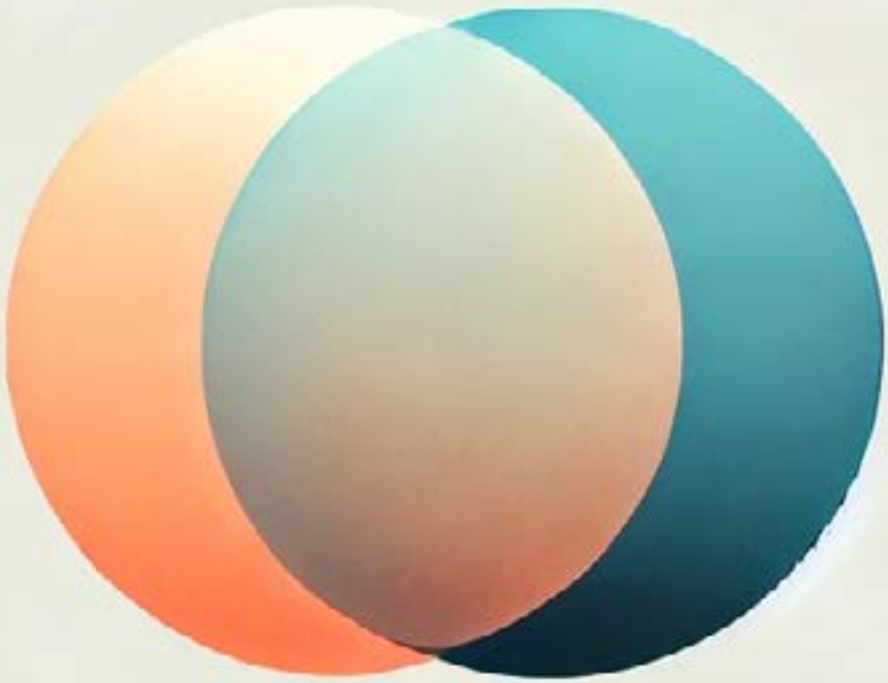
Enhancing inter-disciplinary collaboration between Designers and Engineers

Designing an alignment activity that promotes knowledge integration



Politecnico di Milano

Master of Science
in Design & Engineering
A.A. 2023-2024

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Supervisor
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ABSTRACT

ITA

Negli ultimi anni, la domanda di una collaborazione interdisciplinare efficace è aumentata, in particolare tra designer e ingegneri. Sebbene tali collaborazioni apportino prospettive ed esperienze diverse, presentanoanchesfidelegateall'allineamento, alla comunicazione e all'integrazione delle conoscenze. Questa tesi si propone di affrontare queste sfide proponendo due modelli concettuali che supportano i team non gerarchici nel mantenere l'allineamento e nell'integrare le conoscenze tra discipline diverse. Sono stati sviluppati due modelli di ispirazione, il Project Timeline e il Tasks Planner, con l'obiettivo di fornire un quadro flessibile per strutturare compiti e responsabilità, garantendo che i membri del team restino allineati durante l'intero progetto. Questi modelli sono intesi come basi per lo sviluppo futuro di strumenti che possano migliorare il teamwork interdisciplinare. La tesi sottolinea l'importanza di un allineamento continuo fra i membri del gruppo nelle diverse fasi del progetto, proponendo un'attività autogestita che può essere svolta in contesti non gerarchici.

ENG

In recent years, the demand for effective interdisciplinary collaboration has increased, particularly between designers and engineers. While such collaborations bring diverse perspectives and expertise, they also present challenges related to alignment, communication, and knowledge integration. This thesis aims to address these challenges by proposing two conceptual models that supportnon-hierarchicalteamsinmaintaining alignment and integrating knowledge across disciplines. Two inspiration models, the Project Timeline and the Tasks Planner, were developed to provide a flexible framework for structuring tasks and responsibilities, ensuring that team members stay aligned throughout the project's life.
These models are intended to serve as foundations for future development of tools that can enhance interdisciplinary teamwork. The dissertation emphasizes the importance of continuous alignment at different stages of the project, proposing methods to achieve this through a self-managed activity that can be done in non-hierarchical settings.

INDEX

INTRODUCTION

The following dissertation presents the development of a practical solution aimed at improving alignment and knowledge integration between non-hierarchical interdisciplinary teams of designers and engineers.

My research was inspired by firsthand experiences in hybrid teams, both in Milan, at Design & Engineering master, and during my Erasmus experience in Madrid, at Universidad Politecnica. I noticed that, despite the overall success of the collaboration, certain challenges occasionally arose due to the absence of a structured process for bridging the gap between the two disciplines' mindsets. I observed that engineers and designers have distinct ways of thinking, understanding and solving problems, and prioritizing tasks. Their divergent approaches to solving the same issues can make it difficult for teams to collaborate smoothly without a structured method to harmonize these viewpoints. This led me to explore how interdisciplinary teams could better align their efforts to ensure cohesive project development.

In today's environment, inter-disciplinary collaboration between designers and engineers is increasingly common in both academic and professional settings. Despite this, I noticed a gap in practical tools designed specifically to support alignment in those teams.

To address this gap, I developed two inspiration models as conceptual frameworks to support alignment in interdisciplinary teams. These models are designed to help teams collaborate more effectively by promoting continuous synchronization among members and ensuring the integration of each discipline's knowledge and methods throughout the project life. While not final tools, these models lay the foundation for future developments in creating effective resources for design and engineering teams.

In the following dissertation, I will outline the relevant literature on collaboration in plural teams, with a specific focus on designers and engineers, which forms the basis for these models. Through this research, I aim to provide practical solutions to the challenges of interdisciplinary teamwork, offering inspiration for future tools that can enhance collaboration between designers and engineers.

THE RESEARCH RATIONALE: INCREASING RELEVANCE OF NON-HIERARCHICAL INTERDISCIPLINARY TEAMS OF PRODUCT DESIGNERS AND INDUSTRIAL ENGINEERS

CHAPTER INTRODUCTION

This first chapter of the thesis will explore several key themes surrounding the evolution of work dynamics, focusing on the increasing relevance of non-hierarchical, inter-disciplinary teams in product design and industrial engineering.

The chapter begins by discussing the shift from traditional hierarchical structures toward more collaborative, team-based approaches, driven by the need for adaptability and innovation in today's fast-changing industries. The concept of plurality will be central to this analysis, referring to the integration of diverse professional perspectives within teams, particularly between designers and engineers. This chapter will examine how these professionals contribute different reasoning styles to the product development process.

By delving into these topics, the chapter will highlight how non-hierarchical, plural teams are better equipped to tackle complex challenges, blending creativity with technical rigor. This exploration sets the foundation for understanding how diverse reasoning styles and team structures foster innovation and adaptability in interdisciplinary settings.

The chapter concludes with a detailed explanation of what interdisciplinary collaboration entails and its significance, particularly the ways in which it merges different disciplinary knowledge to address multifaceted issues effectively.

1.1

EVOLVING WORK DYNAMICS: THE SHIFT FROM HIERARCHICAL TO INTER-DISCIPLINARY COLLABORATION

Throughout the 20th century, the dominant approach to work organization was the one theorized by Frederick Taylor, known as “scientific management” (Taylor, 1911). The fundamental principle of scientific management is the application of scientific methods to optimize production processes and enhance productivity. In this system, the manager is responsible for thinking and supervising, while the workers are tasked with execution. The work structure is hierarchical: the manager, positioned at the top, analyses tasks and divides them into smaller, individual tasks to be performed separately. The system is designed so that each activity is interconnected, yet individuals work independently to complete their tasks. This method remains in use today in certain industries, particularly in facilities where large quantities of standardized products are produced.

However, its effectiveness is contingent on specific conditions: the task must remain consistent over time, as changes are difficult and costly, and the process should not be overly complex or prone to disruption, given that workers are generally unaware of activities outside their assigned tasks and the overall system.

The global challenges the world faces today have necessitated a change in work organization, as emerging technologies disrupt industries, connect people in new ways, and transform production, management, and governance. Market expansion and global competition compel companies to innovate continuously to meet consumer demands. Teams have become essential in scenarios where rapid change is necessary, where innovation or improvement of a product or service is the goal, where customer service and quality are priorities, or when tasks are inherently complex. As a result, organizations have shifted from a hierarchical system of managers and workers to a more dynamic, non-hierarchical structure that emphasizes teamwork. This approach facilitates learning, adaptation, and creativity (Levi, 2017).

Particularly within the field of design, collaborative teamwork is indispensable, driven by both the intrinsic demands of the design process itself and the nature of the challenges it seeks to address. The development of a product typically involves

various stages, including research, ideation, testing and prototyping, manufacturing, marketing, and sales. Each stage necessitates expertise from diverse disciplines and, consequently, a collaborative approach. Many of the challenges in contemporary design can be categorized as “wicked problems” — problems characterized by their complexity, unclear definitions, non-linear solutions, and the involvement of multiple perspectives and interests (Buchanan, 1992).

In engineering and other technical fields, as social and technological challenges grow increasingly complex, there is a corresponding need for broad-based collaboration skills (Richter & Paretti, 2009). Addressing issues such as water scarcity in developing nations, creating innovative energy solutions for a global economy, and managing global climate change, along with other sustainability challenges, necessitates ongoing collaboration among professionals from diverse engineering and scientific fields, as well as experts in business, economics, politics, rural and urban planning, and beyond. Such collaborations must go beyond compartmentalized or segmented approaches, instead operating in a dynamic, integrative mode of continuous learning and exchange of ideas and information. Consequently, there is a growing demand for engineers and other professionals who can thrive in these interdisciplinary contexts (Richter & Paretti, 2009).

Hierarchical structure

Self-directed team

Figure 1
Hierarchical vs non-hierarchical structure

1.2

THE NON-HIERARCHICAL STRUCTURE: IMPLICATIONS OF SELF-DIRECTED TEAMS

A growing number of organizations have adopted self-directed or self-managed work teams in response to increasing competitive pressures in their business environment (Spreitzer et al., 1999). These changes have often been driven by organizational "downsizing" and "rightsizing" efforts, which have eliminated entire layers of management, shifting decision-making authority to the lowest levels of the organization (Davis et al., 2004). This shift aligns with the rising demand among employees for greater participation, flexibility, and autonomy in their work (Wellins, 1992), leading organizations to implement self-directed teams that meet both organizational goals and employee needs.

Self-directed teams are often seen as a strategy to empower employees by enriching their job roles (Hackman & Oldham, 1976), which enhances workforce satisfaction (Abbott et al., 2006) and commitment (Kukenberger et al., 2015), while also contributing to a more humanized workplace (Paul et al., 2000). According to Davis et al.(2004), self-directed teams are defined as:

"Any teams that engage in decision-making typically performed by a manager or supervisor"

These decisions may include project scheduling, problem-solving, selecting team members, and assigning work roles. Unlike traditional hierarchical models, self-managed teams promote a model where individuals take on multiple roles, thereby fostering a more dynamic and collaborative environment. This approach ensures that team members possess the authority and autonomy to make decisions relevant to their roles (Abrahamsson et al., 2016).

The implications of this non-hierarchical structure for group dynamics are significant. Such structures necessitate enhanced self-management, open communication, and effective conflict-management skills among team members. According to Moe et al. (2022), the increased autonomy in self-managed teams requires individuals to take greater personal responsibility for their tasks, promoting a collaborative and innovative atmosphere. In this context, the ability to resolve conflicts becomes crucial, as the absence of a formal hierarchy can make it challenging to address disagreements swiftly and fairly.

Furthermore, recent studies emphasize that collective decision-making, rather than centralized control, encourages active participation and mutual respect among

team members (Scott-Young et al., 2019). This participatory approach not only results in higher job satisfaction and organizational commitment but also enhances overall engagement, as team members feel more empowered in their roles (Daspit et al., 2013)

However, maintaining effective group dynamics in a non-hierarchical structure also requires robust mechanisms for coordinating activities. As highlighted by Park et al. (2023), clear communication and shared leadership are essential for navigating complex tasks and ensuring that team objectives are met efficiently. This structure demands that team members possess a high degree of adaptability and the ability to manage interpersonal relationships and professional responsibilities, particularly in dynamic environments where challenges are unpredictable and solutions are not straightforward.

1.3

THE ROLE OF PLURALITY IN DESIGN TEAMS

Especially in the professional design field, team plurality is crucial, as it leads to several benefits over homogeneous teams, such as better customer representation, increased creativity and innovation, and a multiplicity of perspectives that enhance flexibility and adaptability. Modern organizations, which interact with diverse populations, must ensure that their products cater to the nuanced needs of each potential customer. When teams are plural in terms of gender, age, culture, and knowledge, they are better equipped to understand and address the needs of various market segments, thus enhancing an organization's cultural and social sensitivity and mitigating the risk of perpetuating stereotypes or inadvertently isolating consumer groups. This diversity not only promotes greater consumer engagement and cultivates brand loyalty but also confers a competitive advantage by enabling organizations to adapt more effectively to dynamic market shifts, address customer needs proactively, and anticipate future trends (Sri Ramalu et al., 2012).

For example, a study conducted by Hewlett-Packard on workplace diversity showed that teams with a broader range of ages and gender were 15% more likely to introduce market innovations than their counterparts (Hewlett et al., 2013). Similarly, a Forbes study highlighted that companies with diverse top management teams experienced a 19% increase in revenue compared to less diverse teams, pointing directly to greater innovation (Lorenzo et al., 2018).

From a methodological standpoint, diverse teams leverage a wider array of problem-solving approaches, which can lead to more innovative outcomes. Research by Jones et al. (2020) supports this, finding that such teams are better at solving complex problems due to their varied approaches and interpretations of information. The diversity of thought processes and problem-solving techniques in these teams leads to a richer array of ideas and solutions, from initial brainstorming through to the execution phase.

The variety of perspectives also fosters a more robust approach to risk assessment and decision-making. Diverse teams often spend more time considering and evaluating risks, which can result in more thorough and innovative outcomes. This dynamic is particularly crucial in the design field, where anticipating market needs and mitigating potential issues before they arise can significantly impact a product's success and reception.

However, the benefits of team plurality extend beyond just enhanced creativity. They also include the development of more comprehensive and effective solutions that are more likely to satisfy a diverse customer base, reflecting a broader range of consumer needs and expectations. Thus, in the professional design field, the strategic assembly of plural teams is not just a matter of social responsibility or ethical practice but a foundational element of competitive strategy and business success.

+15%

Market innovations introduced by plural teams compared to homogeneous ones (Hewlett et al., 2013)

+19%

Revenue generated by companies with diverse top management teams (Lorenzo et al., 2018).

Figure 2
Studies on plural teams

1.3.1

PLURALITY VS DIVERSITY: THE WORDING CHOICES WITHIN THIS RESEARCH

In this research, the focus will be on plurality within inter-disciplinary design teams. Specifically, the emphasis will be on plurality in terms of professional backgrounds rather than the coexistence of multiple genders, ages, and cultures. Although many sources use the term “diversity” more frequently, the choice to use “plurality” is intentional and based on several reasons.

Employing the term plurality when discussing inter-disciplinary groups better highlights the collaborative and inclusive nature of such teams, avoiding the potentially divisive connotations associated with the term “diversity”. The aim is to emphasize the integration of different disciplines and perspectives rather than their mere coexistence within a group.

The term “diversity” can be perceived as divisive, because it underscores differences and potentially inequalities among group members. It often implies a collection of distinct and separate elements that must be managed to coexist, which can lead to a perception of enforced inclusion rather than natural cooperation. This term tends to overlook the aspect of integration an synergy, which is the primary focus of this research.

Conversely, the term “plurality” carries a more neutral value, embracing various perspectives as integral parts of a cohesive system without implying comparison or contrast. It suggests that each discipline is part of a larger integrated whole, creating added value that surpasses the simple sum of its parts.

1.3.2

PLURALITY IN TERMS OF PROFESSIONAL BACKGROUND: DESIGNERS AND ENGINEERS REASONING IN PRODUCT DESIGN DEVELOPMENT

In his synthesis of team dynamics research, Daniel Levi (2017) discusses three prevalent types of plurality within teams: demographic, psychological, and organizational. Demographic diversity covers various social categories, including gender, race, and age, which are recognized across different cultural and historical contexts. Psychological diversity includes variations in personal values, beliefs, personality traits, and behaviours, influencing individual actions and interactions within a team. This type includes differences in risk orientation, conservatism, and interpersonal behaviours that significantly affect team dynamics. Finally, organizational diversity relates to individual roles within an organization, such as rank, departmental affiliations, and tenure, which can affect the power dynamics and communication patterns among team members.

Demographic	Psychological	Organizational
• Gender • Race & ethnicity • Nationality • Age/generational • Religion • Sexual orientation	• **Values, beliefs, attitudes** • **Personality, cognitive and behavioural styles** • **Knowledge, skills and abilities**	• Status • Occupation • Department • Tenure

Figure 3
Three types of plurality within teams
Adapted from (Levi, 2017)

This thesis primarily focuses on plurality in terms of professional knowledge, skills and abilities, where designers and engineers come together, each armed with distinct methodologies rooted in their respective fields. While this diversity can lead to differing approaches in problem-solving, decision-making, and project management, it is precisely these differences that can catalyse innovative and well-rounded solutions that effectively balance technical precision with user-centric design.

Plurality in terms of diverse professional backgrounds leads to some differences between designers and engineers in problem-solving, decision-making and project handling. Designers and engineers often adopt different reasoning approaches, partly reflecting their professional backgrounds and respective areas of expertise. These differences in reasoning can result in complementary perspectives within a project team, where collaboration can potentially lead to innovative and balanced solutions that consider both technical aspects and user needs. Each type of professional training has its own strengths, and understanding them leads to better planning and management of a project (Volpentesta et al., 2009).

Designers, traditionally trained to prioritize aesthetics and user experience, often approach problems with a focus on how the product feels and interacts with the user. This human-centred design philosophy has become increasingly pronounced over the past two decades, emphasizing the need to understand and address human needs comprehensively (Redström, 2006). In contrast, engineers often approach product development from a more technical perspective, prioritizing reliability, safety, and efficiency. Their training typically emphasizes quantifiable outcomes and the functional integration of systems, which, while crucial, sometimes overlooks the broader socio-technical implications (Chakrabarti & Blessing, 2014).

It is important to note that these characterizations do not imply rigid absolutes but rather general trends that can vary widely between individuals within each profession. The collaboration between these two disciplines does not simply blend these approaches but often results in a dynamic interplay where each perspective challenges and enriches the other. This interaction encourages engineers to consider the user experience more deeply, while designers can appreciate the technical constraints that shape product feasibility.

1.3.3

PLURALITY OF THOUGHT: DESIGNERS VS ENGINEERS

In discussing professional plurality, various studies have explored the distinct ways in which designers and engineers approach problem-solving and reasoning, reflecting their diverse professional backgrounds. This analysis sheds light on the differences in reasoning, which can be explained by comparing abductive and inductive reasoning, as well as an examination of varying thinking styles.

Abductive reasoning is characteristic of designers who generate creative hypotheses from incomplete information to innovate and solve design problems creatively. This reasoning style is instrumental in driving the design process where innovation is paramount. Designers often initiate projects with conjectures that evolve into detailed designs, reflecting the exploratory and creative nature of their thinking. According to Cramer-Petersen et al. (2019), this approach typifies the abductive-deductive reasoning patterns that dominate design idea generation.

Conversely, engineers frequently utilize inductive reasoning, focusing on analysing empirical data to derive generalizations that address technical challenges. This method allows for the creation of theoretical models from specific cases, crucial in developing solutions that are both reliable and verifiable.

Inductive reasoning ensures that engineering solutions adhere to rigorous technical standards and systematic verification, as highlighted by Tóth and Pogátsnik (2022) in their examination of advancements in inductive reasoning among engineering students.

Another perspective on understanding the reasoning of designers and engineers is through the lens of thinking styles.

A thinking styles is a preferred way in which a person chooses to interpret the world, it consists of an individual (or shared) system of processing, acknowledging, and using information (Sofo, 2013). Thinking styles may change depending on the context, professional training or experience, although people often have an innate dominant thinking style.

People with different academic backgrounds may adopt different thinking styles to solve design problems and tackle complex and contemporary issues (Kim & Kim, 2015). Thinking styles can be associated with academic paths because each person's choice to pursue a specific professional path often reflects a preference in a thinking style, this is reinforced when working on a problem.

The thinking styles used to approach a design problem has a direct effect on performance: while engineers learn to solve problems by seeking the optimal solution through well structured, scientific, and linear thoughts, designers learn to value creative thinking and experiences, always considering technical aspects as well.

Sofo (2013) identified five thinking styles, based on the theory of reality construction. According to this metacognitive theory, people choose a preferred thinking style in order to optimize their skills in a specific context.

i. The **Conditional style** belongs to professionals who prefer to rely on proven solutions and models, ensuring convergence in the design process, these individuals accept the reality without questioning.

ii. The **Inquiring style** is observed in those professionals who ask questions, they look at the sources of information to contemplate its validity and quality, they forced to challenge assumptions and perceived notions.

iii. The **Exploring style** is commonly associated to innovation because professionals who adopt it tend to seek alternative solutions to the design problem, increasing the potential to achieve new results.

iv. The **Independent style** is observed where the design process is more individualized, when individuals tend to follow their own intuitions, feelings and opinions.

v. The **creative style** is identified in professionals who seek for many different outcomes for a single problem, generating various alternatives to get a holistic sense of reality.

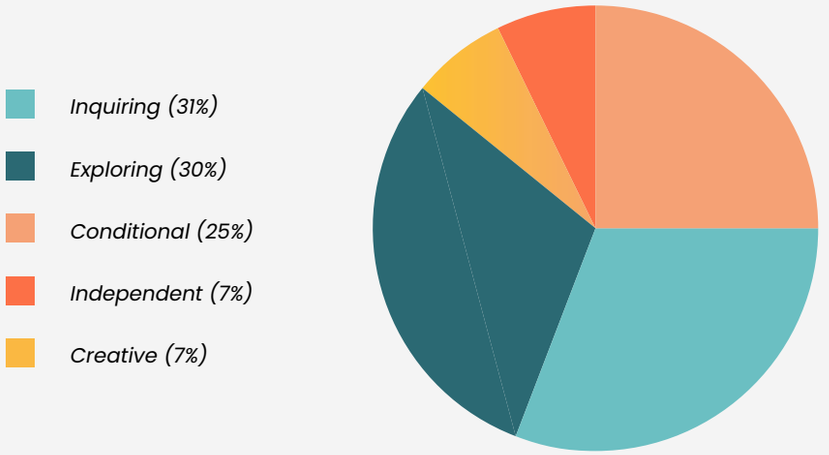
Thinking styles are capable of influencing work performance as well as creative and intellectual skills. There is no thinking style better than others, however, certain thinking styles may be more suitable for specific tasks. For example, in the field of product design, exploring style may be more appropriate for solving complex problems requiring the development of innovative products, while conditional style may be more advantageous when rigorous and structured application of design methods are needed.
Thinking styles can be considered fluid because they can be adapted to a certain environment. When faced with a problem, individuals often align their thinking styles to achieve a positive outcome.

Thinking styles of designers and engineers were compared also in a recent study conducted by researchers from the University of Illinois at Urbana-Champaign and the Universidade Federal do Rio Grande do Sul (Tonetto et al., 2021), where 141 professionals were examined to analyse the differences in their thinking styles during product development. Professionals were graduated in design (40,4%), engineering (27,7%) and architecture (31,9%), all of them working in the product development field. Results revealed that Exploring style is the dominant thinking style for both categories, showing that both designers and engineers consider multiple solutions in response to a design problem.

While designers showed a strong preference for Exploring style, engineers showed almost the same preference for Exploring, Conditional and Inquiring styles. These last two styles characterize professionals who focus more in understanding and interpreting the surrounding reality (Inquiring) and accept the outlines of functions without questioning orders (Conditional). Compared to other professionals, engineers showed a lower inclination toward the creative style, indicating that they place less importance on their emotions and personal opinions.

To sum up, engineers tend to prefer following specific rules and constraints to achieve the optimal solution, which in design refers to a rational use of materials and a practical aesthetic. Designers avoid the concept of optimal solution, leaving many options open to develop more creative approaches. Engineers approach can be useful when designing the shape or geometry of a product, while designers approach may be suitable to face challenges with more uncertain outcomes or when radical innovation is needed.

Engineers thinking styles



Designers thinking styles

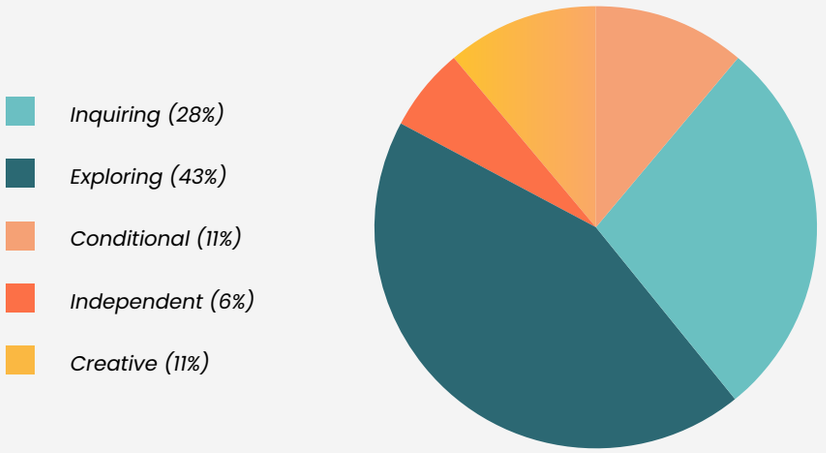


Figure 4
Engineers & Designers thinking styles
Adapted from (Tonetto et al., 2021)

1.4

THE INTER-DISCIPLINARY COLLABORATION

There are several ways in which different disciplines can cooperate together. Before exploring collaboration between designers and engineers in-depth, it is essential to explore how many types of collaboration exist between multiple disciplines.
The following sections examine the distinction between multi-disciplinary, cross-disciplinary, inter-disciplinary, and trans-disciplinary collaborations. Additionally, the rationale for focusing this thesis on inter-disciplinary collaboration between designers and engineers will be elucidated, illustrating its pivotal role in synthesizing diverse competences and perspectives to tackle complex problems effectively.

Figure 5
Team members synthetizing different perspectives in inter-disciplinary team

1.4.1

MIXING DISCIPLINES: EXPLORING MULTIPLE WAYS OF COOPERATION

Collaboration across multiple disciplines can be categorized as multi-disciplinary, cross-disciplinary, inter-disciplinary or trans-disciplinary. All these terms denote diverse disciplines working together to achieve a common goal; the difference between them lies in the level of integration of knowledge (Visscher et al., 2022).

A discipline, as defined by Tress et al. (2005) is a collection of tools, methods, procedures, concepts and theories that organize experiences through a specific worldview. Each discipline operates within a specific framework of beliefs and criteria for analysing reality, limiting the research questions that can be asked. Each discipline sets its own objectives, which are established within its own boundaries and generate new knowledge only within that context.

Both multi-disciplinarity and cross-disciplinarity are characterized by a low level of integration of knowledge, where disciplines work more or less in parallel. In contrast, inter-disciplinarity and trans-disciplinarity are characterized by a higher level of integration.

The term multi-disciplinary refers to:

"[...] research efforts of different academic disciplines that relate to a shared goal, but with multiple disciplinary objectives. Participants exchange knowledge, but they do not aim to cross subject boundaries in order to create new integrative knowledge and theory" (Tress et al., 2005, p. 485)

In this case, each discipline makes a separate contribution (National Academies, 2005); there is no integration of disciplines in the long term. They work separately toward a common goal. Each discipline can contribute independently to understanding and solving a problem without seeking synergy. The relationship between disciplines is merely one of proximity (Moran, 2010), and the distinctive elements of each discipline retain their original identity.

In contrast, inter-disciplinarity deliberately combines insights from different disciplines; it's more inclusive because it selects the most appropriate disciplinary theories, concepts and methods to solve a problem. It also means being receptive to alternative investigative methods, employing various disciplinary approaches, and critically assessing the utility of each approach to shed light on the problem (Nikitina, 2005).
Inter-disciplinary collaboration involves the integration of knowledge, methods or concepts, transcending the boundaries of different disciplines to achieve a broader understanding of an issue (Repko & Szostack, 2016).

The National Academy of Science (2005) defines inter-disciplinary as:

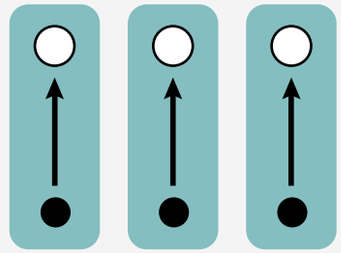
"a mode of research by teams or individuals that integrates information, data, techniques, tools, perspectives, concepts and/or theories from two or more disciplines or bodies of specialized knowledge to advance fundamental understanding or to solve problems whose solutions are beyond the scope of a single discipline area or area of research practice"
(National Academy of Science, 2005, p. 2)

Trans-disciplinarity represents the ultimate step of integration, going beyond the boundaries of conventional academic disciplines by seeking to integrate knowledge from other non-academic disciplines belonging to various categories of stakeholders to jointly create new knowledge and theories while addressing a common problem (Tress et al., 2005). Trans-disciplinarity transcends academia and deals with relevant societal problems, organizing processes of learning between researchers and industrial participants.

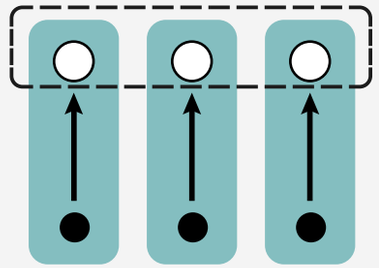
Legend:

Figure 6
Graphic representation of the concepts of Disciplinarity, Multi-disciplinary, Inter-disciplinary, and Trans-disciplinary
Adapted from Tress et al., 2005

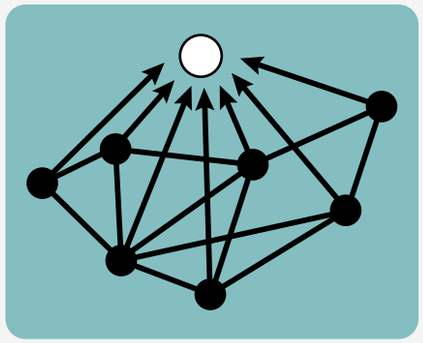
Disciplinarity



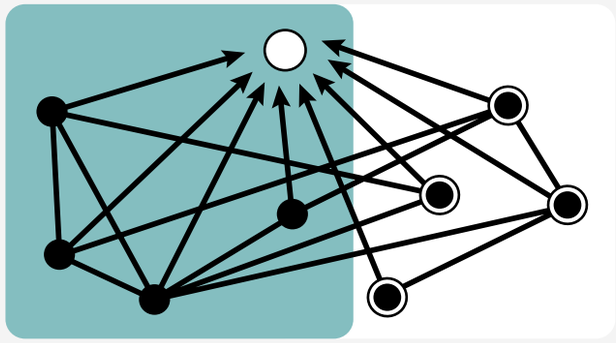
Multi-disciplinarity



Inter-disciplinarity



Trans-disciplinarity



1.4.2

THE MOTIVATION BEHIND FOCUS ON INTER-DISCIPLINARITY IN THIS RESEARCH

The present research will be focused on inter-disciplinary collaboration between designers and engineers. The choice to focus on his type of collaboration is driven by the nature of the design process itself as well as the challenges that design faces today. The concept of inter-disciplinarity emerges from the view of "disciplinary inadequacy": the recognition that individual disciplines alone are insufficient in addressing today's global issues due to their inability to comprehensively tackle complexity (Repko & Szostack, 2016).

Complexity refers to the elements of a phenomenon or problem that interact in surprising or unexpected ways. According to interdisciplinary complexity theory, interdisciplinary study becomes essential when the problem or question is multifaceted and operates as a "system" (Newell, 2001). Individual disciplines lack breadth of perspectives, exhibit partially as they view problems through a singular lens, and are concerned solely with concepts, theories and methods within their own disciplines while rejecting others. The term "inter-disciplinarity" means synthesizing diverse competences and knowledge in order to develop a unique approach to problem-solving, consequently facilitating collaboration on a shared problem that could not be solved by a single discipline (Repko & Szostack, 2016).

For instance, environmental issues are recently proving to be the centre of all the states of crisis. The vision proposed in 2019 by the exhibition Broken Nature, Design takes on Survival, curated by Paola Antonelli and Ala Tannir at Triennale di Milano, highlights the responsibility that designers must take on contemporary challenges:

"[Design] methods should be aimed not only at correcting the self-destructive course of humanity, but also at reintegrating our relationship with the environment and with all species, including other human beings […] the combined effort of inter-disciplinarity and international teams, companies, industries, governments and citizens. In any case, design will be a fundamental connecting element." (Antonelli & Tannir, 2019).

According to Boradkar (2010), the complex problems that design faces as a discipline of the project require both very specialized skills and a broad vision:

"In order for the design artefact to be truly valuable to all those who interact with it, designers have to consider issues of aesthetics, usability, ergonomics, safety, marketability, manufacturability, functionality and sustainability. This requires a wide rage of skills an knowledge. Design has therefore been described as science and art, as communication and argumentation, as thinking and inventing." (Boradkar, 2010, p. 273)

From this viewpoint, it is not sufficient for designers and engineers to merely add new content to their respective fields of study. Instead, they must identify, integrate and value multiple perspectives, learning from one another in ways that reshape their own understanding and practices. This process of mutual learning is characteristic of interdisciplinary collaboration and is essential for addressing the complexities of product design.

BENEFITS OF PLURAL TEAMS IN DESIGN FIELD

2

2.1

THE POWER OF MULTIPLE PERSPECTIVE

The multiplicity of perspectives in interdisciplinary teams plays a crucial role in problem-solving, creativity, and decision-making.

According to Cross et al. (2004) and Bunderson & Sutcliffe (2002), heterogeneous social experiences create individuals capable of embodying multiple perspectives, enriching the cognitive plurality within teams. When people repeatedly work together in interdisciplinary settings, they can develop shared mental models that enhance collective intelligence. This collaboration allows individuals to observe others' thought processes, facilitating the acquisition of diverse knowledge and promoting an understanding of its relevance and applications (Mellers & Mcgraw, 2001).
Research demonstrates that plural teams are more adept at addressing complex problems due to their capacity to draw upon a wide array of knowledge and experiences (Page, 2007).
Inter-disciplinarity fosters creativity by encouraging divergent thinking, where team members generate a variety of potential solutions, leading to more innovative outcomes. This is particularly significant in industries like product design and engineering, where challenges often require the integration of both technical precision and creative ideation.
In addition to these problem-solving benefits, interdisciplinary teams provide opportunities for personal growth and professional development. Working in plural teams encourages individuals to step outside their disciplinary silos, fostering a more holistic understanding of the broader field. This experience cultivates "T-shaped" professionals – those with deep knowledge in one area and a broad understanding of others (Wetcho et al., 2022). These professionals are highly valued in today's dynamic work environments, where adaptability and the ability to collaborate across disciplines are critical for success.

Building upon these insights, several studies reinforce the idea that integrating plural cognitive approaches fosters innovation. This integration is crucial for tackling complex, multifaceted issues, especially when solutions require both creative and technical expertise. Interdisciplinary research teams, in particular, have been shown to enhance collective intelligence, leading to more transformative outcomes by fusing different disciplinary insights to generate novel approaches to problem-solving (Page, 2007).

2.2

PROBLEM-SOLVING

Interdisciplinary teams are particularly effective at tackling complex problems because they bring plurality of perspectives and expertise. As previously discussed, solving complex issues often requires multiple forms of knowledge, which heterogeneous teams are more likely to possess.
Their plurality allows for deeper analysis and critical evaluation of problems from multiple angles. Edmondson and Harvey (2018) note that diverse teams encourage continuous learning and adaptability, both of which are crucial for addressing multifaceted challenges.

Levi (2017) highlights that many teams in professional environments frequently struggle to complete their tasks effectively, often due to poorly defined assignments and a range of obstacles that arise during the process. These obstacles can take many forms, such as technical challenges, conflicting viewpoints within the team, or interpersonal conflicts between team members—topics that will be explored in more detail in the following chapters. A key point is that the most crucial step in addressing these problems is to clearly define the nature of the task or issue at hand. However, teams often fall into the trap of rushing to propose solutions without first taking the time to fully understand the underlying problem. This can lead to misguided efforts and inefficient use of time and resources.
To avoid this, teams must work together to align on the nature of the problem. This involves questioning the initial assumptions or definitions provided, challenging surface-level interpretations, and digging deeper to uncover the root causes. Without this foundational step, teams are more likely to encounter difficulties later in the problem-solving process. Furthermore, many teams overlook the final, critical stage of evaluating the outcomes of their solutions. Often, they fail to assess whether their solutions have been successful or to identify areas for improvement. This lack of reflection prevents teams from learning from their mistakes, causing the same issues to resurface repeatedly.

By combining the strengths of interdisciplinary teams—such as cognitive plurality and adaptability—with a clear problem definition and thorough evaluation, teams can more effectively navigate the challenges they face.

2.3

CREATIVITY

Creativity is the production of ideas or outcomes that are both novel and useful for a specific goal (Amabile, 1996). It is not an innate trait but rather the result of a combination of factors, including talent, learned skills, and external influences. Creativity can be cultivated, both individually and within teams. According to Amabile's componential theory(2012), creativity is influenced by three key components: domain-relevant skills, creativity-relevant skills, and task motivation. Domain-relevant skills refer to knowledge and abilities in a specific field, which is why creativity often emerges in areas where individuals have expertise. Creativity-relevant skills include cognitive styles and personality traits that promote creative thinking, such as the ability to think outside the box, suspend judgment, and approach problems from broad perspectives. Task motivation, which comes from personal interest in the task itself, is critical, as individuals with intrinsic motivation tend to be more creative.

However, creativity can be constrained by psychological factors, such as fear of judgment, which inhibits creative expression, and external pressures that diminish intrinsic motivation. Additionally, rigid mental frameworks can limit creativity, as fresh ideas often emerge from seeing familiar things in new ways. Younger or less experienced individuals, who are free from conventional paradigms, tend to generate more novel ideas.

Working in teams can enhance creativity, as groups foster a supportive environment that encourages the creativity of each member, often producing more ideas than individuals working alone (Paulus, 2000). Plural teams—comprising members with diverse cultural backgrounds, knowledge, and experiences—are particularly effective at generating innovative ideas because their varied perspectives stimulate collective thinking (De Dreu & Weingart, 2003; Somech & Drach-Zahavy, 2013).

This plurality can lead to task conflict, which refers to disagreements on how to approach the task. Task conflict is seen as constructive, as it promotes critical thinking and the exploration of different viewpoints, which are essential for creative problem-solving (Jehn, 1995; Yong et al., 2014). However, for task conflict to be beneficial, psychological safety must be present. When team members feel comfortable sharing ideas and providing feedback in a trusting and supportive

environment, creativity is enhanced (King & Anderson, 1990). Research shows that when team members engage with and consider each other's perspectives, information elaboration is facilitated, which fosters greater creativity (Hoever et al., 2012).

Although plurality in teams promotes creativity, it does not automatically guarantee it. The conflict arising from different perspectives must be managed constructively, and team members must be aware of each other's expertise to focus discussions on unique contributions. While some argue that homogeneous teams can also foster creativity due to familiarity among members, which creates a safe environment, this same familiarity can prevent the generation of new ideas by limiting productive conflict (Farh et al., 2010).

Therefore, to foster creativity, teams must develop cooperation skills, openness to new ideas, and psychological safety—an essential concept that will be discussed in detail in the following chapters. Encouraging both individual and group idea generation, with time set aside for reflection, can enhance creativity at both the individual and team levels (Paulus, 2000).

Figure 7
Key components that influence creativity
Adapted from (Amabile, 2012)

2.4

DECISION-MAKING

As previously said, one of the most significant benefits of working in plural teams is the ability to pool diverse skills and perspectives, leading to better decision-making. Team decisions are often superior to individual ones due to factors like process gain, error reduction, and knowledge aggregation.

Teams have access to a broader range of resources for solving problems compared to individuals. The phenomenon of "process gain" occurs when interaction among members during discussion leads to the generation of new ideas that individual members could not have conceived alone (Rajaram, 2011). Group discussions benefit from a larger pool of information, particularly in plural teams, which consist of members with varied backgrounds.

Error reduction is another advantage. While individuals are prone to errors, a diverse group produces different errors that statistically cancel each other out (Armstrong, 2001; Rajaram, 2011).
Additionally, teams develop collective memory from past experiences, reducing the likelihood of repeating mistakes.

Knowledge aggregation refers to the combining of the group's diverse knowledge, resulting in improved decision-making (Simons et al., 1999; Cronin & Weingart, 2007; Jehn & Mannix, 2001). Groups can review broader goals, consider more alternatives, and account for the uncertainty of outcomes. Team decisions also boost individual motivation, as people are more invested in decisions they've helped shape (Larrick, 2016).

Team composition plays a critical role in decision-making. Heterogeneous teams with complementary skills tend to make better decisions, as diverse perspectives allow for a more comprehensive representation of the problem (Miller, 2008). Diversity of opinion within a team provides an advantage, as plural teams can combine varied expertise to achieve high-quality decisions. However, effective decision-making requires awareness of the distribution of expertise within the team. Recognizing each member's skills enhances coordination, ensuring that the most knowledgeable individuals are consulted for specific tasks (Larrick, 2016).

STAGES OF TEAM DEVELOPMENT

3

3.1

TUCKMAN'S MODEL: FIVE STAGES OF GROUP DEVELOPMENT

Numerous approaches have been developed to explain the transformations that teams experience during their operation, there are many stages theories of group development that focus on the temporal evolution of internal group processes. While each one has its nuances, they share some common elements: all these theories aim to describe why groups require time to mature before reaching optimal productivity and why they experience phases of conflict throughout their development.

The group development model by Tuckman, and extended by Tuckman and Jensen (1977) describes five stages that teams typically experience during a project: forming, storming, norming, performing, and adjourning. These stages outline how team dynamics evolve as the group works toward its goal.

During the *forming stage* (i), members get acquainted, learning to work together. Interactions are generally polite but marked by uncertainty as individuals figure out their roles. Enthusiasm is high, though there may be anxiety about fitting in and performing well.

Next is the *storming stage* (ii), where conflicts and disagreements arise as team members begin to push against boundaries and challenge roles. This phase can be turbulent, with clashes over procedures, tasks, or responsibilities. However, conflicts in this stage are an essential part of team growth, as they encourage open discussion and allow members to address differing viewpoints. If handled constructively, storming helps teams clarify goals and improve work processes.

Once the team overcomes this, the *norming stage* (iii) begins. Members start to work more cohesively, establishing shared norms and values, and focusing on collaboration. Differences are resolved more constructively, and the team becomes more organized, moving toward its common goals.

In the *performing stage* (iv), the team operates smoothly and efficiently, having developed the necessary skills and communication strategies. Productivity is highest in this stage as team members are now fully focused on task execution, leveraging each other's strengths to meet deadlines and produce results.

Finally, the *adjourning stage* (v) marks the project's completion. The team disbands, reflecting on their accomplishments and evaluating the lessons learned for future collaborations.

3.2

THE DOUBLE NATURE OF CONFLICT AND ITS IMPLICATIONS IN TEAMWORK

The storming stage is often characterized by internal conflict, where team members challenge each other's ideas and roles. These conflicts can be functional, such as task conflicts, which stimulate constructive dialogue about work processes, or dysfunctional, where disagreements become personal and hinder team effectiveness.

Functional task conflicts, as discussed in the previous section, allow team members to explore different approaches to problem-solving. These debates help refine the team's work strategies and foster conflict management skills. Early process conflicts are often linked to future success, as they equip teams with the tools to resolve challenges and adapt their strategies effectively in later project stages (Stahl & Maznevski, 2021).

However, not all conflicts are beneficial. Dysfunctional conflicts, often driven by personal friction, undermine collaboration and trust. Such disputes, if left unchecked, can compromise the team's cohesion (Stahl & Maznevski, 2021). Teams must therefore actively manage storming phase, ensuring conflicts remain constructive and contribute to team development rather than creating obstacles.

Managing the storming stage well is crucial to transitioning into norming and eventually performing, where the team can leverage its collective skills to achieve high performance.

3.3

CYCLICAL VIEWS OF STAGES OF TEAM DEVELOPMENT

While stage theories of group development are widely accepted, not all teams follow these patterns. Instead of focusing on a linear progression of stages, some team theorists propose that groups experience recurring cycles throughout their lives.
Some teams bypass certain stages, others become stuck in particular stages, and some follow unique pathways through stages.

Marks, Mathieu and Zaccaro (2001) developed a model of teamwork based on these recurring phases, illustrating how teams operate in temporal cycles that establish a rhythm. These cycles can vary depending on the task. Teams operate in action cycles (task performance), interpersonal cycles (managing social relations) and transition cycles (evaluating performance and planning for the future). These cycles can occur as needed or at predetermined intervals.

Gersick's research (1988) on project teams introduces the theory of "punctuated equilibrium". Each team displayed its own development pattern, yet all experienced phases of low activity followed by bursts of energy and change. Additionally, every team encountered a midpoint crisis when they realize that half their allotted time has passed, but the project remained in early stages. This realization lead to a period of panic, followed by intensified efforts to complete the task. Gersick's model suggests that teams change when external challenges force them to reassess their current practices (Humphrey & Aime, 2014). The most important implication of this model is that focusing on task strategy is particularly beneficial during the midpoint crisis rather than at the start of the team's development. When teams face disruptive events or challenges, they are more likely to re-examine their routine practices and implement changes.

According to Levi (2017), these models highlight how not all teams reach the performing stage in a linear manner. Some may stall in earlier phases, while others might oscillate between stages, encountering obstacles that prevent them from achieving full cohesion and effectiveness. This underscores the need for teams to remain adaptable, regularly assess their progress, and adjust their strategies to accommodate changing circumstances or unforeseen challenges.

3.4

THE STORMING STAGE: WHAT ARE THE MAIN SOURCES OF CONFLICTS?

In conclusion, the stages of group development provide valuable insights into how teams evolve over time.
While the linear progression of Tuckman's model offers a framework for understanding team dynamics, not all teams follow this exact pattern. As discussed, some teams experience cyclical phases or encounter disruptions that require them to revisit earlier stages or develop new strategies to manage conflict and maintain cohesion.

The storming stage, in particular, stands out as a critical phase, where both functional and dysfunctional conflicts can arise. Teams that successfully manage task-related conflicts are more likely to develop improved processes and enhance their conflict resolution skills, paving the way for effective collaboration in later stages. However, teams that allow personal or dysfunctional conflicts to dominate may struggle to move beyond storming and fail to reach their full potential.

In the next chapter, the focus will shift to exploring the barriers that impede collaboration within teams, with a specific emphasis on interdisciplinary groups composed of designers and engineers. Understanding these barriers will provide deeper insight into the challenges that prevent teams from achieving optimal collaboration and how such challenges can be addressed to foster more effective interdisciplinary teamwork.

CHALLENGES OF COLLABORATION IN TEAMWORK

CHALLENGES OF COLLABORATION IN TEAMWORK

This chapter will explore the challenges of interdisciplinary collaboration in plural teams, focusing on several key areas.

It begins by examining the sources and types of conflicts that arise in diverse teams and how they impact group dynamics.
The chapter then discusses the role of an unsafe team climate, highlighting the importance of psychological safety in fostering open communication and collaboration.
It also addresses the issue of misalignment in team activities, exploring how unclear roles and coordination affect team performance.
Lastly, the key barriers of collaboration between designers and engineers will be identified, delving into the specific challenges that hinder collaboration between these disciplines.

Figure 8
Unsafe team climate

4.1

SOURCES AND TYPES OF CONFLICTS

In the context of plural teams, process gains and process losses are critical for understanding group dynamics (Stahl & Maznevski, 2021). While process gains, as discussed in chapter two of this thesis, refer to benefits such as enhanced creativity and innovation that arise from plurality, process losses highlight the obstacles and inefficiencies that can emerge, often in the form of conflict.
According to Stahl and Maznevski (2021), the effects of plurality on team outcomes are not direct but are mediated by key variables such as creativity, cohesion, and conflict, as evidenced by their 2010 meta-analysis of 108 studies on multicultural teams. Plural teams tend to experience lower social cohesion and integration, which can lead to increased conflict. However, contrary to expectations, these teams did not show less effective communication, and team member satisfaction was even higher compared to homogeneous teams.

Conflicts in plural teams emerge from several interconnected factors. One of the primary causes is value incongruence, which occurs when team members from different cultural backgrounds have divergent value systems. These differences can lead to misunderstandings and disagreements about priorities within the group, creating friction and reducing the efficiency of collaboration (Stahl & Maznevski, 2021).

In interdisciplinary teams, both task conflict and relationship conflict exist, but only the latter negatively impacts team dynamics and creativity. Task conflict, centred on differing opinions regarding the work itself, has a positive influence, as discussed earlier. In contrast, relationship conflict, which arises from personal tensions and incompatibilities, disrupts team dynamics. As Yong, Sauer, and Mannix (2014) explain, relationship conflict distracts team members from task-related goals, reducing cooperation and overall performance. While task conflict can fuel innovation by fostering diverse viewpoints, relationship conflict undermines cohesion, making collaboration and creativity harder to achieve.

Several factors contribute to relationship conflict. Personality differences are a common source, as team members with contrasting traits often struggle to align interpersonally, leading to frustration and misunderstandings. This strain hampers communication and collaboration. Emotional tension, such as feelings of annoyance, anger, or resentment,

further intensifies relationship conflict. When individuals become emotionally invested in their ideas or perceive others' contributions as a threat, the resulting tension can disrupt the team's atmosphere (Yong et al., 2014).

Communication barriers also play a significant role in generating conflict. In plural teams, where members may speak different languages or use distinct communication styles, misunderstandings and frustration can easily escalate into larger issues (Stahl & Maznevski, 2021). Particularly in interdisciplinary teams, varying communication styles often lead to misinterpretations, further exacerbating tensions (Yong et al., 2014).

Social categorization further complicates team dynamics, as members may form subgroups based on shared values, disciplinary backgrounds, or personal connections. This can foster an "us versus them" mentality, causing distrust and divisions within the team (Stahl & Maznevski, 2021; Yong et al., 2014). In interdisciplinary settings, subgroup formation based on shared expertise or values can also lead to exclusion, reinforcing interpersonal conflicts.

Another significant source of relationship conflict is the tendency of team members to protect their intellectual turf. In interdisciplinary teams, individuals often feel compelled to defend their expertise or knowledge, prioritizing competition over collaboration. This defensiveness limits openness in sharing ideas and fosters a competitive atmosphere that stifles effective teamwork, making it difficult for the team to function cohesively (Yong et al., 2014).

Finally, plural teams may experience reduced cohesion and trust, weakening collaborative efforts. When team members struggle to build trust or integrate socially, the potential for conflict increases, further undermining the group's effectiveness.

4.2

UNSAFE TEAM CLIMATE

An unsafe team climate poses a substantial barrier to effective collaboration. Psychological safety, which will be explored further in the following chapter, refers to an environment where individuals feel comfortable taking interpersonal risks, such as voicing concerns, admitting mistakes, or offering new ideas, without the fear of retribution or embarrassment.

In the absence of psychological safety, often referred to as unsafe teams, individuals experience heightened interpersonal anxiety, preventing them from speaking up and severely impeding collaboration. This fear of negative consequences fosters a culture of silence, which dramatically limits team performance.

Research indicates that fear within unsafe teams not only suppresses learning and creativity but also diverts cognitive resources away from problem-solving and innovation. Employees in such environments struggle to reach their full potential, as the constant fear of making mistakes or being judged stifles productivity and engagement (Edmondson, 2018).

Moreover, unsafe climates reduce employee satisfaction and engagement, often leading to higher turnover and lower morale. Without psychological safety, teams face significant challenges in fostering the open communication necessary for collaboration and innovation.

As Larrick (2016) explains, in unsafe environments, team members often engage in self-censorship, withholding new or dissenting ideas due to fear of repercussions from colleagues or superiors. This fear limits the exchange of diverse perspectives, a key driver of innovation and effective decision-making. Instead of promoting open dialogue, unsafe team climates encourage conformity, with individuals avoiding challenges to established norms or presenting alternative viewpoints, even when those ideas could lead to better outcomes.

In these climates, relationship conflict, defined by Larrick (2016) as personal tensions and disputes unrelated to the task at hand, tends to escalate. The absence of psychological safety intensifies these conflicts, as team members adopt defensive behaviors, focusing on protecting their reputations rather than resolving interpersonal issues. This tension distracts from task-related objectives

and weakens group cohesion, making collaboration more difficult.

In unsafe team settings, decision-making often shifts from focusing on the best solutions to minimizing interpersonal risk. As a result, teams may miss opportunities to explore innovative ideas or consider alternative strategies, leading to suboptimal decisions. As Larrick (2016) notes, in these environments, the focus shifts from collaborative problem-solving to individual self-preservation, ultimately hindering the team's overall performance and stifling creativity.

The impact on team performance is profound. A psychologically unsafe environment inevitably leads to a decline in team performance. When individuals fear judgment, they withhold critical information, which is essential for maintaining shared knowledge within the team. This lack of information exchange increases perception gaps, causing team members to rely on outdated or incomplete data. Without consistent updates, changes in project context are overlooked, plans are not revised, and the work becomes misaligned with the current situation, leading to inadequate outcomes (A. Edmondson, 1999).

4.3

MISALIGNMENT IN TEAM ACTIVITIES

Misaligned teams refer to groups where there is a lack of clarity regarding objectives, roles, responsibilities, and communication. This misalignment, stemming from poor coordination, unclear task assignment, and inconsistent communication, can severely hinder collaboration and productivity.

As Bick et al. (2018) explain, when tasks and priorities are not clearly defined, teams experience coordination lapses and struggle to synchronize their efforts, leading to delays, task duplication, and project bottlenecks. Misalignment creates dependency awareness gaps, where team members fail to recognize the interdependencies of their work, further complicating collaboration and causing inefficiencies across the team.

Mastrogiacomo and Osterwalder (2021) also identify several signs of misalignment, such as confusion over task ownership, unproductive meetings where decisions are not reached, and siloed work, where individuals focus only on their tasks without integrating their contributions into the larger team objectives. This fragmentation not only results in duplicated efforts and gaps in execution but also weakens overall team cohesion, reducing effectiveness.

In distributed teams, the challenges of misalignment are even more pronounced. Paasivaara et al. (2015) found that socio-technical congruence—the alignment between coordination needs and actual behaviours—was lower in distributed settings compared to co-located teams. This mismatch led to more frequent coordination breakdowns due to the lack of face-to-face communication, resulting in misaligned priorities and task duplication. Informal communication in co-located teams helped mitigate some of these issues, whereas distributed teams, lacking this dynamic, faced greater challenges in keeping their work aligned. Over time, some distributed teams learned to self-select tasks to reduce interdependencies and coordination overhead, but early misalignment led to inefficiencies and project delays (Paasivaara et al., 2015).

Both Bick et al. (2018) and Paasivara et al. (2015) underscore the risks of coordination surprises—situations where the final deliverables deviate from expectations due

to poor integration of individual efforts. In such cases, teams deliver outputs misaligned with original objectives, ultimately leading to low-quality outcomes. Misaligned teams face not only reduced productivity but also frequent missed deadlines, as the lack of communication and transparency between central coordinating teams and individual teams worsens synchronization challenges.

The impact of misalignment extends beyond inefficiencies, stifling creativity and collaboration. When team members are not aligned, miscommunication and misunderstandings become more frequent, leading to friction and a decline in overall team performance. Achieving alignment requires clear communication, frequent synchronization, and ensuring that each team member understands their role within the broader goals. Self-organizing teams, are more successful in mitigating these challenges and improving collaboration.

4.4

KEY BARRIERS OF COLLABORATION BETWEEN DESIGNERS AND ENGINEERS

In reflecting on the challenges of interdisciplinary collaborations, I have wondered whether there are specific barriers that impede designers and engineers to work together effectively:

What are the barriers that prevent engineers and designers from operating successfully in an inter-disciplinary context?

Through an examination of several studies, it becomes evident that there are distinct obstacles rooted in their different educational backgrounds, problem-solving approaches, and communication styles.

The study by Kaygan and Demir (2017), which focuses on design education, identifies several barriers that prevent effective interdisciplinary collaboration between engineers and designers. These barriers include disciplinary silos, clash of priorities and expectations, lack of a common language, role ambiguity and unclear task allocation, and cultural and educational differences.

Disciplinary silos arise because engineers and designers often work within isolated frameworks. Engineers typically adopt structured, methodical approaches aimed at solving well-defined technical problems, while designers engage in more abstract, creative processes that focus on broader conceptual issues like user experience and aesthetics.
This fundamental divergence in problem-solving approaches can lead to misunderstandings, where engineers prioritize technical precision, while designers emphasize aesthetics and user experience. These differences in how each discipline defines and addresses problems complicate collaboration and create frustrations for both sides (ibidem).

A significant challenge also stems from the clash of priorities and expectations.
Engineers tend to focus on functionality, whereas designers are concerned with user experience and aesthetics. This mismatch often creates tension, as engineers may undervalue design considerations, and designers may perceive engineers as dismissive of user-centred solutions. The resulting conflict can lead to a hierarchical division of labor, where technical aspects dominate and design is treated as secondary or superficial (ibidem).

Another key barrier is the lack of a common language. An example can be the use of terms like “prototype” or “model”, engineers

and designers frequently use them, but with different meanings. Engineers may view a prototype as a functional, testable model, while designers might see it as part of the creative exploration process. This difference in terminology causes confusion and hinders effective communication within interdisciplinary teams (ibidem).

Role ambiguity and unclear task allocation further complicate interdisciplinary work. When responsibilities are not clearly defined, engineers and designers may struggle to understand their roles within a project. This leads to inefficiency, confusion, and even duplication of tasks, highlighting the need for well-defined yet flexible roles in interdisciplinary teams (ibidem).

In addition, cultural and educational differences play a critical role in hindering collaboration. Engineering education tends to be more formal, structured, and focused on technical knowledge, while design education is more informal, relying heavily on creative studio work and critique sessions. These contrasting educational backgrounds foster different professional cultures, making it difficult for engineers and designers to work together without mutual understanding

and respect for each other's methodologies (ibidem).

As identified in the study by Tobi and Kampen (2018), which focuses on interdisciplinary research frameworks, epistemological differences present yet another challenge. Engineers often adopt a neopositivist approach, focusing on measurable and observable phenomena, whereas designers tend to gravitate towards constructivist methodologies, which emphasize interpretation and subjective understanding. This difference in how knowledge is constructed and validated leads to divergent goals and methods, complicating collaboration (ibidem).

In the same study, communication barriers were identified as another critical obstacle. Due to differences in terminology and interpretations, engineers and designers often miscommunicate, further exacerbating the difficulties in collaboration (ibidem).

Finally, Richter and Paretti (2009) note that another cognitive barrier that significantly hinders interdisciplinary collaboration is disciplinary egocentrism, that refers to individuals' tendency to focus narrowly on

their own discipline, failing to recognize the contributions of other fields. Such egocentrism prevents students and professionals from appreciating interdisciplinary work and integrating diverse perspectives into their problem-solving processes. This limits their ability to effectively collaborate and incorporate new ideas (Richter & Paretti, 2009).

4.5

KEY BARRIERS OF COLLABORATION BETWEEN DESIGNERS AND ENGINEERS

To sum up the findings discussed in Chapter 4, which analyses the challenges of collaboration in plural teams, several key barriers emerge.

Process losses are a critical factor in plural teams, often stemming from conflicts related to differences in values and priorities. Relationship conflict, which arises from personal tensions and communication breakdowns, tends to undermine team cohesion and performance. These conflicts are further intensified by personality differences, emotional tensions, and communication barriers.

An unsafe team climate also poses significant challenges, as the absence of psychological safety prevents team members from voicing ideas or taking risks. This results in a culture of silence, stifling creativity and innovation, while worsening relationship conflict and diminishing decision-making effectiveness.

In addition, misalignment in team activities—caused by unclear roles, responsibilities, and coordination issues—leads to inefficiencies such as task duplication, delays, and breakdowns in communication. This issue is especially problematic in distributed teams.

Lastly, collaboration between designers and engineers faces additional barriers, including disciplinary silos, clashing priorities, lack of a common language, role ambiguity, and disciplinary egocentrism. These challenges are heightened by cultural and educational differences, which prevent effective integration of diverse perspectives.

In the next chapter, the focus will shift to examining the specific characteristics that enable plural teams to perform at their best. This will involve analysing the factors that drive higher levels of creativity, cohesion, and innovation within diverse teams, as well as exploring the dynamics that foster effective collaboration.
Understanding these characteristics will provide insight into how plural teams can overcome challenges to achieve optimal performance.

SUCCESS CRITERIA FOR TEAMWORK

SUCCESS CRITERIA FOR TEAMWORK

For optimizing interdisciplinary collaboration between designers and engineers, it is essential to define what constitutes successful teamwork.

According to Hackman (1987), team success is determined by three key factors: completing the task, developing strong social relations, and benefiting individual team members. A successful team achieves its established goals while fostering positive social relations among members, allowing for continued collaboration in the future.

Social relations play a crucial role in teamwork, as effective collaboration depends on group cohesion and clear communication. Cohesion is built through emotional bonds and shared objectives, while good communication is founded on mutual understanding and trust. Without strong social relations, teams often struggle with miscommunication, interpersonal issues that impede task performance, and a lack of motivation and mutual support.

Additionally, individual participation is essential, both in terms of contributing to team success and in fostering personal growth. By participating in collaborative tasks, team members not only learn new skills but also gain valuable insights from their colleagues, enriching the overall team dynamic and individual development.

In my view, Hackman's criterion of completing the task naturally aligns with the concept of team alignment, as ensuring clear goals and coordinated efforts is essential for achieving shared objectives. Without alignment, miscommunication and inefficiencies can obstruct task completion, making coordination a crucial factor in team success.

I also interpret developing strong social relations as closely tied to psychological safety. In a team where members feel safe to openly share ideas and address conflicts constructively, strong interpersonal bonds can form, fostering the trust and cohesion necessary for effective collaboration.

Lastly, I connect benefiting the individual with the concept of knowledge integration in interdisciplinary teams. Collaborating across disciplines, such as design and engineering, offers opportunities for personal growth, allowing team members to learn from diverse perspectives. This not only enriches the individual but also enhances overall team performance.

These themes will be further explored in the following sections, where I will delve into how team alignment, psychological safety, and knowledge integration contribute to successful interdisciplinary teamwork.

5.1

SAFE ENVIRONMENT AND PSYCHOLOGICAL SAFETY: KEYS FOR SUCCESSFUL COMMUNICATION

Psychological safety can be defined as the degree to which team members feel comfortable sharing ideas and giving and receiving feedbacks. Each member participation to the group's task is encouraged and received in a trusting and mutually supportive environment (King & Anderson, 1990).

Edmondson (2018) noted that when individuals know that their contributions will be respected and that their mistakes will be met with support rather than criticism, they are more likely to push boundaries and explore innovative solutions. When the climate is psychologically safe, it encourages productive dialogue, fostering proactive learning about the environment and users and leading to effective problem-solving. This, in turn, strengthens the team's common ground – the shared knowledge, beliefs and assumptions that are crucial for seamless collaboration.

In psychologically safe teams, mistakes are not viewed as failures but as valuable opportunities for experimentation and learning. This perspective transforms errors from being points of shame into critical moments of growth and innovation. Working in a safe environment is not about being polite or reducing performance expectations, it is about cultivating a culture of openness and trust. In such a culture, team members feel empowered to express their thoughts honestly, take risks and seek assistance when needed without fearing judgment or embarrassment.
The free exchange of information within such an environment is key to the team's ability to learn and adapt. Team members feel comfortable receiving and giving feedback, asking for help and discussing mistakes, all of which contribute to continuous improvement. This openness contributes to individuals' growth and reinforces team cohesion and alignment.

Conflicts and disagreements are natural occurrences in any collaborative environment. However, in teams where psychological safety is prioritized, these conflicts can be transformed into opportunities for

constructive dialogue. Rather than avoiding or suppressing disagreements, team members are encouraged to discuss their differing viewpoints openly. This approach helps resolve conflicts more effectively and enriches the team's collective understanding by exposing members to broader perspectives.

Moreover, psychological safety supports continuous learning within the team.

When team members feel safe to acknowledge what they do not know, they are more likely to seek out new knowledge and skills individually and collectively. This proactive approach to learning is beneficial in inter-disciplinary teams and helps the team adapt to new challenges and stay competitive in a rapidly changing environment.

Figure 9
Team members sharing ideas in a safe environment

5.2

FROM ALIGNMENT TO EXECUTION: KEY FACTORS FOR COHESIVE TEAMWORK

Effective teamwork relies on several key factors that ensure cohesive and productive collaboration. Successful alignment is fundamental to this process, it ensures that individual contributions are synchronized to achieve a shared goal, transforming isolated efforts into collective success. As noted by Clark (1996) and further explored by Garrod and Pickering (2009), alignment is essential for maximizing team effectiveness. It involves constant synchronization among team members, permitting the achievement of unattainable complex goals through individual efforts alone.

To achieve optimal performance, teams must align their efforts and manage their processes efficiently. The next paragraphs will address four critical aspects of successful teams: building common ground, defining clear team goals, establishing explicit commitments, and implementing effective time management strategies.

5.2.1

BUILDING COMMON GROUND: A KEY TO AVOID MISCOMMUNICATION AND PROJECT FAILURE

Common ground refers to the shared knowledge, beliefs, assumptions, and understanding among team members. This collective awareness forms the basis for effective communication, collaboration and coordination, as it allows team members to anticipate each other's actions, avoid misunderstanding and work together more seamlessly.
This concept has been extensively studied by psycholinguist Herbert Clark (2006) and later expanded upon psychologist Steven Pinker (2019), who both explored the underlined mechanisms of common ground, common knowledge and shared understanding.
Language is a primary tool through which people coordinate shared activities. In a team setting, members are interdependent; their success relies on their ability to work together toward a common goal. This interdependence necessitates that each members aligns their individual contribution with those of the others. Without such alignment, the team's effort can become disjointed and ineffective.

Clark posits that for a team to function effectively, each member must work to establish and maintain an adequate level of common ground. This common ground is not just a superficial understanding but a deep, shared repository of knowledge, beliefs and assumptions that all team members drawn upon. It includes everything from shared goals and expectations to a mutual understanding of tasks and roles within the team. Establishing this common ground is crucial because it enables team members to predict each other's actions and responses, reducing the likelihood of unexpected surprises or misunderstandings.
When common ground is strong, team members can synchronize their efforts more effectively. They know what to expect from each other, which leads to fewer execution problems and a more seamless flow of work. The alignment of actions is continuous, and it helps in avoiding errors or conflicts that could derail the project.
On the other hand, when common ground is lacking, the consequences can be detrimental to the project's success. Klein's research (2005) highlights that many projects failures are rooted in a breakdown of common ground. For example, incomplete requirements may arise when team members do not fully understand or share the same vision of what is needed.

Similarly, the exclusion of key user from the design process may occur when the team fails to communicate effectively about who should be involved. Unrealistic expectation often stem from a misalignment in understanding between what is feasible and what is desired. In such scenarios, team members may not be fully aware of what others are doing or why certain decisions are being made, leading to confusion, miscommunication and ultimately, project failure.

Therefore, maintaining common ground is not just a theoretical concept but practical necessity for successful teamwork. It requires continuous effort from all members to communicate clearly, share information openly, and regularly check it with one another to ensure that everyone is on the same page. This ongoing process of building and reinforcing common ground is what enables teams to function cohesively, make informed decisions, and achieve their goals efficiently and effectively.

5.2.2

DEFINING TEAM GOALS: ENHANCING TEAM MOTIVATION AND PERFORMANCE

A clear understanding of a team's objectives through well-articulated goals is one of the most common characteristics of successful teams (Larson & Lafasto, 1989).

Establish clear objectives is the essential starting point for effective collaboration. It provides team members with a shared understanding of what they are working toward, which in turn fosters engagement, motivation, and a genuine interest in contributing to the collective effort. When individuals understand the purpose of their work, they are more likely to listen attentively, participate actively and invest themselves fully in the process (H. J. Klein et al., 1999).
It is vital that objectives are not only understood by everyone involved but also genuinely shared by all team members. The objective should align with the aspirations and values of the group, while also meeting the specific requirements of the project. A shared objective acts as unifying force, bringing together diverse perspectives and guiding the team's efforts in a coherent and purposeful direction (Tosi et al., 1991).
The process of defining and agreeing upon common objectives is crucial to the success of any collaborative endeavour. When objectives are unclear or poorly communicated, team members may struggle to grasp the significance of their work, leading to a lack of direction and purpose. This confusion can diminish attention, reduce participation, and result in conversations that lack focus and productivity. The absence of clear goals can leave participants feel disconnected, disinterested, and often bored, which undermines the overall effectiveness of teams' efforts.
Therefore, investing time and effort into establishing clear, shared objectives is essential for creating a productive and cohesive team dynamic. Such objectives serve as a roadmap for the project, ensuring that every member is aligned with the collective vision and is working toward a common purpose. This clarity not only enhances individual and group motivation but also ensures that the team's work remains relevant, focused, and capable of achieving the desired outcomes (A. C. Edmondson & Harvey, 2018).

According to Tosi et al. (1991), team objectives need to be clear, specific and measurable. When objectives lack measurability, the team

is unable to receive the necessary feedback to gauge their performance and progress. Feedbacks are crucial to enable the team to assess whether they are on track to meet their goals and to make any necessary adjustments along the way.

Furthermore, there needs to be an appropriate balance in the level of difficulty of these objectives. Challenging goals stimulate team members, as they tend to increase motivation and engagement. When faced with difficult but achievable goals, team members are more likely to be driven and committed to reaching the desired outcomes. These challenging objectives also foster a stronger sense of collaboration among team members, as they recognize that achieving such goals requires mutual support and cooperation. The realization that they cannot succeed alone encourages a culture of teamwork, where individual actively contribute their skills and knowledge to help the group succeed.
However, it is equally important to avoid setting objectives that are overly difficult or unrealistic. When goals are perceived as unattainable, they can have a detrimental effect on the team's dynamics and morale.

Team members may experience feelings of frustration or embarrassment if they fail to meet the objectives, which can lead to a breakdown in trust and cooperation. In such situations, there is a risk that individuals may begin to blame one another for the lack of success leading to conflict and a reluctance to collaborate in future projects. This can undermine the effectiveness of the team, as the negative experiences associated with failure may discourage members from working together again.

5.2.3

COMMITMENTS IN TEAMS: ESTABLISHING ROLES AND RESPONSIBILITIES

In a group or team context, commitments refer to the promises or obligations that team members make to one another regarding the task or responsibilities they will undertake. These commitments are crucial for ensuring accountability and trust within the group. They can include specific deliverables, deadlines, standards of quality, or behavioural expectations that members agree to uphold.

According to Gilbert (2014) it is both necessary and sufficient for group members to openly express their readiness to be committed in front of their peers. By doing so, these commitments become part of the group's common ground. Agreement on "who is responsible for what" creates a set of moral obligations and rights: each member has the duty to fulfill his/her role and, in return, has the right to expect that others will do the same. In this context, expressing readiness to commit serves to solidifying the shared understanding within the group.

This mutual recognition of responsibilities is what integrates commitments into the group's common knowledge, ensuring that everyone is aware and accountable for their roles. Roles should not be fixed but adapted to both individual capabilities and the project's evolving needs.

Ambiguous commitments often lead to a lack of accountability and are particularly prevalent in teams where commitments are implicit or not explicitly stated. When commitments are unspoken, a gray area emerges where team members might assume others will act accordingly to their own convenience, resulting in increased potential for confusion and conflict. This can be reduced just by speaking clearly about commitments and expectations (Mastrogiacomo & Osterwalder, 2021).

5.2.4

TIME MANAGEMENT OF TASKS: THE IMPACT OF TIMEBOXING TECHNIQUE

Once the goals and roles of each team members are clearly defined, it is also essential to establish an effective approach to time management. Setting a clear time horizon for the team is crucial, as it provided a structured framework within which to operate. However, defining the time required to complete a task is only possible when all team members fully understand the group's mission and each person's responsibilities.
Without this shared understanding, it becomes difficult to accurately predict how long tasks will take, leading to potential delays and inefficiencies.

Time constraints play a vital role in focusing the team's effort by eliminating unrealistic and overly ambitious ideas and directing attention toward practical, actionable goals (Mastrogiacomo & Ostewalder, 2021)

Establishing deadlines fosters a sense of urgency and grounds the team activities in tangible outcomes, ensuring that discussion and decisions are oriented toward achievable objectives. By understanding how to manage time effectively, and ensuring that everyone is aligned on the mission and individual roles, the team can better coordinate their effort and maintain momentum, ultimately leading to a more efficient and productive workflow.

A study conducted by Atlassian (2023) involving 5000 professionals working on 4 continents revealed that half of the time spent in meetings is perceived as inefficient and unproductive, primarily due to poor time structuring. This inefficiency often leaves workers feeling drained, unfocused and less capable of advancing high-priority projects. The key to achieving meaningful impact and reducing feelings of overwhelm lies in prioritizing most important work. The research demonstrates that deliberately setting aside time and creating space for such work leads to increased productivity and greater workers satisfaction.

According to Marc Zao-Sanders (2023), timeboxing is a particularly effective time management technique that is especially applicable to creative project. Timeboxing involves allocating a fixed amount of time to a specific task or activity, and the task must be completed within that time frame, regardless of whether all aspects are finished. This method is particularly valuable for managing tasks that have the tendency to "expand" or consume more time than necessary, an issue commonly encountered in design projects.

By establishing clear time constraints, timeboxing helps maintain momentum, prevent procrastination, and ensure that time is allocated efficiently across various tasks.
The primary objective of timeboxing is to create a sense of urgency and sharpen focus, enabling individuals to work more effectively and avoid spending excessive time on non-essential tasks. This approach is not just about setting deadlines, is about fostering a disciplined work ethic that prioritized critical aspects of a task while minimizing distractions. By imposing a strict deadline, timeboxing encourages team members to concentrate on the most vital elements of a task, thereby enhancing productivity and ensuring that progress is made within the allotted time.
Timeboxing is characterized by several key features. One of the most important is the establishment of a fixed time frame. This predetermined period, which can range from few minutes to several days depending on the complexity of the task, is crucial for keeping the work focused and on track. However, is essential that the time frame remains realistic to ensure that the task is manageable within the giving period.
Another essential aspect of timeboxing is the focus on completion. The goal is to accomplish as much of the task as possible within the set time, even if it means that some aspects are not perfect. This focus on getting things done rather than getting them perfect can be particularly beneficial in creative environments.
Flexibility after the timebox is another important element. If the task is not fully completed within the designated time, it's necessary to assess whether more time should be allocated, whether the task should be paused to move on to the next priority, or whether the outcomes should be revisited and refined later.
Finally, frequent review is essential in the timeboxing process. Regularly scheduled reviews allow the team to assess the work completed during each timebox, evaluate progress, and determine the next steps. These reviews are crucial for ensuring that the timebox approach remains effective and that the project continues to move forward efficiently. By regularly reflecting on what has been achieved and what still needs to be done, the team can continuously refine its approach and improve its productivity over time.

5.3

SUCCESS CRITERIA OF INTER-DISCIPLINARY COLLABORATION

Researchesintointerdisciplinaryenvironments, particularly within engineering education, tried to define the criteria for successful collaboration across different fields.

Borrego et al. (2008) and Mansilla et al. (2007) have contributed to understanding what makes interdisciplinary work effective. Borrego has focused on collaboration between engineering and education faulty, noting that successful interdisciplinary efforts are characterized by integrative approaches involving mutual learning and active engagement.

She identified several outcomes indicative of effective interdisciplinary collaboration, including the ability to define and utilize key terms for different disciplines, develop a common vocabulary with collaborators, and describe strategies for learning new content in unfamiliar areas. Additionally, Borrego emphasizes the importance of comparing and contrasting research approaches and values from different disciplines, selecting appropriate methods for organizing interdisciplinary projects, and summarizing current debates on the value and evaluation of such work.

Similarly, Mansilla has highlighted the concept of “interdisciplinary understanding”, which refers to the ability to integrate knowledge and modes of thinking from different disciplines to achieve cognitive advancements that are unlikely through single-disciplinary means. Mansilla proposed that assessing interdisciplinary understanding involves evaluating interdisciplinary grounding, understanding and mastering of content, methods, and inquiry purposes, the advancement of knowledge through integrating different disciplinary perspectives, and critical awareness. This critical awareness includes meta-disciplinary reflection on the integration process itself. Both Borrego and Mansilla emphasize that the goal of interdisciplinary collaboration is to enhance knowledge integration, which is essential for achieving productive and meaningful outcomes in complex, multi-faced problems.

5.4

SUMMARY OF FINDINGS

Chapter 5 identifies key factors for successful interdisciplinary collaboration between designers and engineers, drawing on Hackman's criteria for teamwork (1987): completing tasks, developing social relations, and benefiting individual team members.
Psychological safety is emphasized as crucial for open communication, trust, and continuous learning, which drive team cohesion and creativity.
Team alignment and execution are highlighted as essential elements for ensuring that individual efforts are coordinated and effective. Critical aspects include building common ground, setting clear goals, and employing time management strategies like timeboxing. Successful teams also integrate knowledge across disciplines, creating a shared vocabulary to address complex problems.
The focus of this thesis will be on developing a tailored alignment strategy, specifically designed for design projects where designers and engineers collaborate. This will involve enhancing team alignment and execution while also fostering the integration of knowledge from both disciplines. By optimizing these elements, the goal is to ensure cohesive teamwork and the successful achievement of project outcomes.

Figure 10
Successful team reaching goals

SUPPORTING AUTONOMOUS ALIGNMENT IN NON-HIERARCHICAL TEAMS OF DESIGNERS AND ENGINEERS

6

6.1

TARGET AUDIENCE: WHO BENEFITS FROM THIS ALIGNMENT ACTIVITY?

The primary target for this alignment activity is team members of non-hierarchical groups of product designers and industrial engineers who share equal responsibility for project outcomes. This activity serves as a tool that supports self-alignment, effectively taking on some of the roles traditionally held by a facilitator or project manager. By enabling teams to self-organize and coordinate their efforts, it fosters autonomy and shared ownership within the group.

Another significant target audience is educators who can introduce this tool to students. In academic settings, this activity can help students integrate their individual knowledge with that of their peers, enhancing collaboration and ensuring that group projects benefit from a collective understanding and effort.

6.2

HOW TO CONDUCT THE ALIGNMENT ACTIVITY?

The alignment activity is designed to be conducted in person, bringing all team members together around a table.
Face-to-face collaboration fosters direct and immediate communication, creating an environment where participants can freely express their ideas, clarify uncertainties, and reach consensus more efficiently. It is crucial that each team members actively participates in filling out the alignment activity, contributing their opinions and raising any concerns about the project's direction.

When the team cannot meet in person or prefers to use a digital tool, this activity can be adapted into a template available through Miroverse. I chose Miroverse because it offers a wide range of pre-built templates designed for real-time collaboration, allowing team members to work seamlessly, regardless of location.

Figure 11
Team engaging in discussion

6.3

INTRODUCTION TO TWO INSPIRATION MODELS: THE PROJECT TIMELINE (PT) AND THE TASK PLANNER (TP)

The next sections will explore two inspiration models designed to facilitate effective alignment and coordination within interdisciplinary teams: the Project Timeline and the Tasks Planner.
These models were chosen as a way to represent the findings of this thesis in a designerly manner, they are not final tools but serve as conceptual structures that can inspire the development of future design objects or tools.

The Project Timeline is introduced first as a foundational model. It serves as a strategic framework that guides teams through the different phases of a project, from initiation to completion. This model provides a visual roadmap outlining key milestones, objectives, and deadlines, ensuring that the team remains organized and aligned throughout the project life. The Project Timeline helps teams monitor progress, clarify objectives, and adjust strategies as needed by defining each process stage and scheduling alignment sessions at critical transition points.
According to the Project Timeline, the “Tasks Planner” is employed to provide a detailed approach to task management. This tool is designed to structure the allocation of tasks, roles, methods, and timeboxes within the

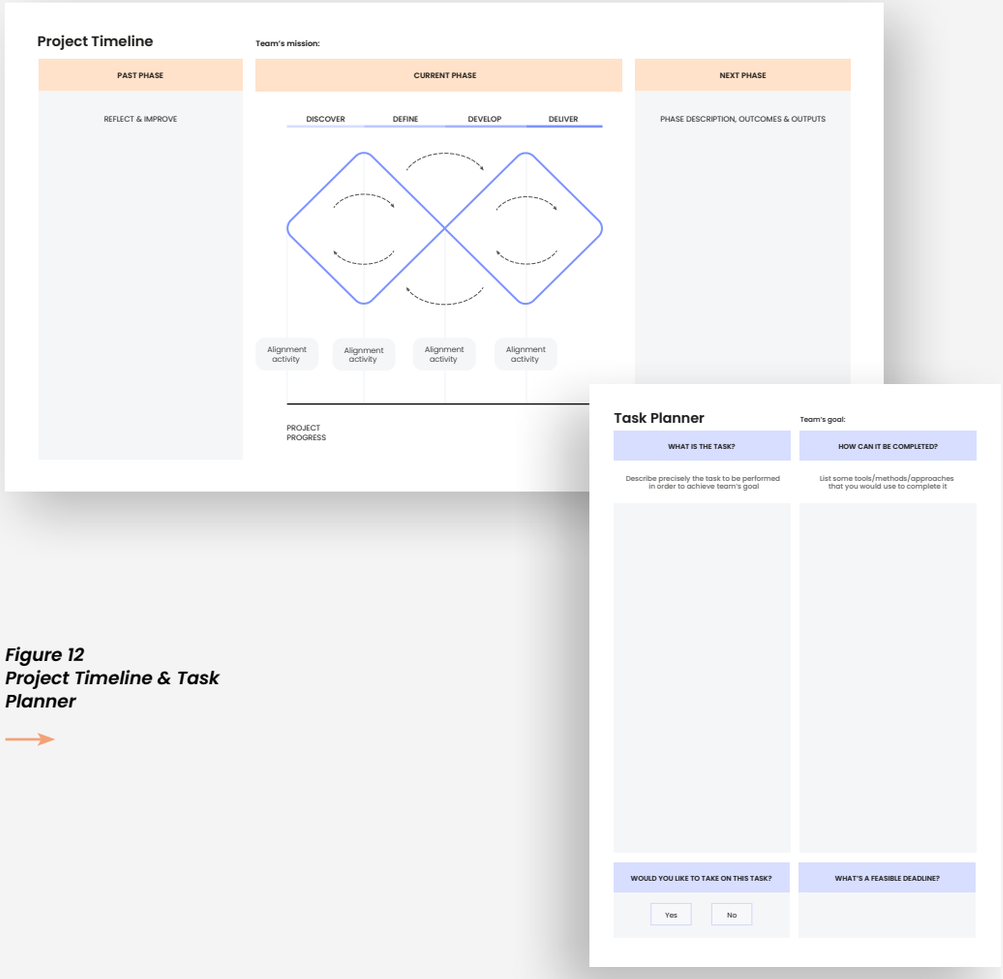


Figure 12
Project Timeline & Task Planner

project. It ensures that each team member clearly understands their responsibilities, the tools and methods required, and the deadlines for task completion. The Tasks Planner also integrates individual and collaborative contributions, fostering accountability and promoting an effective interdisciplinary workflow.

THE PROJECT TIMELINE (PT)

7

7.1

THE MODEL'S STRUCTURE

The structure of the Project Timeline is composed of three main sections, representing the past, present, and future stages of the project.

This layout allows the team to align on the current phase of the project while maintaining a clear understanding of what has been accomplished in previous phases and what remains to be done in the upcoming ones.

By providing a comprehensive view of the entire project, this structure supports continuous synchronization and reflection, ensuring that past lessons are carried forward, the present tasks are well-coordinated, and future milestones are effectively planned.

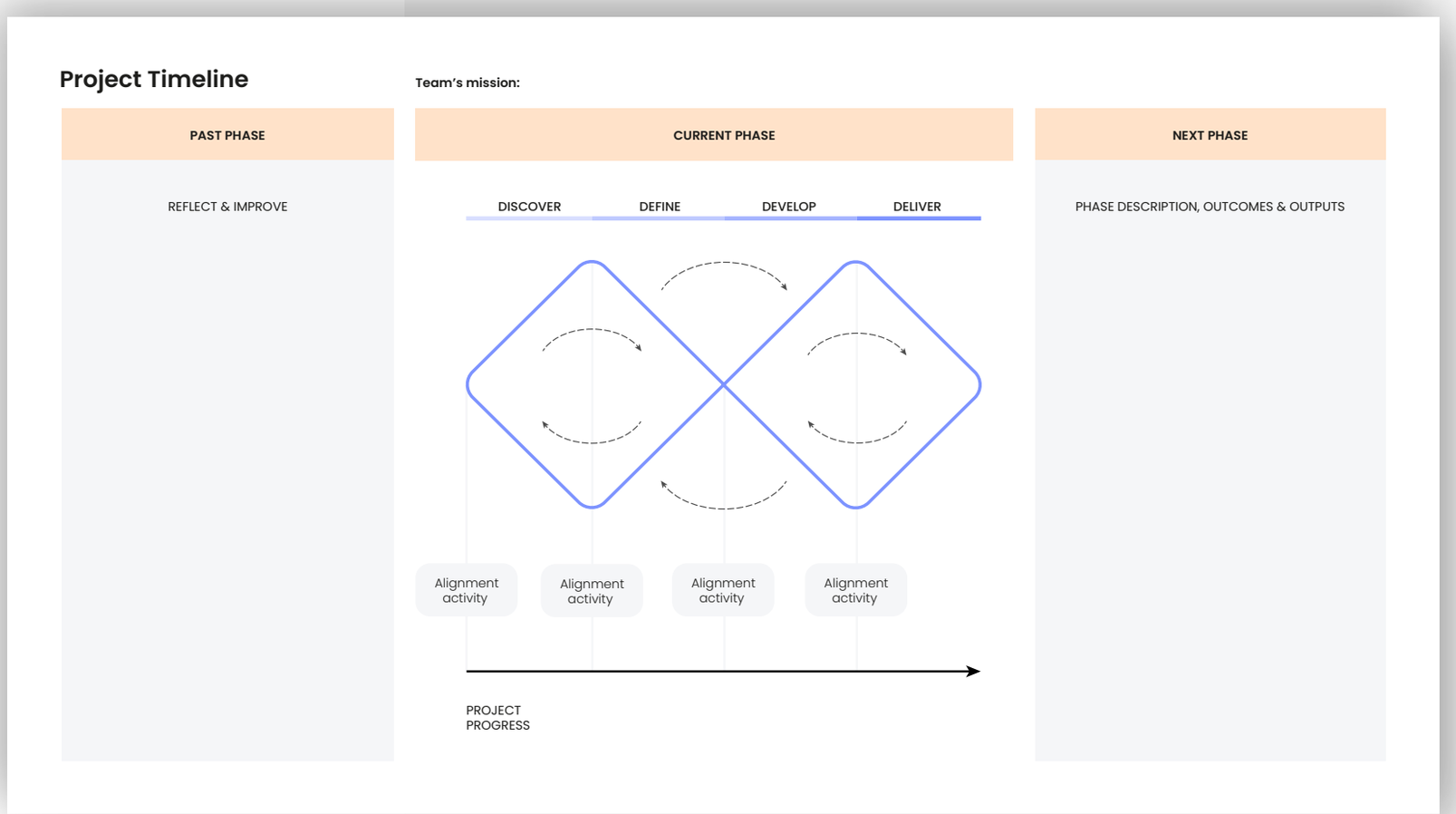


Figure 13
Project Timeline's structure

7.1.1

PAST PHASE: REFLECT AND IMPROVE

The first section of the Project Timeline, “Reflect & Improve,” is designed to be completed after each phase of the project and before moving on to the next one. This step is crucial for maintaining alignment within the team, ensuring that, after each major transition, the team takes time to pause and reflect on the progress made, identify challenges faced, and highlight areas for improvement.

Both individual and group reflections are encouraged. Each team member can jot down their thoughts, which are then discussed collectively to reach a consensus on key insights.

Including this reflective practice in the Project Timeline is essential for several reasons. It promotes continuous improvement, ensuring that processes are refined incrementally. It also fosters open communication, enhancing collaboration and building a safe environment where every member’s contributions are acknowledged. Moreover, this process generates a valuable knowledge base for future projects and documents the rationale behind any adjustments, serving as a reference for informed decision-making in the next stages.

KEY QUESTIONS:

What went well during past phase?
What challenges did we face?
What can we improve in the next phase?
Were the team’s goals and phase outcomes satisfactorily met?

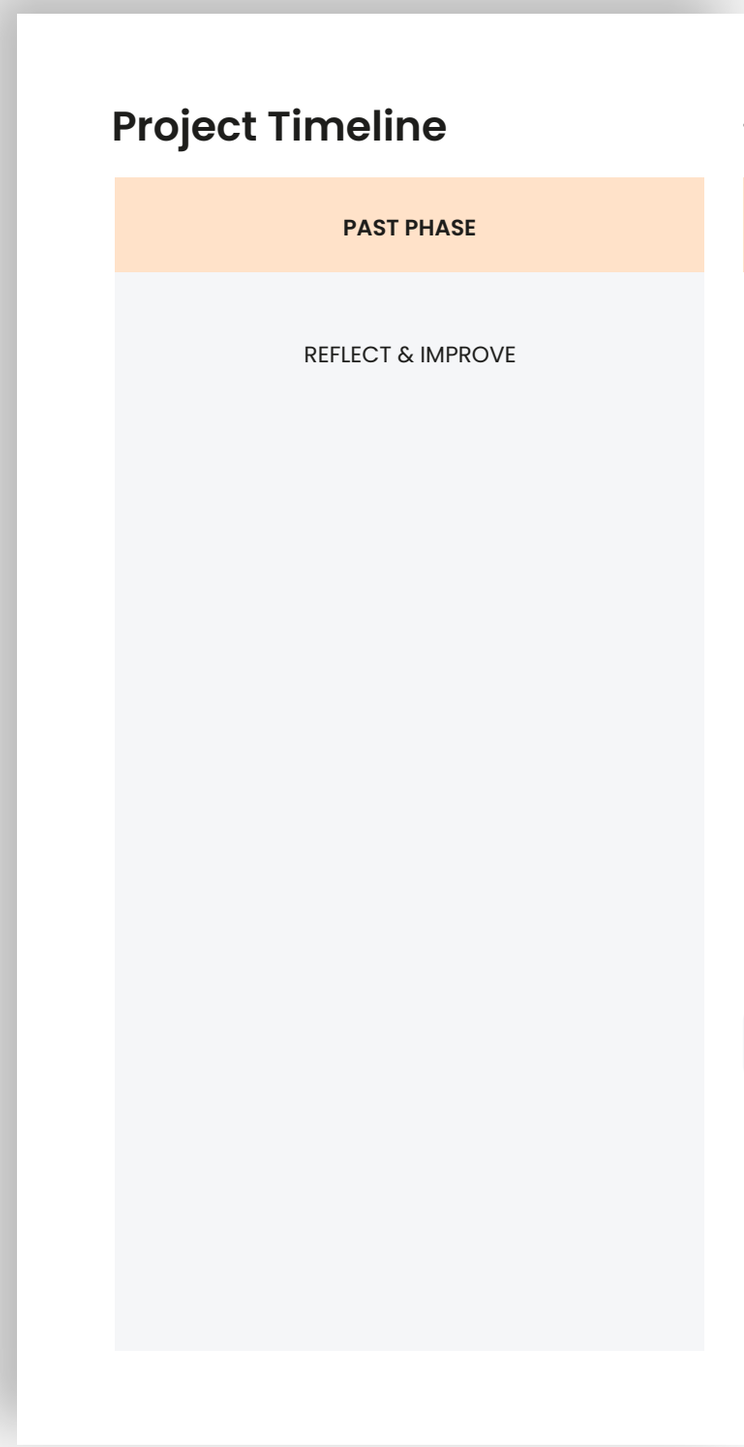


Figure 14
First section of Project Timeline

7.1.2

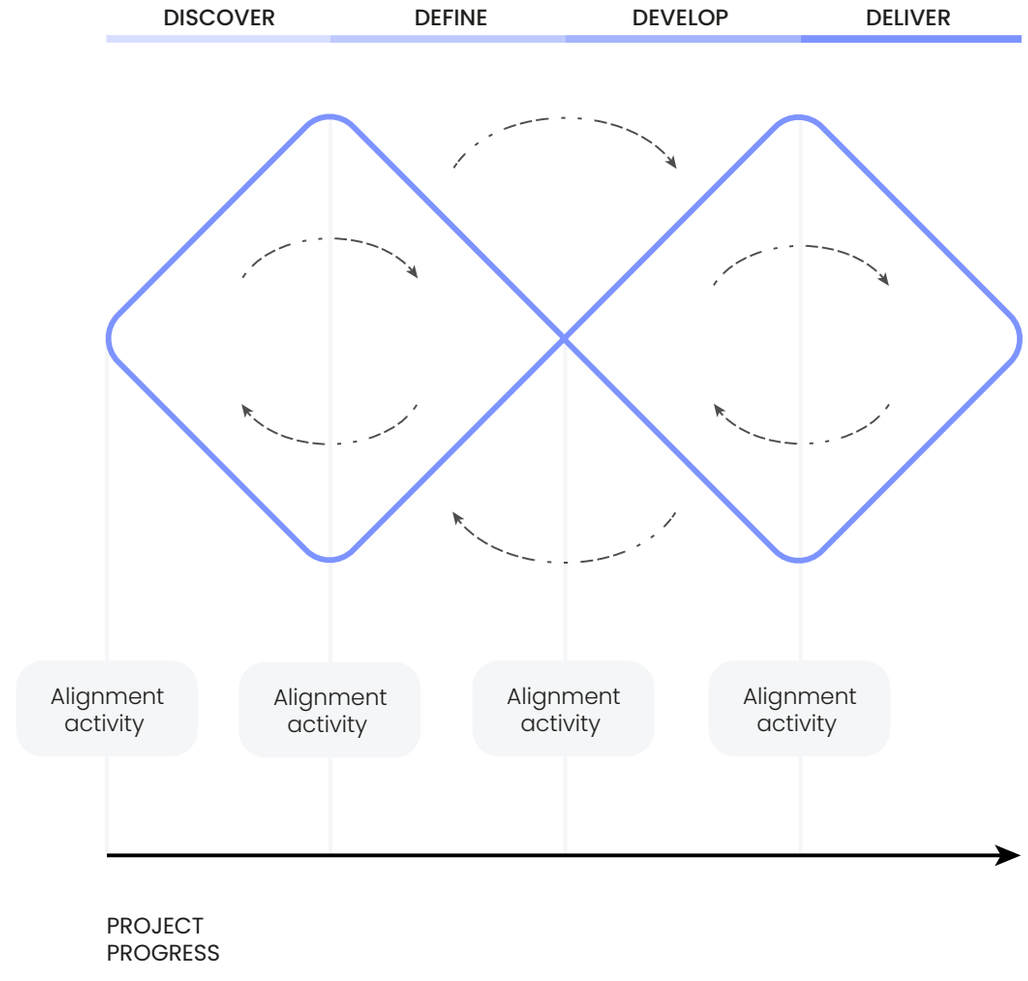
CURRENT PHASE: PROJECT TIMELINE

The central section of the project timeline represents the current phase of the project. This visual representation acts as a key reference point for the team, offering a clear overview of their current position in the project and the stages that lie ahead. To depict the progression of the project over time, I chose to use the double diamond process (Design Council, n.d.), though other methodologies could also be applied.

Within this section, the team defines precisely where they are in the project timeline, allowing for a collective assessment of their current status and preparing them for upcoming tasks and alignment activities. This step ensures that the team shares a unified understanding of their progress thus far and the path forward, creating a foundation for more detailed planning in the upcoming stages.

The aim of using the Double Diamond as a timeline for the project is to identify the key moments in the design process to implement the alignment activity. The model's structured approach, with its phases of divergent and convergent thinking, provides a clear pathway for understanding when and where this activity best contributes to team members' synchronization. This ensures that the

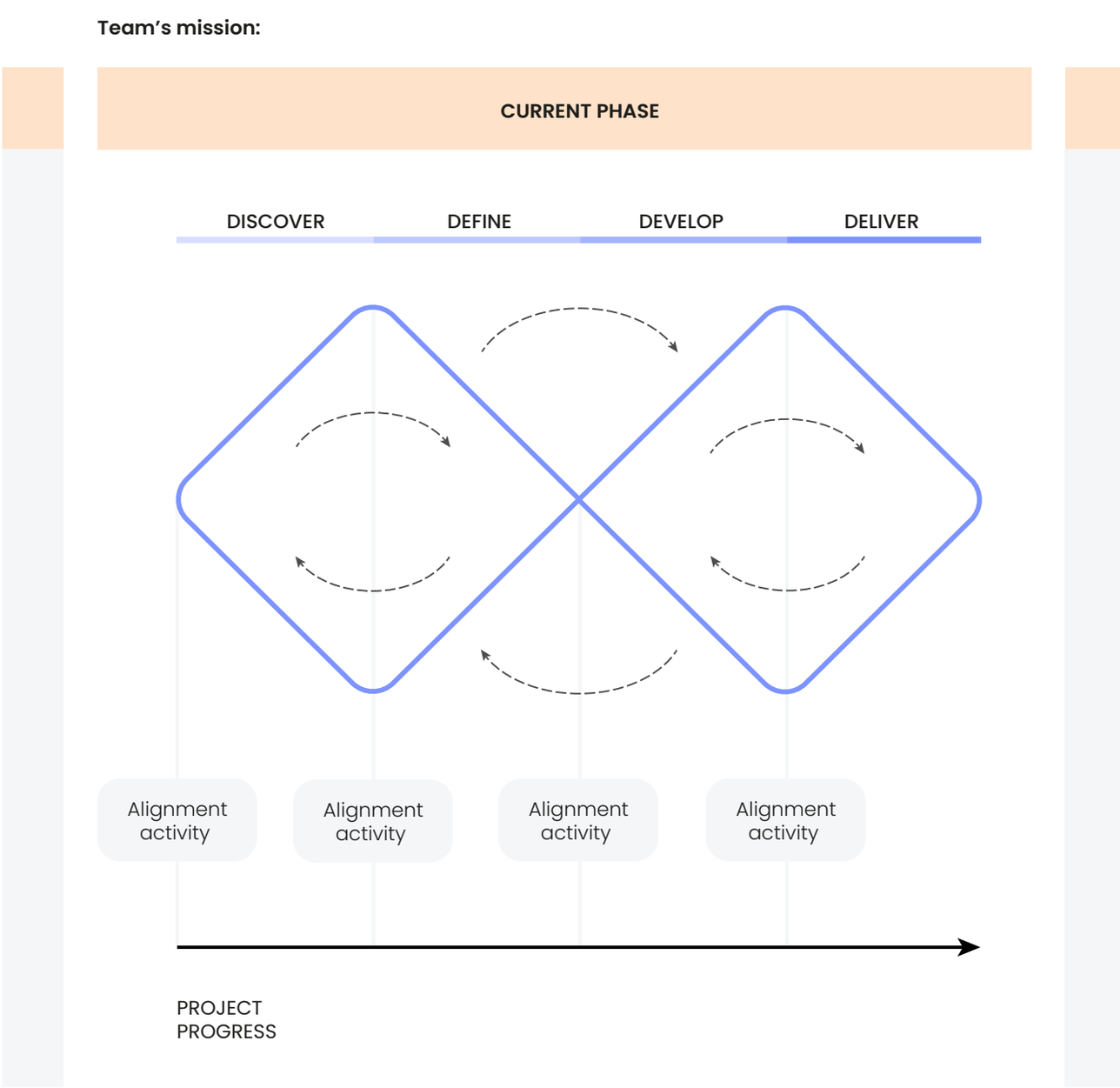
Figure 15
Double Diamond Framework
Adapted from Design Council



integration of knowledge from both design and engineering disciplines occurs at critical points throughout the project's development, thereby enhancing overall collaboration and project outcomes.

Even though the Double Diamond model provides a valuable timeline for the project, the design process is not always linear. The iterative nature of design often necessitates frequent revisits to earlier stages, with adjustments and refinements based on new insights and feedback. The proposed alignment activity is designed to be a flexible tool that can adapt to these changes and the evolving dynamics of the ongoing process. By accommodating the non-linear aspects of the design process, the alignment activity aims to support continuous synchronization and integration of team efforts throughout the project's development.

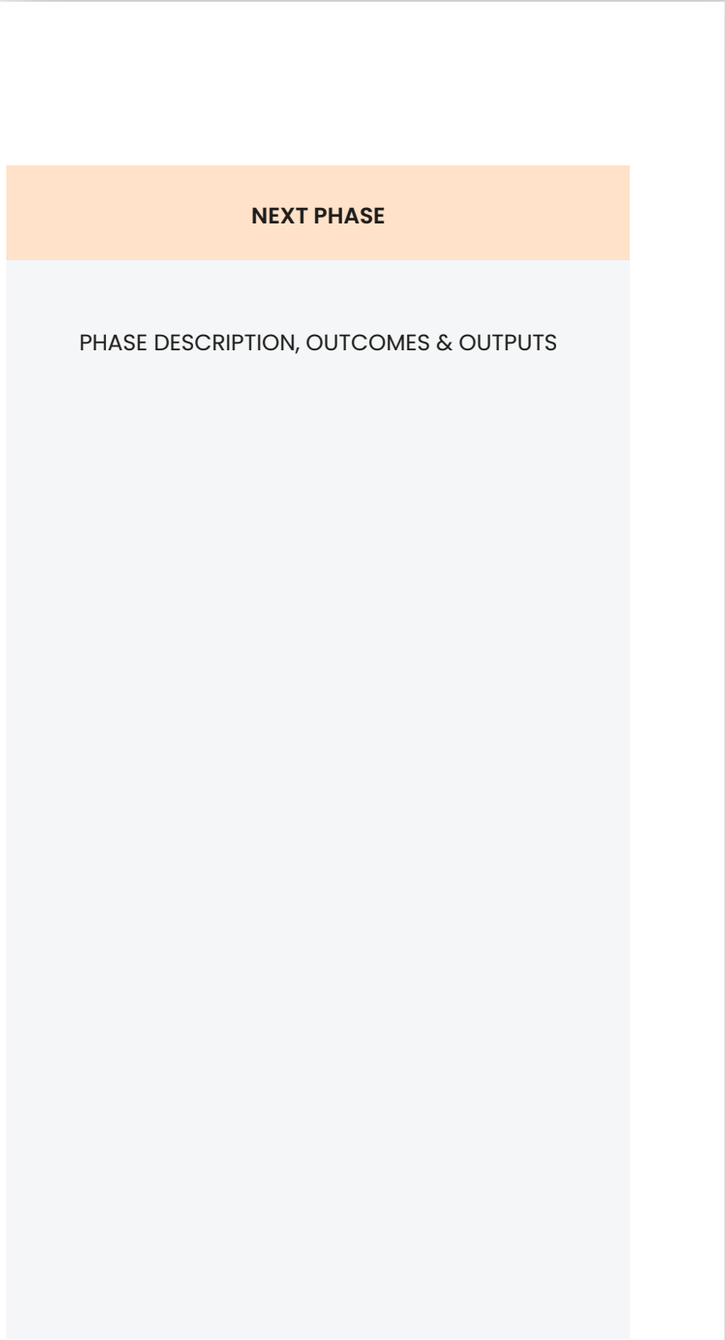
Figure 16
Second section of Project Timeline



7.1.3

NEXT PHASE: PLANNING OUTCOMES AND OUTPUTS

This final section is crucial for creating a shared understanding among team members about the next phase of the project. By using key reflection questions, the team can collaboratively prepare for what lies ahead.
These questions prompt a thorough evaluation of the next steps, helping the team identify what has been achieved and what still needs attention. This is especially valuable in interdisciplinary teams, where members may have varying familiarity with frameworks like the Double Diamond.
By reflecting on these points together, the team ensures alignment and a common understanding. In this section, it's important to provide a comprehensive overview of how the phase is expected to unfold. This serves as the foundation for defining specific, measurable tasks, ensuring that each aligns with the phase's objectives and that progress can be monitored effectively. The team also uses this section to outline the intended outcomes for the phase, keeping everyone focused on achieving these goals. By collaboratively determining these expected results, the team creates a unified effort toward shared objectives, while also clarifying the actual outcomes that will result from meeting those goals. This ensures that everyone is aligned in their expectations and that the team remains on track.



KEY QUESTIONS:

What needs to be accomplished in this next phase?
What are our goals, and what outputs should we deliver by the end of this phase?

Figure 17
Last section of Project Timeline

THE TASK PLANNER (TP)

8.1 The model's structure

8.2 Group discussion

8

THE TASK PLANNER (TP)

The Tasks Planner is designed as a comprehensive tool for interdisciplinary teams, facilitating the structured allocation of tasks, responsibilities, methods, and the estimated time required for task completion within a project.
Each team member is required to maintain their own planner, completing it independently before engaging in group discussions.
This approach encourages individual reflection and understanding of the task before collaborating with the rest of the team.

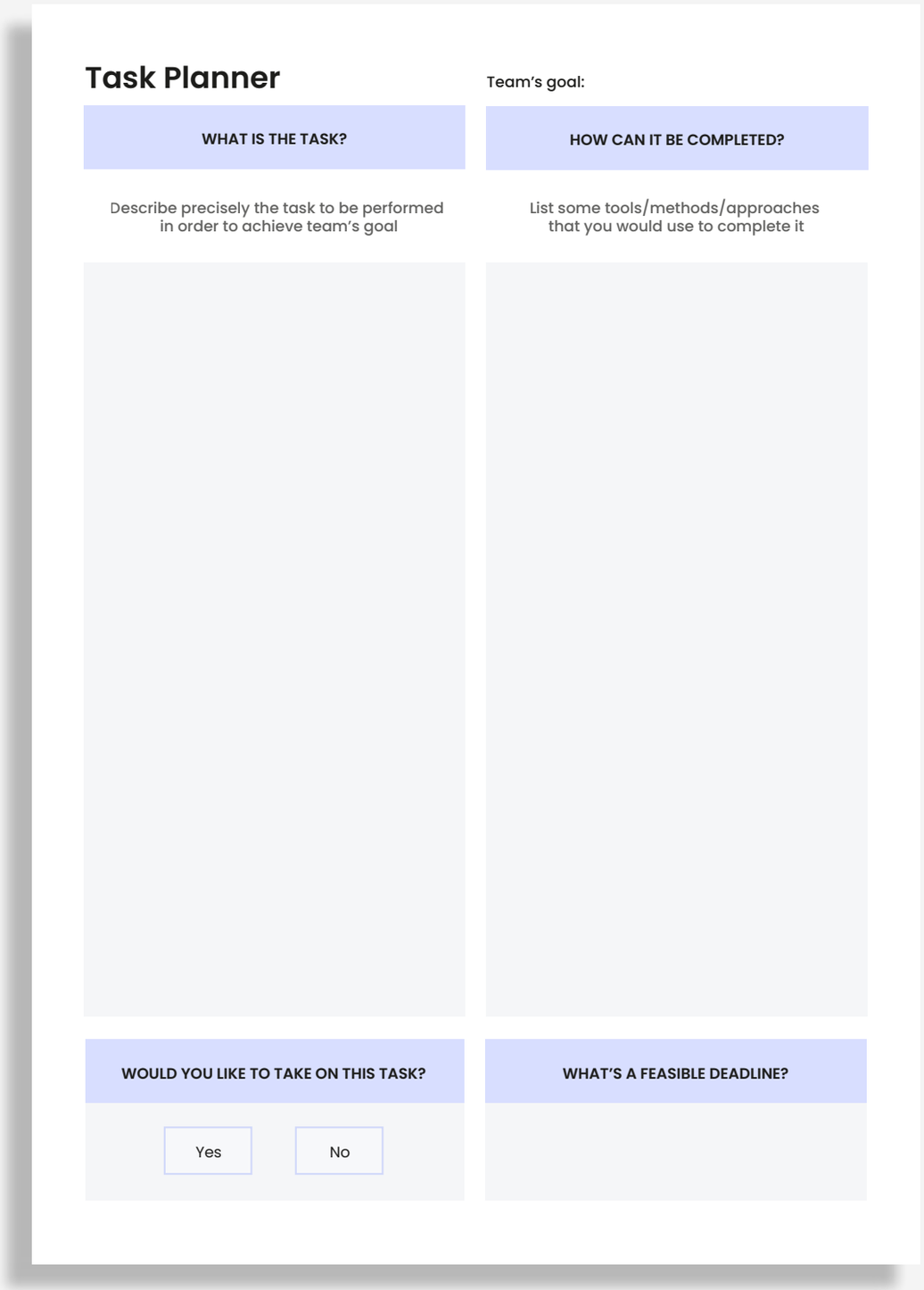


Figure 18
Task Planner

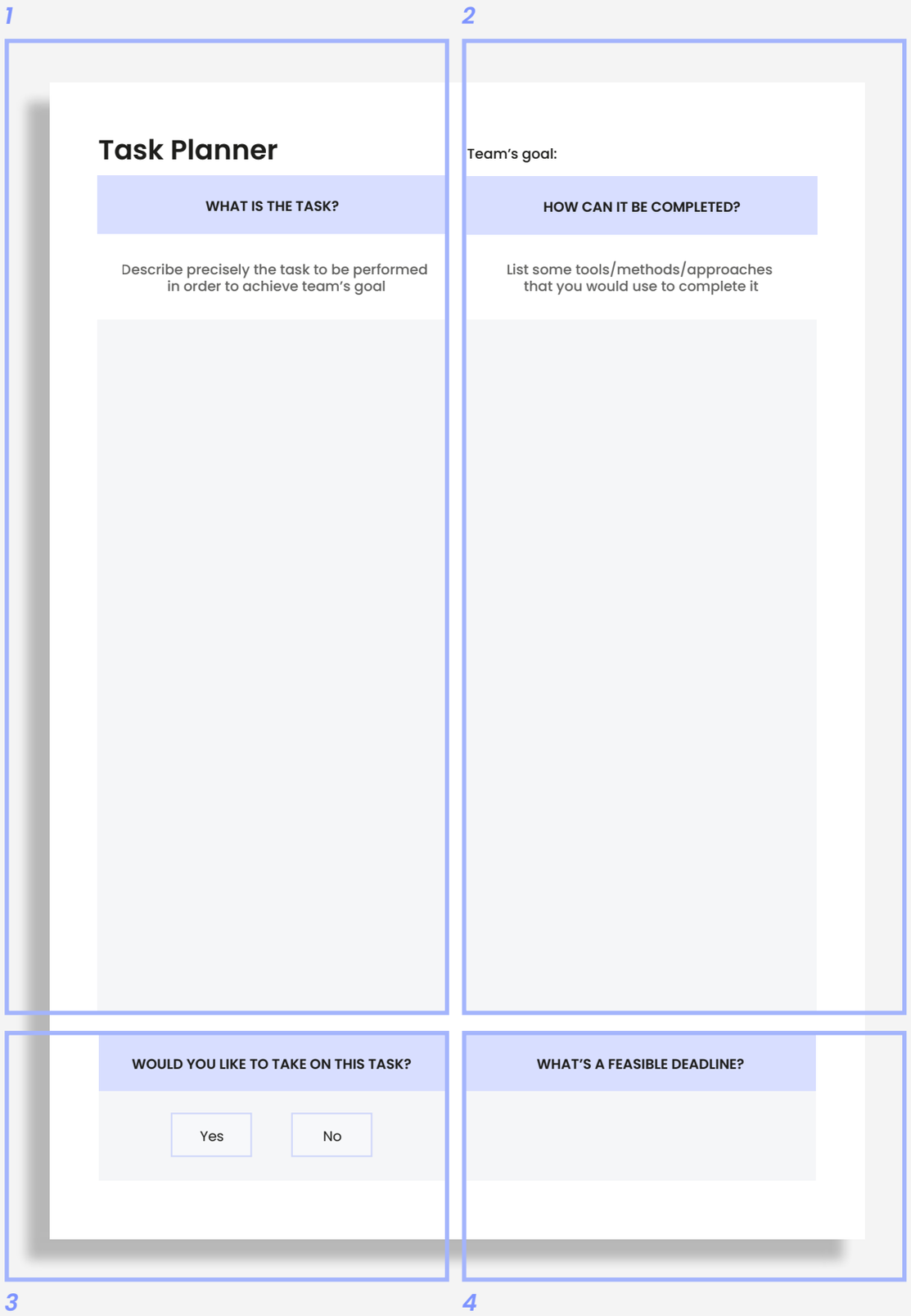
8.1

THE MODEL'S STRUCTURE

The planner is divided into four main sections, each representing a key aspect of task management.
It is intended to be used after the Project Timeline has been established, ensuring that all team members are aligned on the specific tasks to be completed. This tool ensures that every team member fully understands their role, the tools and methods required to complete the task, and the time allocated to it.

In interdisciplinary teams, where diverse expertise and perspectives need to be harmonized, such alignment is crucial. The Tasks Planner helps to prevent miscommunication, foster accountability, and ensure the project progresses efficiently according to the established timeline.

Figure 19
Task Planner's structure



8.1.1

WHAT TASK?

The first section of the Task Planner forms the foundation of the task management process. It breaks down complex project goals, outlined in the Project Timeline, into smaller, actionable tasks. Each task is designed to contribute directly to the overarching project goal, ensuring a clear connection between the broader goals and specific actions required to achieve them.

The process begins with individual reflection, where each team member independently identifies and defines key tasks. This step allows each person to process and interpret the task without external influence, encouraging deeper individual understanding and preventing premature consensus. By giving space for personal reflection, this approach ensures that each team member brings their unique perspective to the table, which is particularly valuable in interdisciplinary teams.

KEY QUESTIONS:

What specific actions are required to achieve the overall project goal?
How can the larger goal be broken down into smaller, manageable tasks?

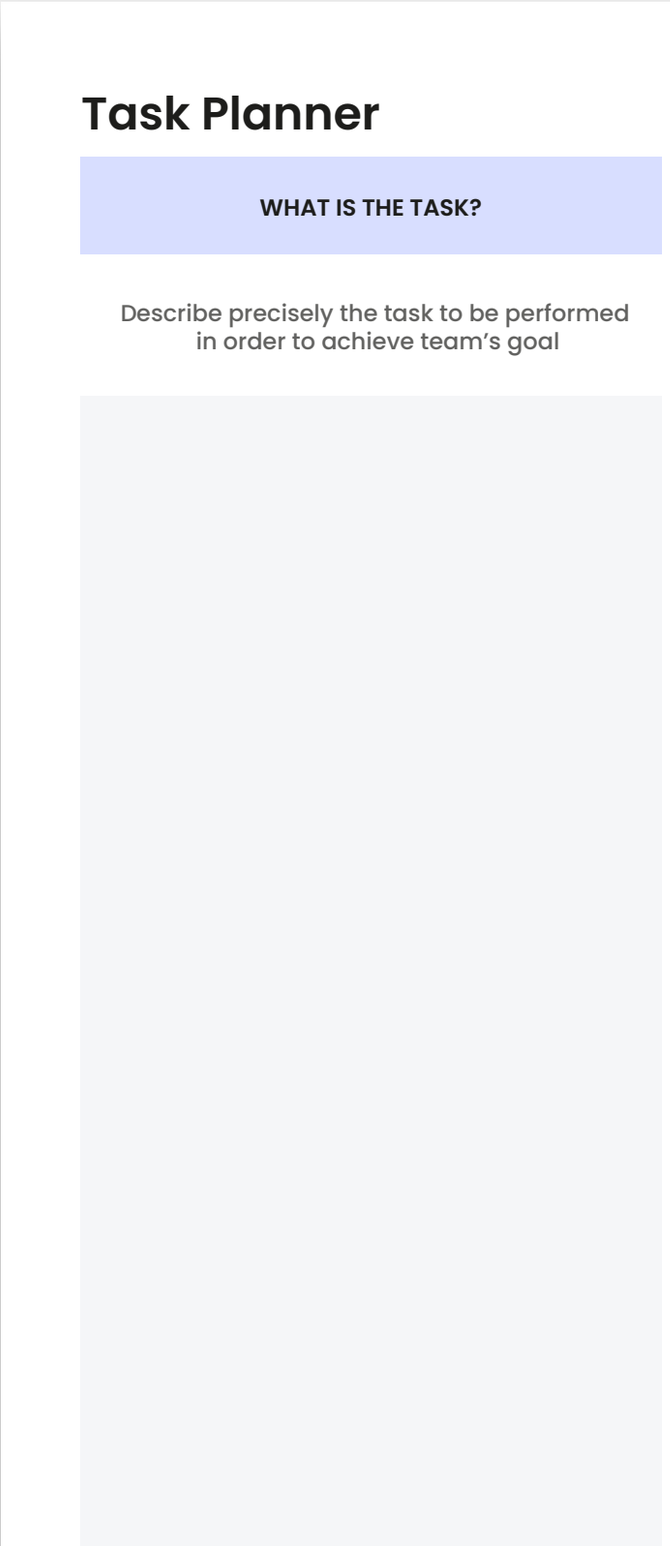


Figure 20
Task Planner's first section

After the individual reflection, the team engages in a group discussion to consolidate their insights.
This discussion is essential for aligning the team's understanding of the tasks, as it provides an opportunity to address any discrepancies and refine the definitions collectively. This collaborative refinement creates a feedback loop, where individual contributions are reviewed and adjusted as a group, helping to ensure clarity and alignment. This approach promotes a well-defined task structure while fostering a shared understanding among team members, which is crucial for the successful execution of the project. By allowing for individual reflection followed by group alignment, the team minimizes misunderstandings and ensures more cohesive task management throughout the project.

8.1.2

HOW CAN THE TASK BE COMPLETED?

The second section, is designed to gather information on the tools, methods, and approaches that each team member would utilize to tackle the task.
At an individual level, this section helps each member reflect on their specific skills and expertise, allowing them to identify the methods they would personally use to complete the task. This step enhances self-awareness by encouraging team members to think critically about their strengths and how they can apply them.
At group level, this section serves as a foundation for collaborative discussions, where team members compare their different approaches. By sharing and contrasting their individual methods, the team can explore diverse perspectives and ultimately determine the most effective way to execute the task together.

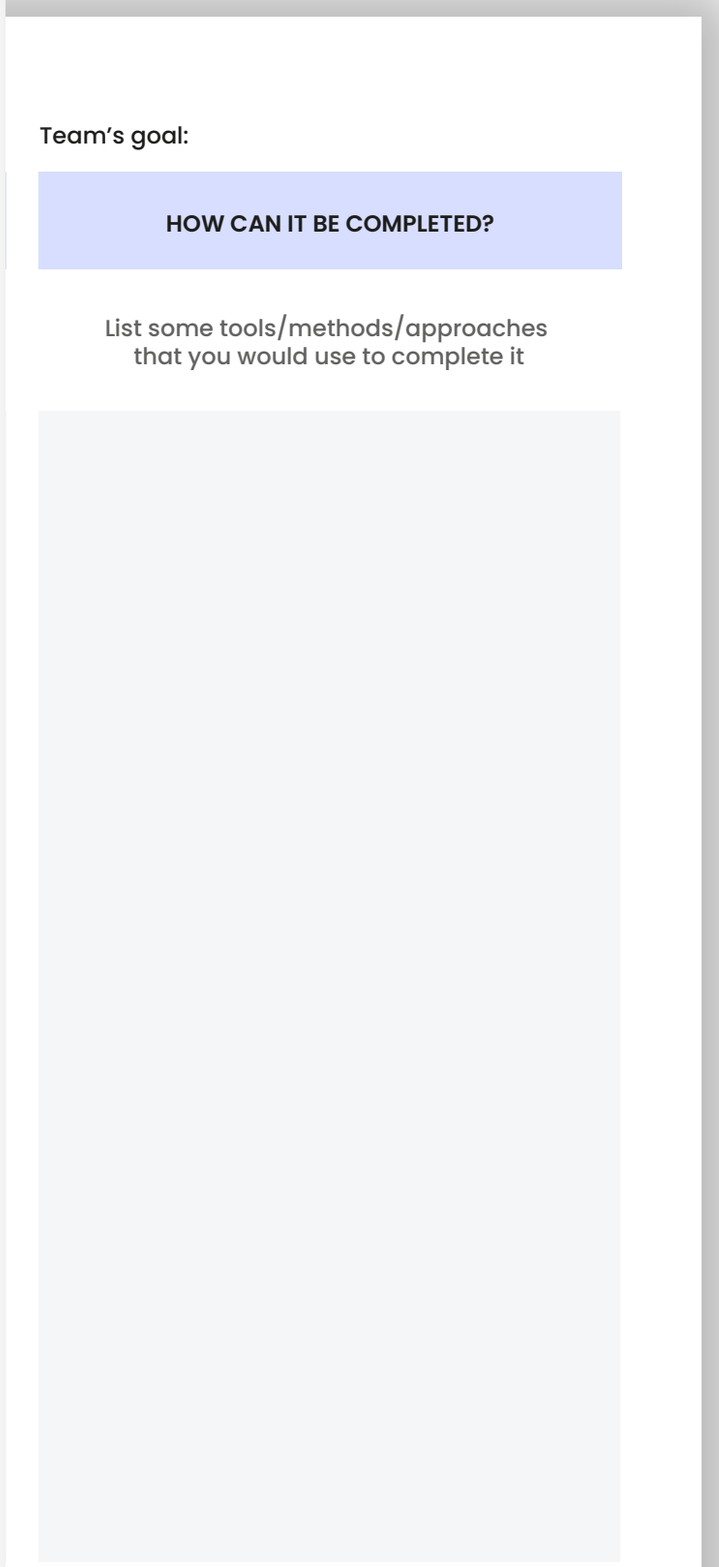


Figure 21
Task Planner's second section

8.1.3

WOULD YOU LIKE TO TAKE ON THIS TASK?

The “Would you like to take on this task?” section in the Task Planner provides an opportunity for team members to actively reflect on whether they are willing and able to take responsibility for a particular task. This section includes a simple Yes/No option, which prompts individuals to consider their capacity, interest, or expertise in handling the task at hand.

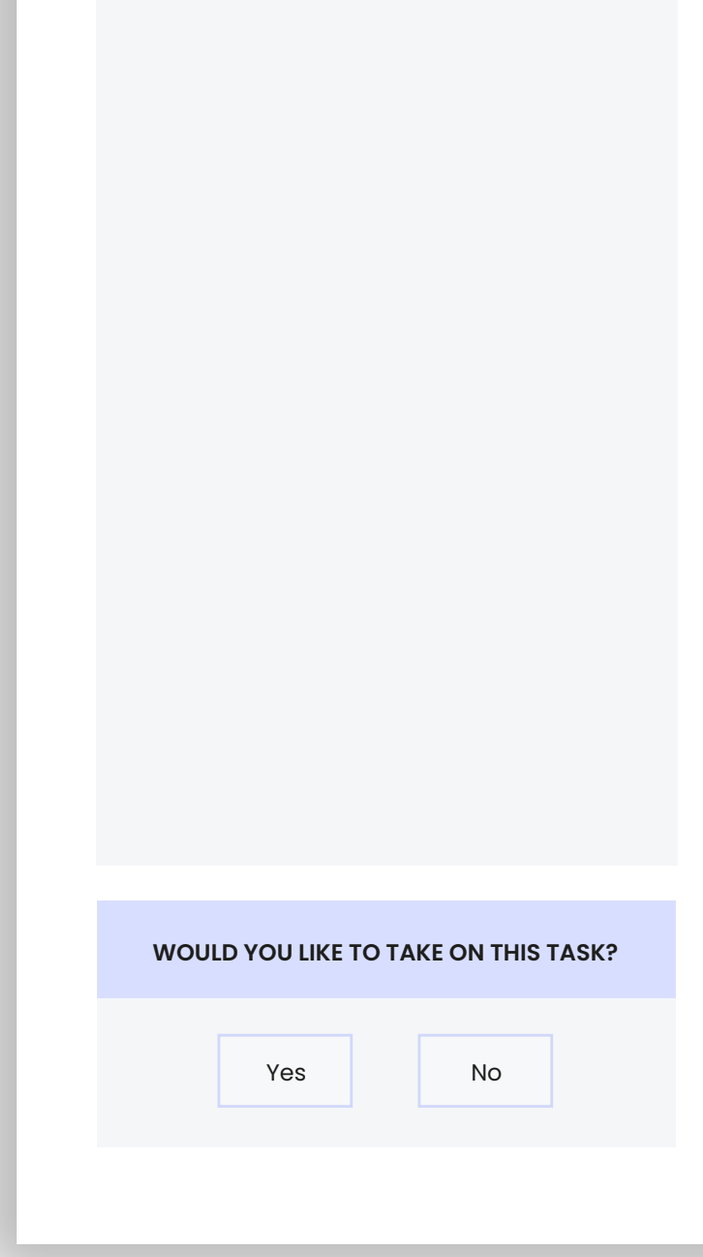


Figure 22
Task Planner’s third section

8.1.4

WOULD YOU LIKE TO TAKE ON THIS TASK?

In the lower-right section of Task Planner, the focus is on estimating the time allocation for the task. This section allows team members to estimate how long they believe the task will take and set specific deadlines. By providing both an estimation of the required time and a clear deadline, this area ensures that each task is not only well-defined but also time-bound, helping the team manage their workload effectively.
At an individual level, it encourages members to reflect on the time they need to complete the task based on their own pace and expertise. At the group level, it facilitates a conversation about aligning these estimations with the overall project timeline, ensuring that the team remains on track and any discrepancies in time allocation are addressed collaboratively.

Figure 23
Task Planner's last section

8.2

GROUP DISCUSSION

In the group discussion phase, each team member presents their completed Task Planner, which is a key moment for integrating diverse perspectives within interdisciplinary teams. The discussion is not just about reaching consensus; it's about leveraging the varied expertise of the group to enhance problem-solving strategies. Given the differences in fields of expertise, members often interpret tasks differently. This is particularly valuable in interdisciplinary teams, where different backgrounds can lead to unique insights and alternative methods for tackling the same task. By openly sharing how each member has approached their task, the team gains a broader view of potential solutions, fostering creativity and innovation.

When the team decides who will take responsibility for a task, individual opinions are carefully considered to make a collective choice. Each member's expertise, preferences, and strengths need to be evaluated to ensure the task is assigned strategically. This process is not merely about distributing duties but is also designed to foster a sense of ownership and commitment within the team. By aligning tasks with members' abilities, the team ensures active engagement from everyone, whether through direct execution or by contributing to the review process.

It can be beneficial to periodically rotate responsibilities, allowing members to broaden their skills and experience different aspects of the project. Additionally, clearly documenting who is responsible for each task can help prevent misunderstandings and ensure that all tasks are going to be completed by someone.

Finally, when discussing how to complete the tasks, the aim is to explore innovative approaches that go beyond each individual's area of expertise, encouraging team members to consider the priorities and methodologies of their peers. This open exchange of ideas not only improves problem-solving but also increases awareness of different perspectives within the group. By doing so, the team promotes a collaborative, interdisciplinary approach to solving complex challenges, leveraging collective knowledge to generate more effective solutions.

This group discussion phase is crucial for aligning the team's efforts, distributing tasks strategically, and ensuring that all perspectives are considered to optimize project outcomes.

CONCLUSION, LIMITATION & FUTURE WORK

In developing the Project Timeline and the Task Planner as inspirational models, I aimed to contribute to the discourse on how designers and engineers can better collaborate in non-hierarchical, autonomous teams. These tools are rooted in the challenges I observed throughout my research, offering potential strategies for overcoming barriers related to communication, task alignment, and knowledge integration.

The development of this thesis has been deeply shaped by my academic experiences in the Design & Engineering course, as well as the valuable perspectives gained during my Erasmus experience at the Polytechnic University of Madrid. Immersing myself in a hybrid environment over the past years allowed me to deepen my understanding of the methods and thought processes prevalent in both technical and creative disciplines, inspiring me to seek ways to bridge the gap between the analytical and the creative.

The limitation of this research lies in the fact that the proposed inspiration models have not been tested in real-world interdisciplinary settings. While the models presented offer a conceptual framework for improving team alignment and collaboration, their effectiveness remains hypothetical until they are applied and evaluated in practical scenarios. Future research should focus on testing these models within actual interdisciplinary teams to assess their impact on collaboration, task coordination, and knowledge integration.

Following these tests, the models can be refined and developed into more sophisticated design objects or tools, specifically tailored to support the unique challenges faced by such teams. By iterating on these models through real-world application, a more polished and practical tool could emerge, offering enhanced functionality for interdisciplinary collaboration.

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LIST OF FIGURES