elmquist & Le Masson, 2009). In a research unit, junior early-stage researchers are mainly motivated to publish scientific papers in high-impact journals to advance in their career, while senior researchers are mainly motivated to patent their innovation for potential start-ups or spin-offs. Since the growth of scientific knowledge is an intrinsic motivation of scientific research, apparent setbacks or failures are often considered positive in terms of the philosophy of scientific pursuit (Elmquist & Le Masson, 2009). In practice, however, producing papers, patents, or bodies of knowledge does not necessarily align with the actual proposed project goals. On the contrary, during the life cycle of scientific RDI projects, motivation towards meeting the actual proposed project goals is often lost or the project end-goals evolve. Consequently, a significant number of scientific RDI projects fail to meet their actual promised project goals and outcomes (Naveh, 2006).

In this context, when the members of the chosen research unit are asked to define a KPI for scientific research projects (Q10), as shown in Figure 15(b), 15% of people choose producing high-impact papers, 30% select enriching the existing body of knowledge, and 55% vote for meeting the actual promised project goals. This is an interesting finding since it reflects mostly (55%) a project-oriented mindset in the people under study. Strictly from a project management perspective, scientific RDI projects must fulfill their actual promised project goals, and the KPIs should be defined based on the performance criteria for meeting those goals. Since the majority (55%) thinks the same, we can conclude that most (55%) of the members of the chosen research unit prioritize project-specific interests (fulfilling project goals) over science-specific interests (producing papers, patents, or bodies of knowledge).

4.2 Qualitative research results

The quantitative research discussed in the previous section clearly answers RQ1 by justifying the relevance of the proposed theoretical framework (Figure 1) in terms of the collective opinions of the people under study. According to the quantitative research results (Figures 11 to 15), the research unit collectively prefers project ideation using blue ocean and lean strategies, project management using hybrid (waterfall and agile) methods, and transformational project leadership. Based on these findings, the qualitative research in this thesis aims to find the answer for RQ2, i.e., to develop a customized project management model for generic scientific RDI projects. Such a model is developed through action research (Mertler, 2016), where qualitative data analysis (QDA) performed in *Excel* (Guerrero, 2018) is employed on the action research data.

In action research, to develop the project management models, an action group is formed by building a focus group (Morgan, 1997) consisting of six members of the chosen research unit who are the participants of the action research. The action group includes 2 top-level, 2 mid-level, and 2 low-level scientists and, hence, covers the whole project hierarchy. Within each action cycle (which lasts one month), three-hour-long intensive and interactive focus group workshops are arranged once a week. Through brainstorming sessions and open discussions, action responses (reflections, retrospectives, etc.) are collected. After that, qualitative content analysis (Kuckartz & Rädiker, 2023; Schreier, 2012) is performed on the action research data (action responses) to develop the project management models as per the requirements of the chosen research unit.

Before presenting the qualitative research results, it is important to highlight the non-disclosure conditions imposed on the research data. The author of this thesis works at the research unit under study, and the action group of participatory action research (Lune & Berg, 2016) consists of people who are coworkers of the author. Consequently, the parent organization (where the research unit under study belongs) as well as the chosen research unit itself enforce a non-disclosure agreement (NDA) on the author and on the sharing of the actual research data related to this thesis. Since the actual research data severely overlaps with the ongoing research projects at the chosen research unit, the active NDA protects the confidentiality of the research and prevents any possible conflict of interest. Therefore, unfortunately, it is not possible to share the action research data (action group responses, transcripts, meeting memos, etc.), and only the action research results, i.e., the developed project management models, are presented in this thesis. Nevertheless, RQ2 is answered by developing a project management model customized for the chosen research unit through qualitative research.

The developed project management framework consists of three models (action plans) covering project strategy, project leadership, and project management. These models are presented and discussed in the following subsections.

4.2.1 Project strategy model

In the *red ocean* of RDI activities, the project company (i.e., the chosen research unit) has many local and global competitors (e.g., other research organizations) when it comes to obtaining research funding. The project strategy should create a *blue ocean* to ensure the competitive advantage and a good strategic position of the project proposal. To make such a *blue ocean shift* (Mauborgne & Kim, 2017), one can utilize the four-action framework of the blue ocean strategy as an analytic tool to realize value innovation (Kim & Mauborgne, 2015). Value innovation aims to simultaneously save costs by minimizing (eliminating and reducing) the competing factors while lifting value by creating and raising new unique elements that are never offered (Kim & Mauborgne, 2017).

According to the four-action framework (Kim & Mauborgne, 2015), the project strategy should focus on breaking the value-cost trade-off by answering the following questions –

i. **Which of the factors that the competitors take for granted should be eliminated?**

- The project strategy should stress shared research infrastructure. By making the equipment, laboratories, offices, and other research spaces common for all units (access via an electronic booking system), it eliminates the necessity of unit-specific infrastructure (dedicated to a department). Such an approach reduces energy costs and operational expenses.

- The project strategy should incline towards digital transformation and cloud-based technology. By making the research materials and data mostly cloud-based and by utilizing digital research tools, it eliminates the necessity of print-on-paper documents in research and the associated delays in access. Again, such an approach reduces operational expenses.

ii. **Which factors should be reduced well below the common standard?**

- The project strategy should stress recycling and minimalist approaches. By making energy-efficient research practices, recycling waste and byproducts (e.g., the byproduct gas of the acceleration laboratory is used for heating on university premises), reducing unnecessary expenses on promotional or luxurious events, and merging multiple small units to form a multidisciplinary central unit (e.g., merging bioscience and environmental science units to reduce two buildings), it reduces the extravaganza of research practices and optimizes the energy cost as well as the operational expenses.

iii. **What factors should be raised well above the common standard?**

- The project strategy should offer a motivating and attractive research environment. By providing multidisciplinary research tracks, strong ties with industry, high-quality research services, and cutting-edge research infrastructure, project strategy should aid the professional growth of the project researchers.

- The project strategy should stress building a culture of project community by offering a supportive and stimulating atmosphere. By enabling transparent leadership, prioritizing equality, diversity, and inclusion, minimizing the degree of hierarchy, offering supports (peer support groups, mentoring, social activities), and promoting multicultural environments, it raises the quality of work culture with a strong feeling of harmony, unity, belonging, and cognitive readiness towards change.

iv. **What factors should be created that have never been offered?**

- The project strategy should aim to offer a high-quality, multidisciplinary, and collaborative research environment. By making the research infrastructure shared among different research units, merging small units into larger units, and eliminating borders between different research units, it creates unique and collectivist multidisciplinary research hubs (e.g., a Nanoscience Center with nanophysics, nanochemistry, nanobiology, and nanomedicine units sharing cross-functional research groups), which a traditional project structure (separate and individualistic units) is unable to offer.

- The project strategy should prioritize the wellbeing of project staff. By making the voices of staff heard in a low-hierarchy background (peer support groups), by promoting and supporting mental and physical health, and by sustaining a bias-free, equality-driven multicultural atmosphere, the project company can offer a unique space for the wellbeing of its employees, which a project company with a traditional and hierarchical mindset is unable to offer.

- The project strategy should focus on offering smart digital solutions for research. By offering a digital, multimodal, high-quality, and flexible digital research environment and by enabling AI-driven high-quality digital environments, it steps towards a radical digital transformation with high efficiency and agility. Such an approach makes the project company unique since it is perfectly aligned with the global trend in the post-COVID era, which project companies with a traditional mindset are often unable to foresee.

- The project strategy should nurture and promote entrepreneurship by relating it to research and innovation. By providing industrial ties and opportunities for possible startups, by motivating researchers to turn their innovation into a startup idea, and by offering business development services, the project company can provide a unique platform for spin-off projects that project companies with traditional settings are unable to offer.

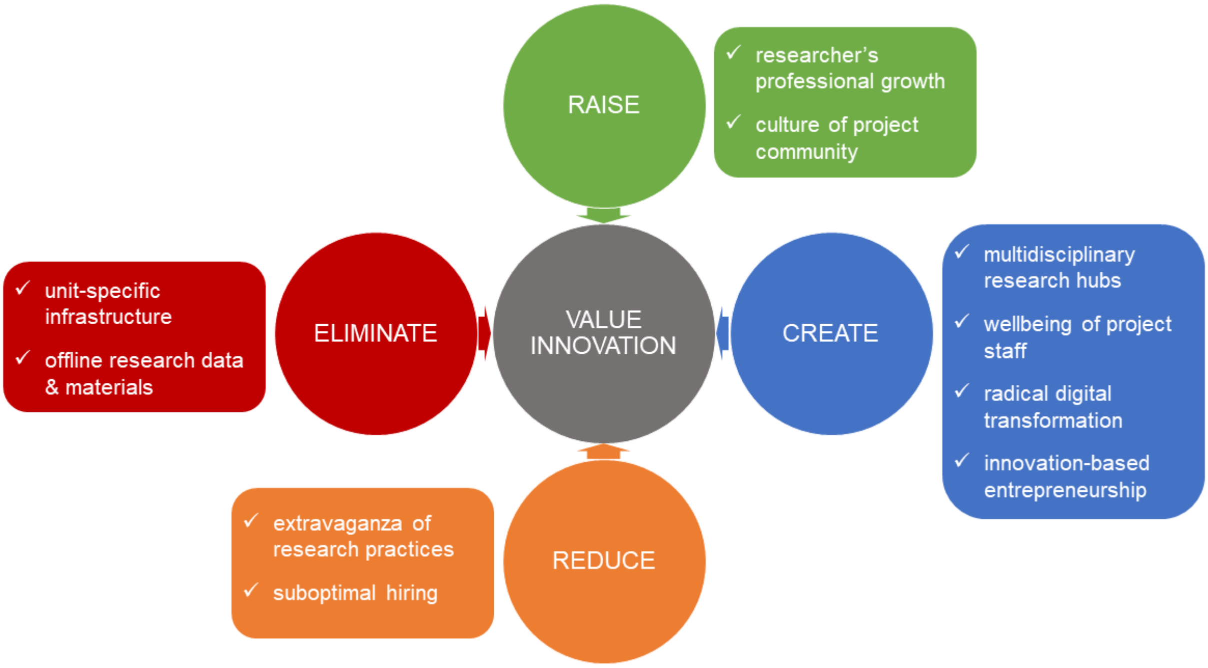

Figure 16. Blue ocean strategy model for scientific RDI projects.

Mapping these answers into the four-action framework yields the blue ocean strategy model for the scientific RDI projects as depicted in Figure 16. From the figure, it is clear that

- The project strategy should *raise* the professional growth of the project researchers and the culture of the project community. Since scientific RDI projects are long (5 to 10 years in average), a strong sense of community in the work environment during the project life cycle will help to sustain the productivity and motivation of the project teams. At an individual level, the productivity and motivation of the project staff can be further enhanced if the project strategy aids their professional growth. Scientists will engage themselves more and more in achieving the project goals if they experience professional growth and community feeling.

- The project strategy should *reduce* the extravaganza of research practices in terms of suboptimal actions, expenditures, and hirings. Such an approach ensures optimal utilization of project resources, whether they are time, money, or humans.

- The project strategy should *eliminate* unit-specific infrastructure and offline handling of research data and materials. Using shared infrastructure and cloud-based research data management, the project cost can be significantly reduced.

- The project strategy should create unique project values. On one hand, scientists will be much more excited to work in multidisciplinary research hubs where innovation-based entrepreneurship is promoted since such a work environment accelerates their career advancement. In addition, radical digital transformation will make project operations smoother and faster. On the other hand, if the project strategy promotes the well-being of project staff, then a healthy and productive work culture can be achieved. Again, scientists will engage themselves more and more in achieving the project goals if they experience career advancement and a high degree of wellbeing.

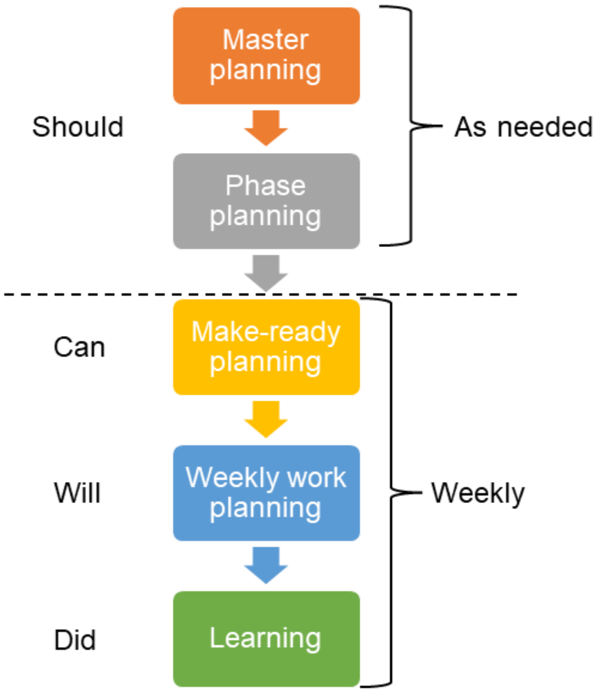

Figure 17. Lean strategy model for scientific RDI projects.

The blue ocean strategy model (Figure 16) aims to minimize project costs and enhance project values by removing suboptimal project operations. To make it happen, one needs to incorporate lean principles into the project strategy. By adopting a lean protocol, i.e., the last planner system (Tzortzopoulos et al., 2020; Wu et al., 2019), into project planning, this can be achieved in practice.

The lean strategy model for the scientific RDI projects based on the last planner system (LPS) is illustrated in Figure 17. According to the LPS (Tzortzopoulos et al., 2020; Wu et al., 2019), as shown in Figure 17, the project operations are divided into five different phases –

i. **Master planning:** Master planning is the initial phase of project planning where the project milestones are defined as per the project goals. The project is first divided into multiple phases, where each phase contains a work package (WP). The milestone of each WP is predefined to gauge the progress of the project. These WPs are the project work modules that *should* be done to attain project success. Master planning yields a master schedule, including the completion dates of the main WPs.

ii. **Phase planning:** Phase planning refers to the planning of each phase, i.e., the planning of each WP. During phase planning, only the project operations adding value to the project are planned, and any non-value-adding operations are identified and eliminated. Phase planning creates a sequence of value-adding project operations, i.e., a flow of value stream, and defines the completion criterion of the phase (WP), i.e., the project work modules that *should* be done to complete that WP. Phase planning also ensures a steady project workflow with minimal variation.

iii. **Make-ready planning:** Make-ready planning refers to the planning of the execution of the project tasks within a WP at ground level. The make-ready plan further breaks down the project tasks of a WP at the level of weekly operations with finer task details. Project teams often prepare make-ready plans collaboratively. In other words, a make-ready plan includes project tasks that *can* be done to execute the WP in practice. At this stage, the possible constraints, i.e., any non-value-adding operations and elements that can hinder value-adding project operations, are identified and eliminated.

iv. **Weekly work planning:** Weekly work planning refers to the roster of weekly operations defined in make-ready planning. The weekly work plan assigns specific project tasks to specific project teams for each day of the following week. In other words, the weekly work plan includes project tasks that *will* be done on a daily basis to execute a part of the WP in practice.

v. **Learning:** In the learning phase, the project teams focus on lessons learned from the performed activities. Usually implemented as a daily coordination meeting, the teams confirm the accomplishment of the assigned tasks, report possible constraints, and discuss changes or adjustments if required to avoid delays and keep the weekly work plan in order.

The blue ocean model (Figure 16) and the lean model (Figure 17) together form the project strategy model for scientific RDI projects. An optimal scientific RDI project strategy should employ the blue ocean model (Figure 16) when forming project proposals for funding (project ideation) and must implement the lean model (Figure 17) in project planning and during project execution. The lean model further complements the blue ocean model by securing an optimal value stream with reduced costs and minimal waste.

4.2.2 Project leadership model

As discussed in the previous section, the project strategy model ensures project value innovation and project cost minimization via the blue ocean model (Figure 16) during project ideation. After that, it further secures the flow of created project values and project cost reduction via the lean model (Figure 17) during project planning and execution. However, certain elements of the blue ocean model cannot be addressed via the lean model. The blue ocean shift requires a project environment where the work culture promotes professional growth and wellbeing of project workers, fosters a community culture, and inspires entrepreneurial mindsets. These project values are unique, and only an emotionally intelligent, people-oriented project leader can implement them in project culture and project operations.

Scientific leadership plays a key role in the professional growth of researchers and requires a dynamic mindset to maximize the productivity of subordinate researchers (Evans, 2012). The role of a project leader in scientific RDI projects not only includes guiding scientific research but also demands strategic mentoring of the subordinates so that they can grow and attain their full potential (Kwok, 2018). Usually, leaders in scientific research are the experts in their corresponding scientific fields, but they often lack the managerial and leadership competencies required in project management (Haage et al., 2021). Consequently, inappropriate leadership style often affects the scholarly performance of a research group, the mental health of the subordinates, the organizational climate of *group or team science*, and the zeal or stimulation among researchers in scientific pursuit (Verbree et al., 2014). Therefore, scientific RDI projects require an optimal project leadership model.

Since the chosen research unit predominantly prefers transformational leadership with a middle-of-the-road managerial style (see Figure 12), the project leadership model for scientific RDI projects illustrated in Figure 18 is developed from a conceptual model of scientific leadership (Hurley, 2012) implemented through a 6-L framework (Aqeel Tirmizi, 2002) for leadership.

The conceptual framework (Hurley, 2012) of the project leadership model, as depicted in Figure 18(a), has three scopes for a leader –

i. **Individual:** In individual scope, the leader will work as a mentor, coach, and role model for the subordinates at an individual level. Coaching can include teaching the discipline, offering personalized hands-on trainings, and assessing the professional growth of the researchers through development discussions. The mentoring not only covers scientific guidance but also extends to aiding the growth or development of subordinates. The leader should guide the subordinates in non-scientific issues as well (e.g., work-life balance) and act in a transformational way so that the leadership can be person-specific (1:1 level). To deeply engage the individuals in the group functionality and to motivate them, the leader should reflect a role model, i.e., an attitude or a behaviour that will stimulate and inspire the subordinates.

ii. **Team:** In team scope, the leader should create a collaborative, competitive (in a healthy manner), and entrepreneurial climate in the research group. A collaborative attitude can be created by assigning cross-functional micro-groups within the unit. Healthy competition can be created via interim rewards or performance feedback. Discussions and brainstorming on patenting innovations and potentials for startups or spin-offs can build an entrepreneurial climate in the research group. In this scope, the leader should use 360-degree feedback to improve team management and take initiatives (e.g., leadership trainings) to improve leadership competencies.

iii. **Project:** In project scope, the role of a leader is to manage project resources (funding, recruitment, etc.) and integrate different entities of a scientific project to manoeuvre the innovation. In this scope, autonomy is very important since the leader should make strategic decisions and take risks to leap for a greater vision (e.g., radical innovation).

Therefore, the leader should have situational traits to orchestrate the volatility of scientific research projects.

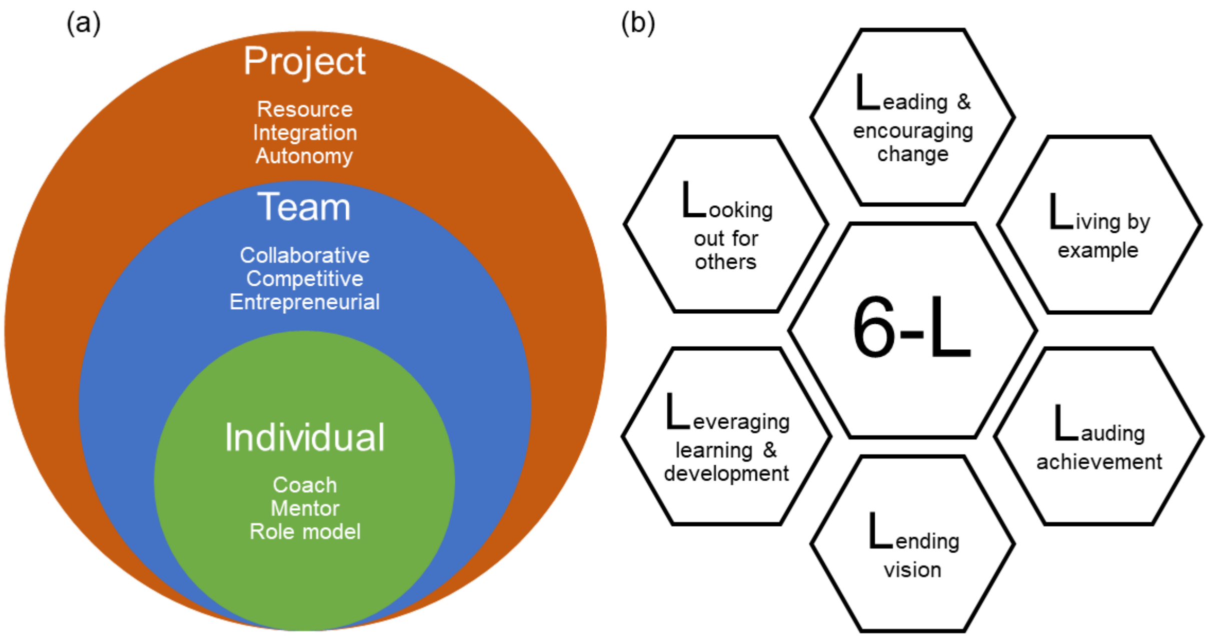

Figure 18. (a) Conceptual and (b) 6-L frameworks of project leadership.

The conceptual framework presented in Figure 18(a) can be implemented in practice through a 6-L framework of leadership, i.e., a leadership model having six behavioural dimensions (Aqeel Tirmizi, 2002), as depicted in Figure 18(b). The project leaders of scientific RDI projects should practice these six dimensions while leading their research units to attain optimal functionality from their research groups.

The six behavioural dimensions of the 6-L framework of leadership (Aqeel Tirmizi, 2002) are

i. **Leading and encouraging change:** The leader should seek out new opportunities, i.e., possible research collaborations, emerging research trends, and radical innovations, to improve the quality and impact of the research group. The leader should stimulate others to import new ways to resolve a problem, i.e., new techniques, skills, perspectives, etc., to improve the research performance and outcome.

ii. **Living by example:** The leader should reflect an inspiring and stimulating attitude through daily interaction with the subordinates. To become a role model, the leader should set an example by practicing a growth mindset that promotes values, ethics, credibility, positivity, empathy, and encouragement. The leader should reach out to each subordinate and maintain connections with them at an individual level through meetings, discussions, daily scrums, stand-up meetings, personal (1:1) sessions, and social group events.

iii. **Lauding achievement:** The leader should recognize, praise, appreciate, and reinforce the subordinates for their performances, achievements, and contributions. A healthy competitive environment for boosting their productivity can be implemented through interim and major rewards after each sprint, such as vacation allowance, internal promotions, travel abroad for research visits, etc.

iv. **Lending vision:** The leaders should communicate their vision with the subordinates in a convincing way so that the subordinates feel engaged with it. The leader should align the personal motivations of the subordinates with that vision. To do so, the leader should highlight why and how the strategic plans, project goals, and development roadmaps will be beneficial for the group and its members.

v. **Leveraging learning and development:** The leader should maintain a dynamic, adaptive, and competitive environment within the research unit to promote a continuum of competence development (e.g., job rotations, performance dashboarding, etc.). The leader should create favorable conditions for learning and development by allowing the active participation of the subordinates in decision-making processes.

vi. **Looking out for others:** The leader should develop a cooperating climate within the research group also in non-academic issues (e.g., helping, sharing, giving emotional support and friendliness, etc.). The leader should practice the social side of leadership in an emotionally intelligent way, e.g., by being approachable, by guiding researchers in work-life balance and career choices, by maintaining the physical and mental wellbeing of the research unit through fitness and recreational events, etc.

The project leadership model (Figure 18) echoes the pedagogical commitment of leaders in scientific research. It is important to note here that the junior early-stage researchers will eventually become project leaders in the near future. Therefore, a leadership style that aids researchers' growth is immensely important for them. In addition, an optimal leadership style will also train them to become better leaders in the future and to create a culture of practicing growth-oriented leadership.

4.2.3 Project management model

The project management model for scientific RDI projects is developed based on the standard prescribed by the International Organization for Standardization (ISO), i.e., ISO 21500 (International Organization for Standardization, 2012). In ISO 21500, as shown in Figure 19, an overview of project management is provided, covering the external, organizational, and project environments (Takagi & Varajão, 2021).

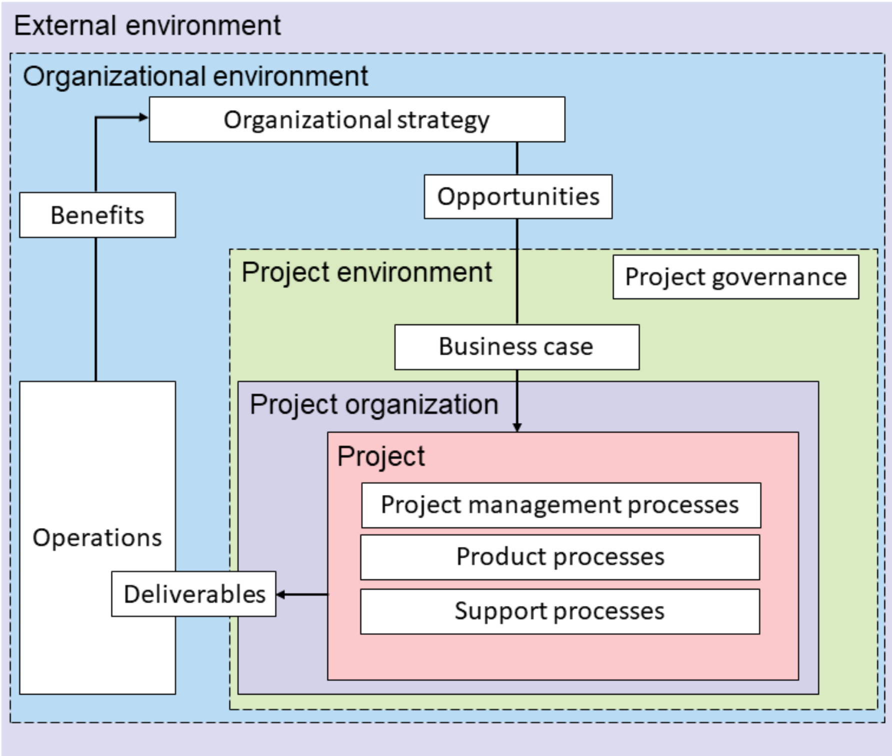

Figure 19. Overview of project management in ISO 21500.

In this thesis, only the project environment is considered, which includes project governance, project business case, and project organization. The project organization includes the project, i.e., the project management processes, product and support processes, and project deliverables (Takagi & Varajão, 2021). Project governance provides guidelines for how a project should run (Muller, 2017). Therefore, in this thesis, project governance can include how the project will be planned (the blue ocean model in Figure 16), executed (the lean model in Figure 17), and managed (the leadership model in Figure 18). The project business case gives rationale for the project (Muller, 2017) and thus can be developed from the project strategy model (Figures 16 and 17). In this section, the main focus is on the project management processes to ensure the generation of project deliverables as per the predefined time, cost, and scope boundaries.

According to ISO 21500 (International Organization for Standardization, 2012), the project management processes are realized through five different project phases. The project starts in the *initiating* phase, followed by the *planning* phase. After that, the *controlling* and *implementing* phases go parallel and converge to the *closing* phase (Takagi & Varajão, 2021). A detailed description of the project management phases is given in Figure 20, where certain project tasks are assigned in each phase.

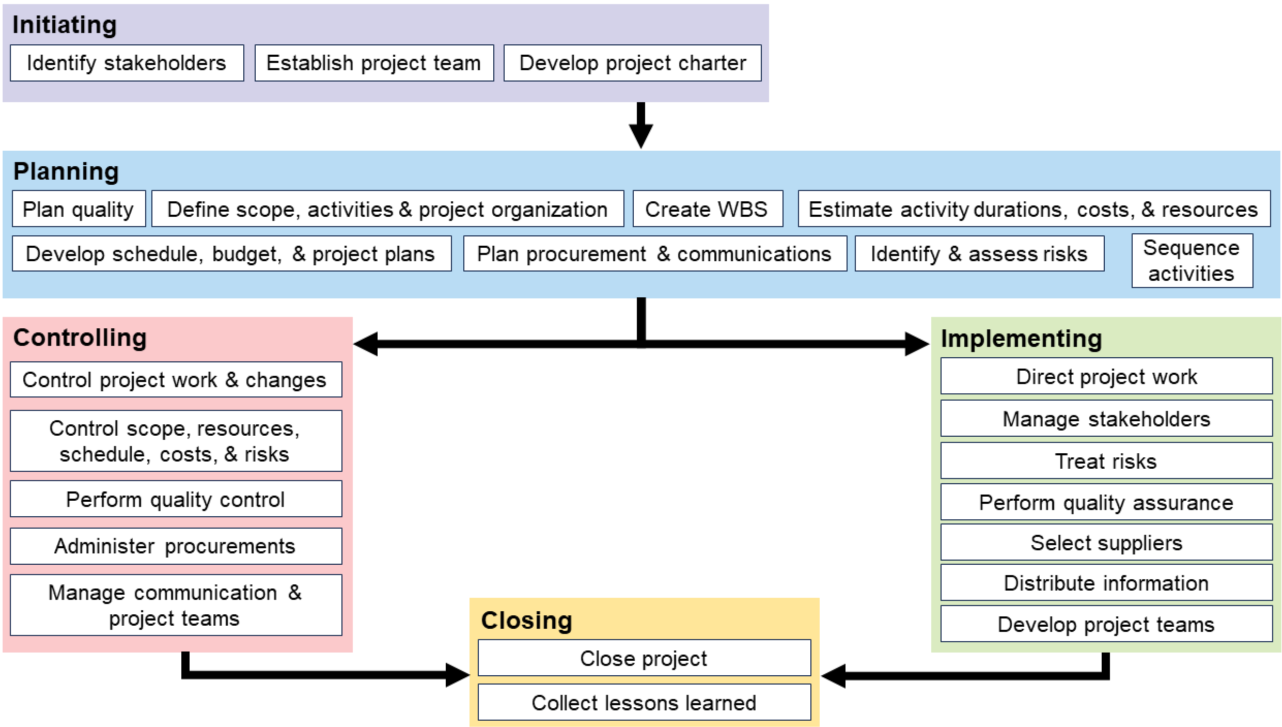

Figure 20. Project management phases in ISO 21500.

In scientific RDI projects, as also discussed earlier, execution of the aforementioned project management phases in practice requires a hybrid approach (Dionisio, 2022). In this thesis, a hybrid project management model for scientific RDI projects is developed based on the hybrid V-model of project management (Copola Azenha et al., 2020; Reiff & Schlegel, 2022). The hybrid V-model depicted in Figure 21 combines waterfall and agile methods for project execution (Reiff & Schlegel, 2022). The high-level project tasks, i.e., tasks that require *more planning,* are performed using the waterfall method, while the low-level project tasks, i.e., tasks that require *more agility*, are conducted in an agile way (Copola Azenha et al., 2020). The project starts with a *waterfall-up-front* approach where the project requirements are analyzed and the initial project design is constructed using the waterfall method. After that, detailed design and implementation of the WPs leading to incremental project delivery are realized using the agile method.

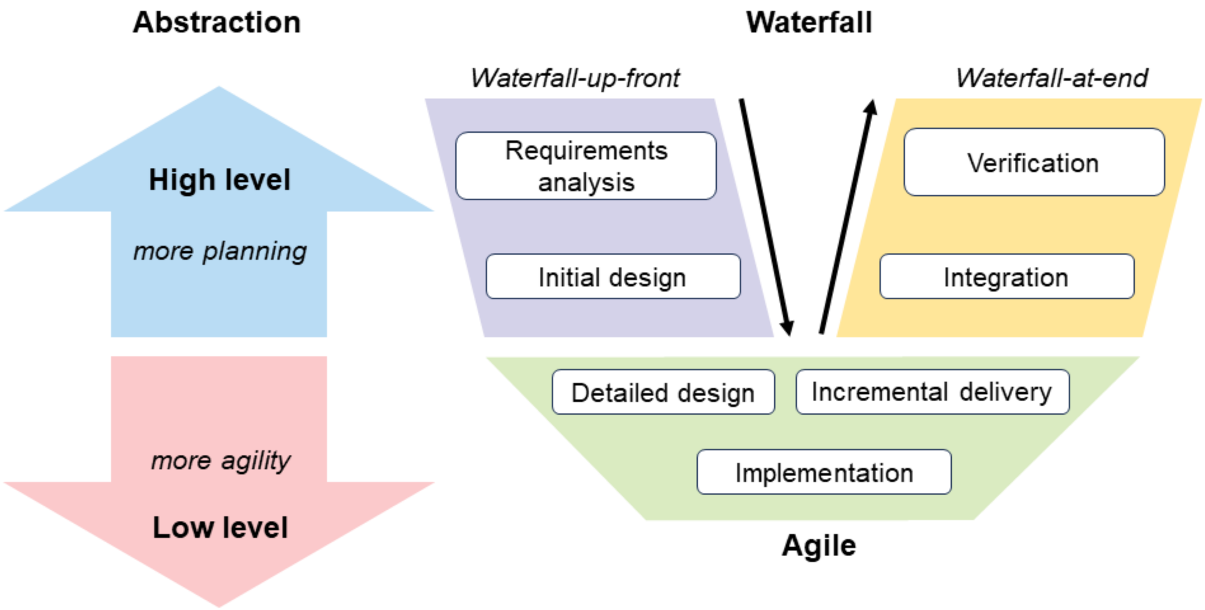

Figure 21. Hybrid project management model for scientific RDI projects.

When the incremental project deliveries converge, a *waterfall-at-end* approach is employed to integrate the partial project outputs, verify the final project product, and draw the project closure if all project goals are met (Copola Azenha et al., 2020; Reiff & Schlegel, 2022).

Project operations in the hybrid V-model (Figure 21) can be understood from Figure 22. As shown in the figure, the project manager, i.e., the project leader (e.g., chief scientist) in our case, supervises both waterfall and agile processes during the project life cycle. The scrum master, i.e., an immediate subordinate of the project leader (e.g., senior scientist), orchestrates the agile processes. In the waterfall phase (*waterfall-up-front*), requirements for the project end-product are divided into *components*, i.e., in WPs, e.g., from 1 to *n* (requirements analysis), where each WP has its own work breakdown structure (initial design). When the project enters the agile phase, sprint backlogs (detailed design) are prepared from the work breakdown structure (WBS), and each sprint iteration (implementation) releases a part of the project end-product (incremental delivery). The partial end-products are handled again using a waterfall approach (*waterfall-at-end*) for feedback (integration and verification) so that product requirements can be refined if needed (Copola Azenha et al., 2020).

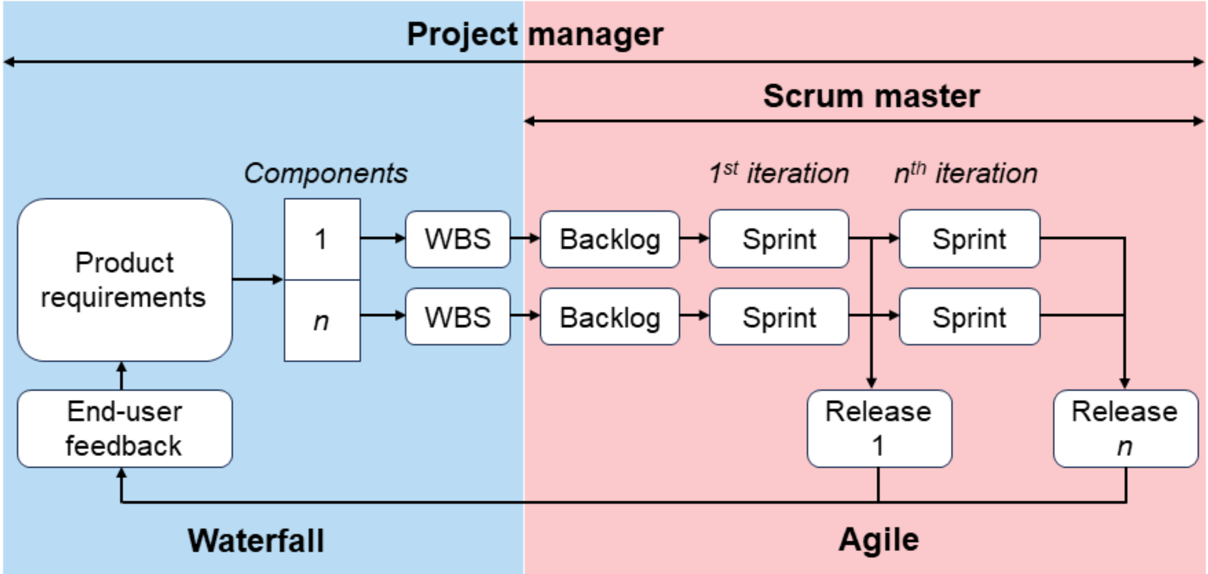

Figure 22. Project operations in hybrid V-model.

From the perspective of project team management (Cobb, 2012), project team activities in the hybrid V-model (Figures 21 and 22) can be elucidated from Figure 23. As shown in the figure, the top-level project team (waterfall team), consisting of chief and senior scientists, develops project vision, project planning, and initial project design (WBS of each WP) using the waterfall method. In the agile phase, low-level project teams, i.e., small scrum teams (agile teams), are formed under the supervision of scrum masters (senior scientists) consisting of junior scientists. The agile teams deliver the project product in increments and by parts (Copola Azenha et al., 2020).

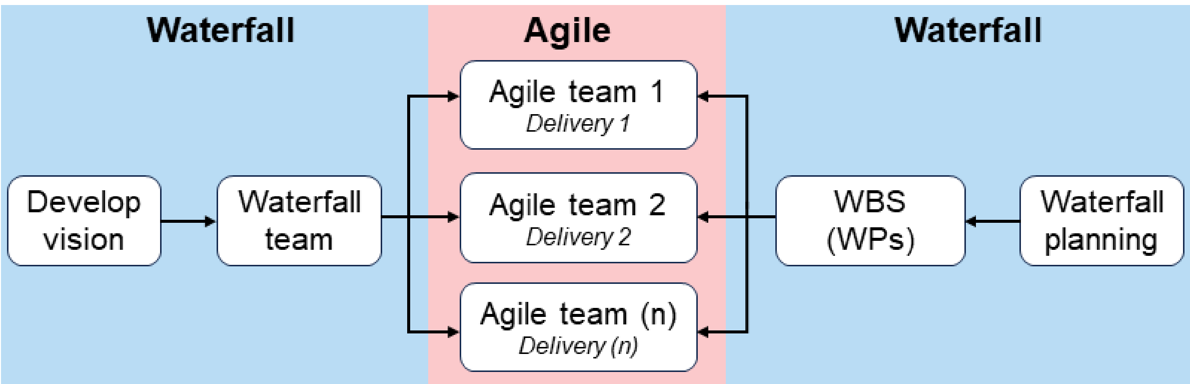

Figure 23. Project team management in hybrid V-model.

At this stage, it is important to integrate the lean model (Figure 17) into the hybrid V-model (Figures 21, 22, and 23) to complete the project management model for scientific RDI projects. Such a *lean-hybrid* project management model can be formed by mapping the lean model phases into the hybrid V-model. As reported in Table 6, the master planning (project planning) and the phase planning (WBS of WPs) of the lean model should be done using the waterfall method. The make-ready planning (product backlog and sprint backlog) and the weekly work planning (sprint planning) of the lean model should be performed using the agile-scrum method. The learning phase in the lean model should be realized through daily scrum, sprint review, and sprint retrospective. In a holistic view, the *lean-hybrid* project management model suits best for scientific RDI projects since it secures project values, minimizes project waste, and adapts well to the volatility of scientific research. Consequently, project success can be assured since such a *lean-hybrid* approach provides optimal mitigation of risks and uncertainties associated with any scientific RDI activities.

Table 6. Lean-hybrid project management model for scientific RDI projects.

Lean	**Hybrid**
Master planning	Waterfall
Phase planning	
Make-ready planning	Agile-scrum
Weekly work planning	
Learning	Daily scrum Sprint review Sprint retrospective

Chapter summery

This chapter reports and discusses the quantitative and qualitative research results included in the thesis. The quantitative research results answer RQ1 by showing that the research unit under study collectively prefers project ideation using blue ocean and lean strategies, project management using hybrid (waterfall and agile) methods, and transformational project leadership. The qualitative research results answer RQ2 by developing models of project strategy, project leadership, and project management. Based on the findings of RQ1 and RQ2, conclusions are drawn on the overall thesis in the next chapter.

5 CONCLUSIONS

This thesis investigates how project management can be utilized for managing scientific research. The research objective of this thesis consists of two research questions: what is the optimal project management framework for scientific research? (RQ1), and how to develop such a framework for scientific research projects? (RQ2). To address these research questions, quantitative and qualitative research are performed, while a small research unit is chosen for the study.

This thesis explains the motivation for exploiting project management in the context of scientific research in Chapter 1 and proposes a project management framework for scientific research projects in Chapter 2. After preparing such a foundation, this thesis documents the quantitative and qualitative research methods in Chapter 3, while reporting and discussing the research results in Chapter 4. In this chapter, conclusions are drawn based on the findings of RQ1 and RQ2.

The quantitative research, implemented through an online survey and statistical analysis of the survey responses, clearly answers RQ1 by justifying the relevance of the proposed project management framework in terms of the collective opinions of the research unit under study. According to the quantitative research results, the chosen research unit collectively prefers project ideation using blue ocean and lean strategies, project management using hybrid (waterfall and agile) methods, and transformational project leadership.

The qualitative research, implemented through action research and qualitative content analysis on the action responses, clearly answers RQ2 by developing guiding models for project strategy (blue ocean and lean), project leadership (transformational 6-L), and project management (lean-hybrid). The project strategy model ensures project value innovation and project cost minimization via its blue ocean component during project ideation and further secures the flow of created project values and project cost reduction via its lean component during project planning and execution. The project leadership model prescribes an emotionally intelligent, people-oriented, and growth-oriented leadership style that resonates well with the intended blue ocean shift and the pedagogical commitment of leaders in scientific research. The project management model adopts a lean-hybrid approach to secure project values while minimizing project waste via its lean component and mitigating the volatility of scientific research via its hybrid component. In the hybrid component, the high-level project tasks, i.e., tasks that require more planning, are performed using the waterfall method, while the low-level project tasks, i.e., tasks that require more agility, are conducted in an agile way.

Even though the research unit under study holds a positive attitude towards project management as a fruitful change in their work practices, and although the guiding models are straightforward to implement for actual real scientific research projects, there are limitations to the research work presented in this thesis. In quantitative research, survey participants are chosen via convenient sampling, and the sample size of the survey is very small. Consequently, the survey is prone to statistical bias. Therefore, the findings of quantitative research and RQ1 are too specific for the chosen research unit, and generalizing them for scientific research in general beyond the studied research unit is a poor extrapolation. In addition, a lack of knowledge in project management among survey participants can also affect their responses and judgments. In qualitative research, only a minor fraction of the total research unit forms the action group and decides guiding models for the whole unit. Therefore, the consensus regarding those guiding models is suboptimal and does not reflect the mindset of the whole unit. In the end, it is the people who decide how to accept change and what to include in their work practices. Therefore, there is a significant chance that scientists will feel that adhering to project management protocols in addition to doing science is an extra burden and against their spontaneous scientific pursuits. They can also think that the guiding models are too sophisticated to implement since the importance of project management in scientific research is yet not fully accepted and is often neglected due to the reluctance of the scientists.

Nevertheless, this thesis has potential for future scopes. By providing key information on how to implement project management in scientific research along with the guiding models, this thesis becomes useful for research and development management in university research, academic entrepreneurship, and innovation-based small and medium enterprises (SMEs) or startups. Conducting both quantitative and qualitative research on large populations of scientists and research organizations and performing an empirical study by testing the guiding models in real-life scientific research projects could be possible follow-up initiatives. By scaling up, this thesis can even address innovation management, which is pivotal in contemporary entrepreneurial scientific research.

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