Adopting Design Science Research to Develop a Framework for Systematic Technology Application Selection

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Abstract

Research institutes and universities play a crucial role in developing and commercializing new technologies, providing researchers with opportunities to leverage their scientific developments for innovation. However, several obstacles, such as technological uncertainty, market dynamics, and researchers' lack of entrepreneurial awareness, impede commercialization. In the early stage, specifically the Technology Application Selection (TAS) phase, where the decisions made significantly influence later success or failure, multiple challenges prevail. Thus, it is essential to navigate through this phase systematically.

This research project aims to address critical gaps in selecting technology applications. The TAS Framework developed in this dissertation consists of five canvases, each designed to support specific objectives to reach the overall goal. It provides researchers and innovators with a systematic approach to identify and select promising technology applications. The framework facilitates informed decision-making during the fuzzy front-end phase by promoting a comprehensive understanding, the systematic exploration of alternative ideas, evaluation, alignment of the idea with the problem and customer, and a systematic examination of the market potential. The dissertation contributes to theory by resolving methodological challenges in TAS processes, improving the understanding of TAS, and laying the foundation for a rigor conceptual model.

Further, it demonstrates the successful application of the Design Science Research (DSR) methodology in entrepreneurship, serving as a benchmark, which adds a crucial pillar to entrepreneurship education, while providing design knowledge for the intersection of technology innovation and entrepreneurship. The artifact aligns with contemporary entrepreneurial tools and can positively impact society by fostering technological innovations that improve feasibility, efficiency, and affordability of products and services. The dissertation holds significance at a scientific, macroeconomic, and microeconomic level. It has also received interest and positive feedback from innovation scholars and technology transfer representatives.

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List of Abbreviations

B2B	Business to Business
B2C	Business to Consumer
DSR	Design Science Research
e.g.	exempli gratia/ for example
i.e.	id est/ that is to say
HCD	Human-Centered Design
ISIC	International Standard Industrial Classification of All Economic Activities
ISO	International Organization for Standardization
KIT	Karlsruhe Institute of Technology
PESTLE	Political, Economic, Social, Technological, Legal, Environmental
px	Pixel
RQ	Research question
SDGs	Sustainable Development Goals
SQ	Sub-question
SWOT	Strengths, Weaknesses, Opportunities, Threats
TAS	Technology Application Selection
TP	Technology Push
UX	User experience
VRIO	Valuable, Rare, Inimitable, Organized

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1 Introduction

Research institutes and universities play a crucial role in developing and commercializing new technologies, providing researchers with opportunities to leverage their scientific developments for innovation. However, several obstacles, such as technological uncertainty, market dynamics, and researchers' lack of entrepreneurial awareness, impede commercialization (Kock, Gemünden, Salomo, & Schultz, 2011; Kock, Heising, & Gemünden, 2015; Maier, Hofmann, & Brem, 2016). In particular, the early stage of this process, namely the Technology Application Selection (TAS) phase, in which a potentially promising application for the technology has to be identified and selected, represents a critical hurdle. The "right" decision at this stage significantly impacts later success or failure (Markham, 2013). Due to the challenges above of navigating through this phase systematically, structured guidance tailored to individuals without a business background is needed to adequately support researchers in identifying and selecting promising applications for their technologies. This, in turn, can increase commercialization by creating spin-offs in universities and research institutions.

1.1 Motivation

In today's rapidly evolving economy, technological innovations are pivotal, affecting various industries and attracting considerable attention (Yamin, 2019). Technological innovation is the creation, application, and diffusion of new products, processes, and services that improve the quality of life, increase productivity, and solve societal problems while leading to significant improvements in performance, quality, efficiency, and sustainability (Maier et al., 2016). The challenge lies in effectively exploiting the given technologies to leverage their transformative potential (Bozeman, Rimes, & Youtie, 2015).

One of the primary mechanisms for transferring these technologies or technological knowledge to society and the economy is the creation of spin-offs (Pirnay, Surlemont, & Nlemvo, 2003; Rasmussen, 2011). Spin-offs, a specific technology-based innovation unit (Djokovic & Souitaris, 2008), can exploit new knowledge or technologies developed or acquired in research organizations. Spin-offs can be distinguished according to various criteria such as their origin, ownership, relationship and dependence on the parent organization (Mustar et al., 2006; Wright, 2014). In particular, "nascent spinoffs" represent the stage where they are still in the early stages of legal and financial separation from the parent organization and are still searching for suitable applications for a given technology (Davidsson & Gordon, 2012). Identifying and selecting applications for new technologies is necessary (Spanjol, Qualls, & Rosa, 2011), as subsequent development paths depend on it. Some researchers even argue that making the right decisions at this stage may be the most essential step in the process (Felkl, 2013). Overall, successfully navigating this stage is crucial, as making the right decisions in the early stages determines whether one succeeds or fails later on (Kock et al., 2015). Therefore, an appropriate strategy is crucial (Zhang & Doll, 2001). Identifying applications requires a creative and systematic analysis of technological opportunities, customer needs and market potential. It can lead to new sources of value, differentiation from competitors and solutions to societal challenges (Manthey, Eckerle, & Terzidis, 2022a). Despite the importance of successfully navigating this stage, there is relatively little research in this regard and a lack of processes to support this stage (Terzidis & Vogel, 2018).

For technology spin-offs specializing in highly innovative or complex technologies, identifying and validating suitable applications for their technology is particularly acute (Terzidis & Vogel, 2018). This phase, also known as technology application selection (TAS) phase (Terzidis & Vogel, 2018), poses a significant challenge for researchers who are keen to develop their technology further in the pre-seed stage of activity, the nascent spin-off stage (Davidsson & Gordon, 2012). In addition, they mostly lack the necessary resources, skills, experience, and legitimacy to conduct a thorough and reliable environmental analysis of different alternatives (Rasmussen, 2011; Wright, 2014). Moreover, nascent spin-offs operate in a highly uncertain and dynamic environment that requires them to constantly adapt and learn from feedback (Blank & Dorf, 2012; McMullen & Shepherd, 2006; Sarasvathy, 2008).

It is, therefore, surprising that, despite the importance of these decisions, there is little research in this area (Zhang & van Burg, 2020). Recognized as central to the development of technology-based innovations, application identification remains a neglected research topic. Kock et al. (2015) highlighted that ideation does not dominate the literature on developing technology-based innovations. Another study found that only 5% of the innovation research identified addressed innovation and creativity (Page & Schirr, 2008). They also pointed out that academic research, ideation, and activities in the early phase, the so-called front-end of technology commercialization, are not the main focus of literature (Page & Schirr, 2008; Williams & Samset, 2010). This leaves the understanding of front-end activities unclear and is even more ambiguous in the case of emerging spin-offs. (Kock et al., 2015).

Terzidis and Vogel (2018) also emphasize in their study that the second phase of the technology push innovation process, TAS, plays a crucial role in success and is often overlooked in practical settings. Despite its importance, TAS is frequently neglected, leading to mismatches between technology functions and customer needs, which can cause delays in commercialization. While established systems exist for earlier and later stages, the TAS stage, which links the scientific and industrial worlds, is typically challenging and underserved (Manthey, Terzidis, & Tittel, 2022b). Hence, Manthey et al.'(2023) highlight the need for further research in the area of TAS, particularly in relation to university spin-offs.

The identification and selection of applications for new technologies is a crucial and under-researched topic in innovation studies, both from a theoretical and practical perspective. As a specific type of technology-based innovation, researchers at the nascent spin-off stage face particular challenges and opportunities in this process.

This dissertation aims to close this gap and to deliver insights and guidelines for the identification and selection of applications for nascent spin-offs. By analyzing the TAS nexus in literature and in practice, a profound picture of the status quo can be achieved, building the foundation for the design of systematic guidance for researchers and supporting them within a systematic and tailored TAS process.

1.2 Research Questions

To resolve the ambiguity of the early stages and guidance within the TAS process, this study seeks to answer the overarching research question:

How to support researchers in identifying and selecting promising applications for given technologies?

Four sub-research questions are raised in order to address the main research question of the dissertation. Of these, three research questions focus on the theoretical underpinnings of the TAS nexus, while the fourth research question addresses the design of the solution to the identified gap. In the following, a brief reasoning is provided for each underlying research question.

Table 1: Research Questions

<table>
<tr><td colspan="3">How to support researchers in identifying and selecting promising applications for given technologies?</td></tr>
<tr><td colspan="3">Exploring the TAS Nexus</td></tr>
<tr><td>RQ1
What are the challenges and influential factors in application identification processes?</td><td>RQ2
How does the TAS process manifest in practice?</td><td>RQ3
How should an ideal TAS process be conceptualized?</td></tr>
<tr><td colspan="3">Designing the TAS Framework</td></tr>
<tr><td colspan="3">RQ4
How to design a systematic process for researchers to improve the identification and selection of technology application?</td></tr>
</table>

The application identification process, synonymous with idea generation, is highly complex due to challenges like inherent uncertainty, ambiguity, resource restrictions, and the need for market validation (Mary George, Parida, Lahti, & Wincent, 2016). Particularly in technology push innovations, idea generation is critical in order to develop technology-driven ideas (Maier et al., 2016). Nascent spin-offs utilizing university research must actively seek commercial opportunities for wealth generation (Klocke & Gemünden, 2010), overcoming the challenges of time and costs involved (Frishammar, Lichtenthaler, & Rundquist, 2012). Thus, application identification represents a focal area within the TAS process, highlighting the need for further research. Thus, the first research gap is about identifying the challenges and influential factors in technology-based application identification in the literature. Hence, the first break-down research question is:

RQ1 What are the challenges and influential factors in application identification processes?

By answering RQ1, the first insights can be derived for the understanding of the TAS process, focusing on the application identification for technologies. Although these findings offer relevant insights into this field, the practical perspective needs to be investigated to paint a comprehensive picture. Conducting interviews with relevant stakeholders is advised to gain a thorough understanding not only of the practical perspective but also of the entire process. In particular, focusing on the perspectives of researchers and their technology transfer nexus enables a profound understanding of the TAS manifestation in practice. By conducting an extensive series of interviews with the respective stakeholders involved, practical insights can be revealed, as well as current practices, challenges faced, and the support sought for and provided identified. Hence, the second break-down research question is:

RQ2
How does the TAS process manifest in practice?

Answering RQ2 reveals that the practical aspects of TAS tend to be neglected. Furthermore, a business-oriented mindset is identified as a significant barrier for researchers transitioning from academia to entrepreneurship. Consequently, support mechanisms such as coaching, entrepreneurial training, and methodological assistance are valued, while the recognition of room for improvement is highlighted, especially in mentoring and early-stage support. The findings provide evidence of the actual presence of TAS in practical scenarios and call for further theoretical examination of this crucial aspect. While this study sheds light on the underrepresented area of TAS processes in practice, it does not provide insight into existing TAS approaches designed to support the TAS process. Identifying existing processes that support the practical execution of TAS and analyzing and deriving the building blocks are necessary to explore the area of the TAS nexus further. Furthermore, the conceptualization of an ideal TAS process would highlight whether valid TAS approaches exist and guide the design of an enhanced version if needed. Thus, the third break-down research question is:

RQ3
How should an ideal TAS process be conceptualized?

Although there are many processes, they only partially address certain areas within TAS. Therefore, by answering RQ3, not only a wide range of approaches designed to support the TAS process are identified, but a conceptualized theoretical model that highlights the need for a targeted systematic TAS process is developed. In addition to the model, the challenges, influencing factors, and supporting mechanisms identified in RQ1 and RQ2 should be considered in this process. Furthermore, to increase the uptake and reduce the potential rejection of a systematic process, targeted implementation, taking into account the needs and challenges, should be considered when approaching researchers. This leads to the formulation of the final research question:

RQ4
How to design a systematic process for researchers to improve the identification and selection of technology application?

In the area of early-stage start-ups, there is a need for a methodical approach to help founders identify the appropriate technological solutions for their ventures. This is due to the significant barriers caused by uncertainty and lack of business skills that prevent these start-ups from accurately assessing promising technology applications. Therefore, the focus of this dissertation is to develop innovative methodological tools to support the identification and selection of appropriate technology applications for start-ups. A critical issue for nascent spin-offs is the lack of necessary resources, skills, and experience in entrepreneurial exploration and processes (Wright, 2014). As a result, they may tend to go with the first application they identify rather than explore further alternatives and select the most promising one. As one of the main reasons for this is the lack of systematic guidance, but also the lack of commitment to invest time in this theoretically and practically neglected topic, nascent spin-offs tend to avoid systematic approaches in this regard for fear of wasting their precious time and resources.

1.3 Research Design and Structure

The thesis is divided into four parts and a total of seven chapters. Figure 1 depicts an overview of the thesis' structure. Part I outlines the introduction and foundations of the thesis. Thus, the main motivation and the relevance of a systematic, guided technology application selection process for researchers to improve technology transfer are discussed. Furthermore, the structure of the thesis is described. Chapter 2 is an introduction to the theoretical underpinnings of the thesis. Part II highlights the TAS nexus and aims to unravel its ambiguities. Thus, Chapters 3-5 explore different aspects of the TAS nexus to provide a more holistic understanding of the TAS nexus while also introducing a conceptual model of an ideal TAS process. This provides the foundation for addressing RQ1, RQ2 and RQ3. Part III outlines the overall DSR methodology used to design a systematic TAS process. The development of the TAS framework over three design cycles is presented, resulting in the final and fourth version of the TAS framework. Part IV represents the final version. The results are summarized, and the limitations are discussed. In addition, the relevance of this work is highlighted, and an outlook suggests potential areas for future research. The chapter concludes with final remarks.

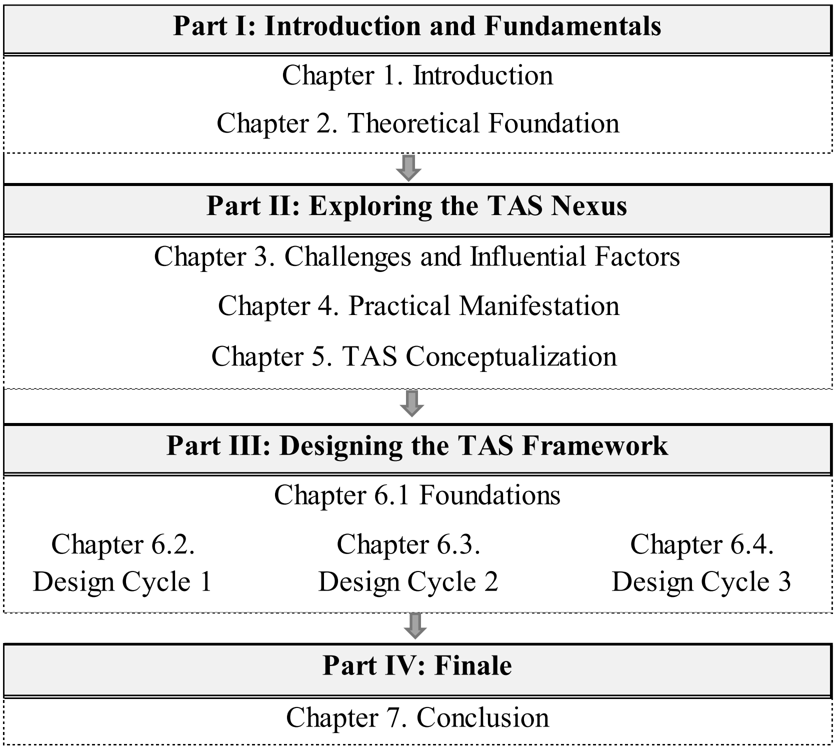

Figure 1: Structure of the Thesis (Own Illustration)

1.4 Related Work and Publications

Several contents of this thesis have been presented and discussed at international scientific conferences. The corresponding papers were published in the respective conference proceedings. Furthermore, some contents of the thesis have been published as working papers. Therefore, the core content of Chapter 2 was presented at the ISPIM Connects Salzburg, 2023, and subsequently published in the conference proceedings. Moreover, the main content of Chapter 3 was presented at the ECIE conference in Cyprus (2022) and published afterwards. Further, parts of Chapters 6.1 and 6.2 were presented and published at the conferences International Conference on Engineering, Technology, and Innovation (IEEE ICE) 2023 in Edinburgh, the conference International Association for Management of Technology (IAMOT) 2023, and the CIRP Design Conference 2023 in Sydney. Further, published papers at KIT working papers were incorporated.

However, if the contents of these publications were used, this was indicated by clear quoting and reference of the work.

2 Theoretical Foundation[1]

The importance of swift technological advancements and innovations in the contemporary economy is undeniable. Technology has become an indispensable element of daily life, influencing diverse industries and production sectors and attracting significant attention (Yamin, 2019). Within technological advancements, significant opportunities exist to bring about substantial impact (Lee, Cho, Choi, & Yoon, 2017; Saari, Suomalainen, Kuusela, & Hämeen-Anttila, 2016; Yun, Song, Kim, & Lee, 2021). Considering the rapid development of these, missed opportunities and unrealized potential for innovation and technology transfer are increasing (Bozeman et al., 2015). However, to leverage this transformative potential, it is essential to undertake the crucial process of commercialization, which is particularly difficult when it comes to new technologies (Maier et al., 2016). Successfully transitioning new technologies into tangible products or services is challenging as it is typically accompanied by technological uncertainty, technical or business inexperience, technology development costs, and the need for a change in customer behavior and existing markets (Kock et al., 2011)). Fostering a successful transition in his regard often leads to unexplored potential and economic and societal losses (Budi & Aldianto, 2020). However, it has great potential for radical innovations (Terzidis & Vogel, 2018). Therefore, the need to address this gap to profit entirely from the potential benefits of technological innovations is immanent. Baregheh et al. (2009) argue that technological innovation is critical in generating value and maintaining competitive advantages, with potential benefits for enhancing quality of life. In technology innovation approaches, the notion of technology push is essential (Brinkmann, 2017). Technology push involves commercializing innovative technology derived from research efforts, distinct from the standard market pull approach where innovation originates from market needs (Maier et al., 2016). However, despite its potential for breakthroughs, commercializing technology through a technology push approach poses multiple challenges and risks due to uncertainty arising from unknown market demands (Terzidis & Vogel, 2018). Notably, the early stage of this innovation strategy, also referred to as Fuzzy Front End (FFE), is characterized by numerous uncertainties while being equally recognized as crucial for later success.

Research institutions and universities are crucial in bridging the gap between technological breakthroughs and practical applications (Kivimaa, Boon, & Antikainen, 2017; Rasmussen & Wright, 2015). One of the main mechanisms to push technology transfer and generate impact is the creation ofpin-offs (Pirnay et al., 2003; Rasmussen, 2011). As academic researchers often make discoveries and develop intellectual property that has the potential for commercial applications (Dutta & Hora, 2017), universities can utilize the application of the technologies and innovations developed in their research institutes by creating spin-offs. This widely used commercial approach (Cubero, Gbadegeshin, & Segura, 2020) contributes to the country's economic growth and development (Gómez Gras, Galiana Lapera, Mira Solves, Verdú Jover, & Sancho Azuar, 2008). In detail, spin-offs are typically formed to

[1] The chapter is based on Manthey, Eckerle, Finner, & Terzidis 2023 – forthcoming.

commercialize a specific technology, innovation, or intellectual property developed academically, creating new applications or building new markets from their discoveries (Caputo, Charles, & Fiorentino, 2022).

Researchers' motivation to find a spin-off usually stems from several motivations. They are motivated by the opportunity to chart their course, make independent decisions, and have control over the direction of their ventures (Ryan, 2014; Yu & Lu, 2023). Further, recognition plays a critical role. Being recognized for their work, receiving awards, securing patents, or seeing their products succeed in the marketplace gives researchers a sense of accomplishment and validation of their efforts (Ryan, 2014; Ryan & Berbegal-Mirabent, 2016). Financial incentives also play an influencing role, although it is recognized that this depends on the environment and the financial stability perceived. One of the primary motivations for researchers is the potential impact their technologies may have. When they recognize that their discoveries have the potential to address pressing challenges, improve lives, and contribute to economic growth (Urbano & Guerrero, 2013), the intrinsic motivation to transform their technology into a marketable product increases. By commercializing their innovations, they aim to create positive change, whether through advances in healthcare, technology, sustainability, or other areas (Olaya Escobar, Berbegal-Mirabent, Alegre, & Duarte Velasco, 2017; Roncancio-Marin, Dentchev, Guerrero, & Diaz-Gonzalez, 2022). The prospect of seeing their ideas transformed into practical solutions that benefit society is a powerful motivator for researchers who want to become entrepreneurs (Padilla-Meléndez & Garrido-Moreno, 2012).

However, researchers struggle with several challenges throughout the commercialization process. They lack business experience (Hayter, Nelson, Zayed, & O'Connor, 2018; Sciarelli, Landi, Turriziani, & Tani, 2021), stemming from a lack of entrepreneurial training within their careers. Also, commercialization can be challenging without market evidence and customer demand for their products or services (Hayter et al., 2018). Turning ideas and innovations into viable businesses also requires adequate funding (Abd Rahim, Mohamed, Amrin, & Masrom, 2021; Taheri & van Geenhuizen, 2016). The high-risk nature of emerging technologies makes it difficult to attract potential investors or stakeholders, which is a critical hurdle in the lack of business experience. In addition, the market acceptance of their discoveries may be uncertain, as the commercial viability and customer demand may not be well-established (Helm, Mauroner, Dowling, & Pöhlmann, 2013).

Further, the conflict of interests within a dual role emerges, struggling to navigate between the research and industry world. Time and resource constraints can be challenging, as time constraints are faced when balancing roles as researchers and entrepreneurs (Müller-Wieland, Muschner, & Schraudner, 2019). Further, from an academic background, academic entrepreneurs often have a small network of business and industry contacts. This lack of a robust network may hinder their access to potential customers, investors, and strategic partners (Hayter et al., 2018). Balancing the pursuit of scientific knowledge with the drive for commercial success can be delicate (Abd Rahim, Mohamed, & Amrin, 2015). Researchers usually do not have enough knowledge to commercialize their technology (D'Este & Patel, 2007).

A critical and yet understudied area represents the TAS within the FFE phase, representing the step to identify and select the most promising application for the given technology. Successful management of these initial steps helps ensure that research results and inventions become actual products and services (Fischer & Pohle, 2018) and can guide researchers in identifying their research's impact, increasing their intrinsic motivation (Urbano & Guerrero, 2013). While a structured and guiding TAS process could support researchers in overcoming the struggles to transfer between academia and industry while also guiding them to identify the potential impact of their technology and enabling structure in the fuzzy front end of the innovation process, few practical approaches supporting the TAS process are known in general (Terzidis & Vogel, 2018). Further, none is explicitly targeted at researchers (Manthey et al., 2022a). Consequently, to support the technology transfer by enhancing the commercialization of technologies of researchers, a structured and comprehensible procedure by applying a systematic TAS approach tailored towards researchers' needs in this phase could powerfully support the successful transfer of innovative ideas and inventions into the economy.

2.1 Technology Transfer in Universities

Technology transfer is a complex process that involves various stakeholders with differing perspectives on the value and potential applications of the technology (Wahab, Rose, & Osman, 2011). Baranson (1970) contextualizes technology transfer with the knowledge and capabilities that must also be transferred to eventually produce the technology independently from the initial provider. Expanding on this idea, technology transfer involves the entire journey of technology, from its origins in research to its adoption by end-users who utilize the technology (Johnson, Gatz, & Hicks, 1997). Rogers (2002) presents a broader perspective of technology transfer as the practical application of information, which includes the technology itself. Technology transfer is a bilateral communication process where researchers transfer technological innovations to users in recipient organizations. The users may then commercialize the innovation in the form of a product or service and remain in steady exchange even thereafter (Rogers, 2002). The perspective of Eveland (1986) emphasizes the significance of technology transfer as a process that extends beyond the transaction itself and encompasses the outcomes that emerge from the transaction. Katzman and Azziz (2021) describe technology transfer as a process of transferring technology from one person or organization to another aimed at introducing innovations onto the market. These stakeholders include universities, companies, and governments or countries that generate economic value for all participants and provide society with opportunities to benefit from it (Katzman & Azziz, 2021). Technology transfer ultimately increases the rate of technological innovation and fosters new innovation. Successful technology transfer can also enable recipients of a technology to become future providers (Choi, 2009).

The transfer of technology from universities to industry is sometimes referred to as university technology transfer in the literature. This involves technology that originates from university research and is then transferred to industry (Siegel, Waldman, Atwater, & Link, 2004). Universities have the potential to contribute to economic growth by generating and disseminating knowledge within innovation systems (Shen, 2016, as cited in Quiñones et al., 2020). Leveraging university research can provide a swift solution to technical challenges, as universities typically engage in numerous ongoing research projects across various clusters or units (Maresova, Stemberkova, & Fadeyi, 2019).

Technology transfer, and therefore university technology transfer, is worth investigating due to its capacity to integrate theory and practice through collaborative research, as well as the potential to create spin-offs, its potential to foster the creation of new technologies, and the regional impact these technologies can bring about, contributing to economic and social development (Chais, Patricia Ganzer, & Munhoz Olea, 2018). Broadly speaking, technology transfer is a fundamental process that promotes economic and social advancement (Mazurkiewicz & Poteralska, 2017).

2.2 Researchers' Role in Academic Spin-Offs for Technology Transfer

Researchers play an essential role in academic spin-out companies for technology transfer (Hayter et al., 2018). Their expertise and innovations developed through academic research form the basis for creating spin-off companies. Further, they are in a unique position to identify and exploit the commercial potential of their technologies, leading to the creation of academic spin-offs (Krabel & Mueller, 2009; Müller-Wieland et al., 2019). This involvement bridges the gap between academic knowledge and real-world applications, facilitating the transfer of cutting-edge technologies from research institutions to the commercial sector (Hayter et al., 2018). Academic spin-offs are an essential type of technology transfer project, with researchers emerging as the architects of this entrepreneurial journey. It is an independent company that emerges from an existing university or institutional research institution or company (O'Shea, Chugh, & Allen, 2008). Spin-offs refer to new companies created by academic entrepreneurs, defined as university professors or researchers, students or outsiders, who commercialize research results due to technology transfer from universities or research institutions (Autio & Laamanen, 1995). These companies are typically created to commercialize a specific technology, innovation, or intellectual property developed academically, creating new applications or building new markets from their discoveries (Caputo et al., 2022). Through spin-offs, researchers find a new way to apply the technologies and innovations developed in their research, contributing to the economic growth and development of the country (Gómez Gras et al., 2008) while also bringing impact (Urbano & Guerrero, 2013).

Researchers not only develop innovative technologies but also possess the means to exploit them (Hayter et al., 2018). Academic spin-offs present a strategic approach for these researchers to apply their creations directly in practical settings (Krabel & Mueller, 2009). When researchers are the driving force behind implementing these technologies, it ensures a thorough comprehension of their potential, fostering avenues for broader societal and economic impact (Müller-Wieland et al., 2019). Thus, they contribute not only to the initial formation of spin-off companies but also to the ongoing development and refinement of technologies as they navigate the challenges of the market. In essence, researchers act as catalysts in the technology transfer process, driving the practical application and commercialization of academic innovations by establishing and growing spin-off ventures (Hayter et al., 2018; Krabel & Mueller, 2009; Müller-Wieland et al., 2019).

2.3 The Fuzzy Front End of Innovation

Innovation management comprises extensive steps that generally begin with theoretical research and development (R&D) and terminate with the product market introduction stage (Specht, 2002). One can divide the innovation process into three general process segments: (1) the front end, (2) new product development, and (3) the commercialization (Koen et al., 2015). The front end of innovation covers the time and activities spent on the ideas before the official screening of a new product idea in an organization (Reid & Brentani, 2004), whereby the ideas can originate from internal or external sources (Von Hippel, 1988). Previous studies describe the front-end phase by terms like chaotic, confusing, the "mysterious portion" (Koen et al., 2001, p. 46) of the innovation process, or with high levels of uncertainty, unknowable factors, and uncontrollability (Markham, 2013; Reid & Brentani, 2004), due to the difficulties and challenges of understanding and mastering the processes in this stage (Koen et al., 2001). In parallel, however, unanimity prevails about its importance for managing the innovation of new products (Brem & Voigt, 2009). Therefore, this phase of the innovation process is also called "fuzzy" since innovation managers often describe it as confusing and challenging to deal with (Zhang, Cao, & Doll, 2019), which explains the often used prefixed term FFE (Koen et al., 2001). The FFE starts with a technology push when technology is examined for the first time with the intention of further ideation, exploration, and assessment. It terminates with the investment commitment to the idea, ensuring resource availability for the development and the final launch of the technology (Khurana & Rosenthal, 1998).

The FFE phase is also an initial and exceptionally creative phase in innovation management (Herstatt & Verworn, 2004). As they constitute the basic building blocks of innovation, they significantly impact the later success (Koen et al., 2001; Markham, 2013). During this phase, companies will make fundamental decisions about which applications are the best to select (Herstatt & Verworn, 2004). The main activities of an innovation team in the FFE stage are to discover and choose compelling innovation opportunities (Koen et al., 2001). This includes creating and selecting ideas that address those opportunities and consolidating the most viable ideas into product or service concepts for further advancement (Zhang & Doll, 2001).

Consequently, the decisions made in the FFE determine the further development activities undertaken in the later process steps and decide on the potential technological innovation options, building the fundament (Koen et al., 2001). Therefore, this stage is characterized by high uncertainty, ambiguity and lack of structure, making it particularly challenging (Manthey et al., 2022a). As a result, potential technological opportunities are often left unexplored due to the complex technological landscape, incomplete information and the lengthy R&D required for successful commercialization (Koen et al., 2001; Manthey et al., 2022a). Another hurdle in technological innovation is identifying suitable application fields for new technologies (Manthey et al., 2022a). Therefore, successfully managing a well-structured FFE is crucial for identifying technological opportunities to obtain better results and provide competitive advantages for companies (Calabretta & Gemser, 2015). Researchers have attempted to address this challenge by developing theoretical and practical frameworks for guiding the technology application identification process (Manthey et al., 2022a). However, despite these efforts, a comprehensive and detailed approach to technology application identification is still lacking, as pre-development activities for opportunity identification still seem to be an unexamined research area (Manthey et al., 2022a). Although these preliminary decisions have the greatest influence on the further commercialization of innovations, the FFE is the least-well-structured part of the innovation process, although it is the key contributor to the majority of new innovations introduced each year (Koen et al., 2001; Manthey et al., 2022a; Zhang et al., 2019)).

2.4 Technology Application Selection

Technology Characterization, Application identification, and Application Selection phases characterize the TAS process, which is a significant part of the FFE phase. Successful management of this initial phase thus helps to ensure that research results and inventions become actual products and services (Fischer & Pohle, 2018). Despite the acknowledged relevance of the early phase and the high demand for technological innovations in industry and research, few practical approaches supporting the TAS process are known (Terzidis & Vogel, 2018). Thus, a high need for systematic TAS processes was identified (Kuo, Lin, & Yang, 2011; Manthey et al., 2022a; Platzek & Pretorius, 2020), as this process can support managing the uncertainties of the FFE. Applying structured methods within TAS processes can act as a filter, improving the quality of the ideas generated by enabling the identification and prioritization of the most promising ones. By applying a systematic process in the early stages, TAS facilitates efficient resource allocation, optimizing time, money and effort. In addition, by systematically evaluating and selecting technology applications, TAS helps to reduce risk by ensuring a higher probability of success for selected ideas (Finner & Manthey, 2023; Manthey et al., 2022a). For researchers, TAS can play a critical role in navigating the early stages of the commercialization process, providing structure and guidance to enhance the overall success of technology transfer and innovation (Finner & Manthey, 2023).

Nevertheless, besides recognizing the importance of this phase, it remains a neglected topic in research. Meanwhile, in the high amount of TT literature, the accredited belief is that the opportunity to initiate a transfer typically occurs for the recipient as soon as the need for technology is discovered (Battistella, Toni, & Pillon, 2016). Amongst others, this represents one perspective that supports explaining the scarcity of studies in the field of TAS, making the need for further research on the topic even more scientifically imperative.

2.4.1 Technology Characterization

The phase of the technology characterization is the first technology advancement activity in the TAS process and aligns the characteristics, advantages, and challenges of a given technology (Albrechtsen, Magleby, & Howell, 2010; Terzidis & Vogel, 2018). All features and basic concepts of the technology are analyzed to gain an in-depth understanding and transfer detailed facts about the nature of the technology (Plüddemann et al., 2010). It serves as the ground for the subsequent processes by structuring and aligning the present concepts. Other researchers describe technology characterization as a process where technology refers to solutions to solve a problem or fulfil a functionality (Manthey, 2023). Due to the information about the technical capabilities, the basic principles are mediated, and ambiguity can be reduced. The intention is to facilitate communication and ensure an equal understanding among diverse types of engineers (Galvan & Malak, 2015). On this basis, numerous ideas can begin to be collected for the technology's application during the following step, the *application identification* (Brem & Voigt, 2009; Henkel & Jung, 2009).

2.4.2 Application Identification

The application identification represents the second phase of the TAS process (Terzidis & Vogel, 2018). After the technology is characterized, diverse application possibilities must be generated (Danneels, 2007). An application is a way in which something can be used for a particular purpose – analogous to searching for the proper use case (Strøm, 2018). Ordinarily, the outcome of this phase is not just a single use case but many different possible applications (Kornish & Hutchison-Krupat, 2017). The identification process depends strongly on knowledge and further cognitive aspects (Ucbasaran, Westhead, & Wright, 2009). Above all, creativity and divergent thinking are crucial aspects during this phase that can be triggered by various external or internal stimuli (Salvi & Bowden, 2016). Examples of such stimuli are discussions, communication exchange, technological or industry trend screenings (Schallmo, 2018) or patent mapping (Cooper, 2008). The latter looks at existing patents to identify new, unavailable application areas for technologies through comparisons to draw up new opportunities (Cooper, 2008). Many well-known creativity techniques, e.g., brainstorming, 5W+H method, role-playing, social listening, brain sketching, 6-3-5 or mind mapping, support this process (Linsey et al., 2011). The present technology must be understood entirely since, without a clear understanding, no acceptable use cases can be identified (Gallersdorfer & Matthes, 2020). Other researchers use the synonym opportunity identification or idea generation to describe this process (Ardichvili, Cardozo, & Ray, 2003) – while these terms are often found in entrepreneurship literature (Ucbasaran et al., 2009). In sum, ideas must be rigorously reviewed and cultivated to result in profitable opportunities (Short, Ketchen, Shook, & Ireland, 2010).

2.4.3 Application Selection

Application selection represents the last phase of the TAS process (Terzidis & Vogel, 2018). Evaluating and selecting ideas is one of the most critical steps in the new product development process (Stevanovic, Marjanovic, & Štorga, 2012b), can provide immense business value (Koen et al., 2001), and coins the future shape of the company's success (Cooper, 2008). Finding the most promising opportunity for technology can be called the ideal selection in innovation management (Danneels, 2007; Henkel & Jung, 2009). During the process, vague ideas are transformed into promising concepts worth entering the subsequent development stages (Kim & Wilemon, 2002). It is about uncovering hidden opportunities or novel application areas for new or existing technologies, thereby creating central value for users (Magistretti, Dell'Era, & Verganti, 2020). Since the classic market pull approach only offers short-term innovations (Maier et al., 2016), the idea selection from a technology-based view is focused upon. Exploiting market opportunities for novel or existing technologies is common for technology-based companies, starting with a given technology and not with a given application area (Henkel & Jung, 2009).

2.5 Relevance of TAS for Researchers

In the scientific community, the commercializing of research is seen as a significant role in the innovation process as it helps to bridge the gap between academia and industry, leading to the development of new products and services. This whole process, including a wide array of social, economic, and political factors, is referred to as TT or, in a broader definition, TT between research and industry (Autio & Laamanen, 1995). Given the extensive research on technology transfer (Battistella et al., 2016) and the limited exploration of the TAS process for new technologies (Manthey et al., 2022a), despite its integral role in technology transfer, a need for further investigation is identified. TT in research institutions is typically supported by Technology Transfer Offices (TTOs), specialized units within universities or research institutions responsible for managing and protecting the intellectual property (IP) generated by research (Wu, Welch, & Huang, 2015). Working closely with researchers, TTOs secure IP through patents, trademarks or copyrights, thereby increasing the attractiveness of university discoveries to potential partners or licensees (Zhou & Tang, 2020). In addition, TTOs assess the commercial potential of these discoveries, considering factors such as market demand, competition, and technical feasibility to priorities resource allocation (Wu et al., 2015). While TTOs play a crucial role in facilitating the commercialization of university discoveries by managing the transfer of knowledge and technology from academic institutions to the marketplace, the management within the TAS process necessitates dedicated and customized support.

Delving into the literature, several crucial aspects of TAS encompass an understanding of the technology, recognizing the technology's capabilities, limitations, potential benefits, and how it can address problems or enhance existing products or services (Battistella et al., 2016; Turpin, Garrett-Jone, & Rankin, 1996; Wahab et al., 2011). Further support in market research is crucial, as analyzing market trends, growth, and the competitive landscape, coupled with a deep understanding of the needs and capabilities of participants, is necessary to come up with suitable applications (Battistella et al., 2016; Huang, Zhang, Guo, Zhu, & Porter, 2014; Maresova et al., 2019; Turpin et al., 1996). Hence, the overall identification and evaluation of specific tasks are complex, involving recognizing different use cases and application areas, followed by the evaluation and prioritization of these tasks based on their pros, cons, and profitability (Hameri & Vuola, 1996; Turpin et al., 1996; Wahab et al., 2011). Also, engaging with experts and customers represents a massive hurdle for researchers in the TAS process (Battistella et al., 2016; Laine, Leino, & Pulkkinen, 2015). Subsequently, researchers face challenges in communicating the value through marketing to raise awareness, create a value proposition, and showcase competencies through technology demonstration (Battistella et al., 2016; Huang et al., 2014; Laine et al., 2015). The study highlights that TTOs also actively support the establishment of spin-off companies by providing guidance, mentoring, resources, entrepreneurship training, and access to funding sources, thereby contributing to the growth and success of spin-offs in the commercialization process (Rasmussen & Borch, 2010), these do not investigate the TAS process itself, nor the support in this regard in particular. Further, distinct challenges and hurdles within the TAS process are still unknown, as well as the tailored support researchers are seeking within this process. Also, examining existing processes is missing to identify potential methods and steps relevant to a systematic and efficient TAS process.

2.6 Discussion

While studies emphasize the active role of TTOs in actively assisting spin-off companies through guidance, mentoring, resources, entrepreneurship training, and access to funding sources, thereby enhancing the growth and success of spin-offs in the commercialization process (Rasmussen & Borch, 2010), these investigations mostly not delve into the TAS process itself or the specific support offered in this context. Notably, the distinct challenges and hurdles within the TAS process remain unexplored, as well as the customized support sought by researchers in this intricate process (Manthey et al., 2022a). Furthermore, there is a lack of examination of existing TAS processes, which is essential for identifying potential methods and steps crucial for a systematic and efficient TAS process (Manthey et al., 2022a; Terzidis & Vogel, 2018). As a result, there is a need to delve into crucial aspects, investigating challenges and influential factors characterizing application identification processes, understanding how the TAS process unfolds in practical scenarios, and examining the specific TAS processes currently in use. Therefore, the following chapters delve into analyzing these fields.

3 Investigation of Challenges and Influential Factors in TAS[2]

3.1 Introduction

The application identification process, also referred to as idea generation, involves creativity in developing technology-driven ideas (Whitney, 2007). Grégoire and Shepherd (2012) and Conway and McGuinness (1986) have emphasized the critical importance of identifying applications for new technology whilst establishing a solid connection to potential markets. Spin-offs, which utilize new technology from research or universities, must proactively search for commercial opportunities to generate wealth (Klocke & Gemünden, 2010). Frishammar et al. (2012) highlight the time-consuming and costly nature of application identification, which demands a diverse range of knowledge. While most research occurs on the broader concept of opportunity recognition, which includes idea generation and application identification, the focus solely on application identification within the context of technology push innovation remains understudied (Manthey et al., 2022b). This literature gap highlights the need for a comprehensive investigation into the challenges and influential factors unique to the ideation process carried out by spin-offs as they seek technology-driven commercial opportunities.

Overall, application identification is crucial due to various challenges, such as inherent uncertainty, ambiguity, restrictions in resources and cognition, and the need for market validation (Mary George et al., 2016). To overcome these hurdles, it is necessary to use consistent and systematic strategies designed to navigate the complex application identification environment (Manthey et al., 2022a). In the complex process of application identification, numerous factors influence its direction and outcomes, as technology's features, potential customers' nuanced preferences, dynamic market trends, and the broader institutional and cultural context all significantly contribute. Thus, a thorough analysis of the influential factors, as well as the accompanying challenges in this regard, is required to untangle the fuzziness, leading to the formulation of the overall research question:

What are the challenges and influential factors in technology application identification processes?

A SLR has been deemed the appropriate method to explore existing knowledge and address research gaps effectively. This review offers an objective analysis of influential factors and challenges related to the ideation process followed by spin-offs in developing technology-driven innovation. Furthermore, the study contextualizes the investigation by defining and exploring fundamental theories that underlie the ideation process. Through applying an SLR, this study enhances the existing body of knowledge in the TAS field by delving into the intricate details of the fuzzy field. The findings reveal identified challenges and influential factors in the application identification process of technologies, laying the foundation for designing a systematic approach for TAS.

[2] The chapter is based on Manthey, Eckerle, & Terzidis 2022a.

3.2 Research approach

Scholarly strive springs from the well of pre-existing science and knowledge. Recognizing prior research is a customary academic practice and a guiding light for new investigations (Lacey, Matheson, & Jesson, 2011). A systematic and practical exploration of this foundation occurs through a literature review (LR). The LR serves a dual purpose, acting as a compass for researchers to navigate their questions and provide context, advancing the study's overall purpose and offering motivation and clarity (Snyder, 2019). Renowned scholars like Baumeister and Leary (1997) and Tranfield et al. (2003) highlight the LR's meticulous gathering and synthesis of past research, creating a detailed field map. Beyond mapping explored territories, it illuminates uncharted areas, inspiring new investigations and explorations (Snyder, 2019). van Wee and Banister (2016) rightly stress the LR's indispensable role in uncovering previously unnoticed areas and revealing untapped domains or existing research gaps. The effectiveness of a LR depends critically on its systematic approach. A SLR is a stronghold against subjectivity and ensures that the research process is transparent, reproducible, and objectively validated (Booth, Martyn-St, Clowes, & Sutton, 2021). It serves as a structured approach to identify, evaluate, and synthesize all available research about the research questions (Kitchenham & Charters, 2007). The choice to employ a SLR to elucidate the ideation process for application identification within the technology push innovation process is based on its capacity to furnish a thorough and impartial understanding of the present knowledge landscape, following the guidelines established by Kitchenham and Charters (2007). They divide the conduction of an SLR into the following three main phases and the respective activities:

1. Planning the Review
2. Conducting the Review
3. Reporting the Review (Kitchenham & Charters, 2007)

While the primary phases may seem to comply with a fixed structure, it is essential to acknowledge that several are recursive. For example, activities commenced in the review protocol, developed while planning the review, may undergo refinement during the actual review process (Kitchenham & Charters, 2007). In the 'planning the review' stage, the focal point is to devise the research inquiries, as they constitute the entire SLR (Kitchenham & Charters, 2007). It is crucial to align the (1) search process, (2) data extraction process, and (3) data analysis process effectively to address these questions. Kitchenham and Charters (2007) have identified core components outlined in the research quest and reviewed protocol development aims to minimize researcher bias.

Table 2: Core Components of a Review Protocol based on Kitchenham and Charters (2007)

Component	Description
Background	Provides the rationale for the survey
Research questions	States the specific questions the review aims to answer
Search Process	Describes the approach for finding primary studies, including search terms and resources like digital libraries, journals, and conferences.
Study Selection Criteria	Specifies the criteria used to include or exclude studies from the review, often tested on a subset of studies
Study selection procedures	Explains how the selection criteria will be applied, such as the number of assessors per study and how disagreements will be resolved
Challenges in Evaluation Methods	Outlines the development of checklists to assess the quality of individual studies, based on the purpose of the assessment

Search Procedure

The search process follows a search algorithm strategy constructed from chosen relevant terms (Kitchenham & Charters, 2007). Further, the search terms, search engines, inclusion and exclusion criteria, and the screening process are illustrated. Search terms are strategically employed to identify scholarly works on application identification and technology push innovation across various business and economic search engines. The selection of databases defines the boundaries for the SLR's scope. For this purpose, databases such as Web of Science and Scopus were initially checked to verify whether they included relevant papers for the subject area. The final selected search engines encompass Web of Science, IEEE Xplore, Business Source Premier, and EconLit. After selecting the database, the search string was defined. The combination of search terms was based on the key terms "application identification" and "technology push" (Table 3). Synonyms and abbreviations are incorporated to enhance the breadth of literature coverage, resulting in the final combination of search terms. Before the search process, study selection criteria (Table 4) were defined based on the research questions to ensure that the paper aligned with the research goal and was refined during the search process (Kitchenham & Charters, 2007).

Table 3: Core Concepts of the Research Questions and Derived Keywords for a Search Query

Core Concepts	Keywords
Application Identification	application identif*, recognition, ideat*, scenario generat*
	opportunity seek*, discover*, develop*" recognition, identif*
	commercial potential, techno-market insight*, business idea generat*, prospecting, fuzzy*front*end*ideat*
Technology Push Innovation	Technology*push, technology commercial*, technology transfer
	Technologic*Innovat*
Contextualizer	Spin*off, start*up, NBTF, New Technology based Firm
	academic entrepreneur, academic researcher, university entrepreneur*, research entrepreneur*

Table 4: Study Selection Criteria Applied in the SLR

Inclusion Criteria	Exclusion Criteria
Covers or creates theories, influential factors or challenges related to application identification in technology push	Not available in English Generic Model Access to full paper not available Niche topic

The search process, illustrated in Figure 2, commenced with an initial identification of 1024 publications. Subsequently, a meticulous screening based on titles and abstracts was executed, yielding 28 publications. Further refinement through adherence to predefined inclusion and exclusion criteria (Table 4) resulted in the retention of 27 studies for subsequent forward and backward citation analyzes. Consequently, 143 publications were subjected to in-depth scrutiny, culminating in the inclusion of 39 studies. By amalgamating the pertinent findings from the initial search and the forward and backward citation exploration, the total count amounted to 66 papers.

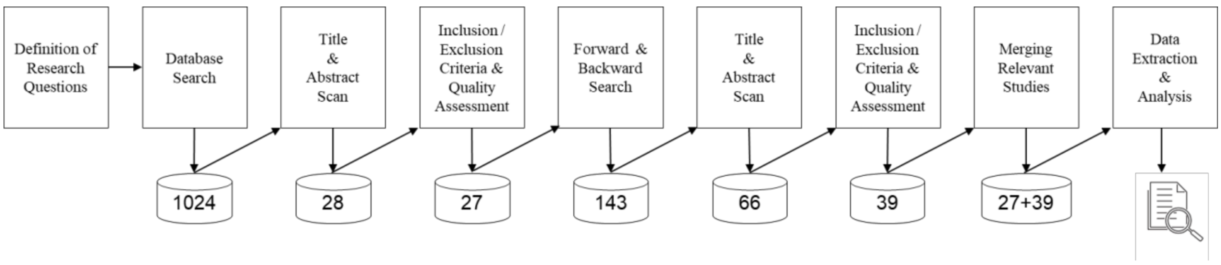

Figure 2: SLR process: Visualization (adapted from Petersen, Feldt, Mujtaba, & Mattsson, 2008)

3.3 Results

Based on the initial results of the database query of 1024 papers, the SLR resulted in 66 papers. The publications include journal articles, theses or dissertations, books or book chapters and conference papers. 50 of 66 publications are journal articles. Among these journals, Technovation, including seven hits, and Journal of Product Innovation Management, counting three hits, are the primary sources. 16 of 66 publications are from conference papers, books, theses and other types. The following section first highlights the most relevant literature according to their research contributions to get an understanding, description, and overview of the contents of the studies included in the further analysis. Hereafter, the contents will be analyzed according to the research questions, investigating influential factors and challenges in the application identification in technology push.

3.3.1 Influential Factors of Application Identification

A total of thirteen influential factors impacting ideation processes could be identified in the literature. These factors, delineated in Table 5 along with their respective sources, encompass prior knowledge, alertness of entrepreneurs, social network, environment, experience, personality traits, search process, customer inclusion, clear technological advantage, careful examination of alternatives, information transformation, contact with the industry, and contact with the scientific community. Subsequently, a concise introduction to each influential factor will be presented. Based on their prevalence in the literature, the most frequently recurring influential factors include prior knowledge, entrepreneurs' alertness, social network, environment, experience, and personality traits.

Table 5: Influential Factors in Application Identification Processes for Technology Push

Influential Factors	Sources
Prior knowledge	Frishammar et al. (2012); Corbett (2007); Park (2005); Ardichvil et al. (2003); Shane (2000); Ojala & Puhakka (2013); Cooper & Park (2008); Franzoni (2007); Okhli et al. (2019); Veilleux et al. (2018); Siegel & Renko (2012); Shepherd & DeTienne (2005); Hindle & Yencken (2004); Vohora et al. (2004); Baron (2006); Renko (2008); Saemundsson & Dahlstrand (2005); George et al. (2016); Abd Rahim et al. (2015); Wohlfeil & Terzidis (2015); García-Cabrera & García-Soto (2009); Uecke (2012);Danneels (2007); Souder (1989)
Alertness of entrepreneurs	Ardichvili et al. (2003); Lim & Lee (2019); Veilleux et al. (2018); Felkl (2013); Sarasvathy et al. (2003); Baron (2006); George et al. (2016); García-Cabrera & García-Soto (2009)
Social network: Strong ties and weak ties	Corbett (2007); Ardichvili et al. (2003); Lim & Lee (2019); Franzoni (2007); Okhli (2019); Veilleux et al. (2018); Baron (2006); Elfring & Hulsink (2003); George et al. (2016); García-Cabrera & García-Soto (2009); Rasmussen & Wright (2015); Bishop (2004)
Environment	Shane & Venkataraman (2003); Cooper & Park (2008); Strøm (2018); Hindle & Yencken (2004); Herstatt & Lettl (2000); George et al. (2016); Whitney (2007); Börjesson et al. (2006); García-Cabrera & García-Soto (2009); Maier et al. (2016); Souder (1989); Holzleitner (2015); Junglas et al. (2008)
Experience	Park (2005); Shane (2000); Brown (2015); Gruber et al. (2008); Hindle & Yencken (2004); Baron (2006); Venkataraman & Shane (2000); Neill et al. (2017); Abd Rahim et al. (2015); Conway & McGuinness (1986); Wohlfeil & Terzidis (2015); Börjesson et al. (2006); García-Cabrera & García-Soto (2009); Rasmussen & Wright (2015); Uecke (2012)
Personality traits	Ardichvili et al. (2003); Abd Rahim et al. (2021); Veilleux et al. (2018); Dew (2009); Hindle & Yencken (2004); Elfring & Hulsink (2003); George et al. (2016); Neill et al. (2017); Abd Rahim et al. (2015); Börjesson et al. (2006); García-Cabrera & García-Soto (2009)
Search process	Corbett (2007); Dew (2009); Baron (2006); George et al. (2016); Neill et al. (2017); García-Cabrera & García-Soto (2009); Rasmussen & Wright (2015)
Customer inclusion	Herstatt & Lettl (2000); Koen & Kohli (1998); Rasmussen & Wright (2015); Souder (1989); Holzleitner (2015); Bishop (2004)
Clear advantage of technology	Bishop (2004)
Carefully examined alternatives	Bishop (2004)
Information transformation	Corbett (2007)
Contact with industry	Rasmussen & Wright (2015)
Contact with scientific community	Rasmussen & Wright (2015)

Prior Knowledge: Prior knowledge, as posited by Shane (2000), plays a pivotal role in the opportunity recognition process, with information distribution inequalities leading to disparate access among individuals (Shane & Venkataraman, 2000). Shane's framework identifies three crucial dimensions of prior knowledge essential for opportunity discovery in high-technology contexts: prior knowledge of markets, ways to serve markets, and customer problems (Corbett, 2007; Shane & Venkataraman, 2000). Corbett (2007) extends this work by introducing learning asymmetries as a source of knowledge disparity among individuals, asserting that the learning process significantly influences this asymmetry. Siegel and Renko (2012) reveal that technology and market knowledge contribute to the ideation process of spinoffs, with market knowledge exhibiting a linear positive impact. Frishammar et al. (2012) advocate integrating domain-specific and general knowledge from New Product Development to enhance technology identification and match technologies with potential markets.

The alertness of Entrepreneurs: Entrepreneurial alertness, introduced by Kirzner (2009), emerges as a critical determinant of the ideation process, with individuals possessing high alertness potentially requiring less active opportunity searching (Baron, 2006). Personality traits, such as creativity and optimism, positively impact alertness (Ardichvili & Cardozo, 2000; Baron, 2006). The mediating role of entrepreneurial alertness between weak ties and opportunity recognition is affirmed across three dimensions: scanning and searching, association and connection, and evaluation and judgment (Lim & Lee, 2019). García-Cabrera and García-Soto (2009) emphasize the fundamental role of entrepreneurial-technological alertness for spinoffs in capturing technology and market trends.

Social Network: Entrepreneurs leverage their social networks and fragile ties or knowledge exchange, enhancing opportunities for identification and fostering novel idea generation (Lim & Lee, 2019). The distinction between strong and weak ties lies in the relationship, with strong ties being long-term and intensive and weak ties characterized by infrequent connections (Elfring & Hulsink, 2003a). Weak ties provide diverse possibilities, while solid ties are advantageous for trust-building (Elfring & Hulsink, 2003a). Veilleux et al. (2018) advocate social networks as a critical source of opportunity, highlighting their development through professional forums and trade exhibitions. Okhli et al. (2019) confirm a positive relationship between social network and ideation process performance, with individual capability and prior knowledge positively impacting social network.

Environment: Professional and social environments significantly impact entrepreneurs' opportunity recognition capabilities (Cooper & Park, 2008). Mary George et al. (2016) identify the environment as a mediator between personal characteristics and opportunity recognition, positing that environmental changes create opportunities. An open environment is crucial for generating diverse and novel ideas in innovation organizations, necessitating space for free thought and improved communication (Strøm, 2018). Business environment vitality is emphasized, providing crucial data for capturing trends and generating new ideas (Börjesson, Dahlsten, & Williander, 2006).

Experience: Experience, considered a key driver of opportunity recognition, is integral to the ideation process (Conway & McGuinness, 1986; Cooper & Park, 2008; Shane, 2000). Park (2005) underscores the importance of commercial and technical experience in ideation. Commercial experience enhances understanding of customer needs and problems, while technical experience aids in identifying technology potential and trends (Abd Rahim et al., 2015; Park, 2005). Gruber et al. (2008) support the significance of experience, noting that organizations or individuals with previous experience can identify more potential applications.

Personality Traits: Various personality traits, including activeness, creativity, optimism, self-efficacy, self-regulated learning, openness to experience, risk propensity, and self-confidence, are deemed crucial for entrepreneurs in the ideation process (Abd Rahim et al., 2015; Abd Rahim et al., 2021; Ardichvili et al., 2003; Dew, 2009; Mary George et al., 2016; Neill, Metcalf, & York, 2017; Veilleux et al., 2018)

Search Process and Customer Inclusion: Opportunity recognition, conceived as a pattern recognition model by Baron (2006), involves interconnected factors, including the intentional search for connections between changes and trends. The search process proves vital for identifying potential links between seemingly unrelated events, thereby enhancing the identification of opportunities(Baron, 2006; Rasmussen & Wright, 2015). Customer inclusion is meaningful in technology push projects, fostering an understanding of technology innovativeness and benefits (Bishop & Magleby, 2004; Koen & Kohli, 1998; Souder, 1989). Lead users, particularly active and innovative, offer valuable insights without similar products or services in potential markets (Herstatt & Lettl, 2004). A thorough study of potential customers is essential for understanding their needs and increasing success rates (Bishop & Magleby, 2004).

Additional Factors: Clear technological advantage and careful examination of alternatives emerge as success factors, making applications unique and difficult to replicate by competitors (Bishop & Magleby, 2004). Information transformation influences the opportunity identification process, with individuals with different information transformation preferences identifying varying opportunities (Corbett, 2007). Maintaining contact with the academic community and industry is essential for better knowledge transfer (Rasmussen & Wright, 2015).

3.3.2 Challenges of Application Identification

Besides the influencing factors, challenges in the TAS process are also evident. A total of nine challenges impacting ideation processes were identified. These factors, delineated in Table 6 along with their respective sources, encompass Cognitive Challenges, Lack of Market Knowledge, Unstructured Ideation Process, Challenges in Obtaining Alertness, Resource Constraints in the Search Process, Difficulty in Exploring Multiple Applications, Challenges in Evaluation Methods, Identification of New Customers, and Market Centrism. Subsequently, a concise introduction to each influential factor will be presented.

Table 6: Challenges in Application Identification Processes for Technology Push

Challenges	Sources
Cognitive Challenge	Grégoire & Shepherd (2012); Terzidis & Vogel (2018)
Lack of Market Knowledge	Vohora et al. (2004); Shane (2000); Herstatt & Lettl (2004)
Unstructured Ideation Process	Felkl (2013) and Kuo (2011)
Challenges in Obtaining Alertness	García-Cabrera and García-Soto (2009)
Resource Constraints in the Search Process	Lim & Lee (2019); Gruber et al. (2008)
Difficulty in Exploring Multiple Applications	Gruber et al. (2008); Bianchi et al. (2010); Strøm (2018)
Challenges in Evaluation Methods	Holzleitner (2015); Herstatt & Lettl (2004)
Identification of New Customers	Danneels (2007)
Market Centrism	Herstatt & Lettl (2004)

Cognitive Challenges in Identifying Applications: Grégoire and Shepherd (2012) emphasize the cognitive challenge entrepreneurs face when connecting a new technology with a potential target market, mainly when superficial dissimilarities exist. Terzidis and Vogel (2018) also highlight the difficulty of linking science and industry, adding complexity to the ideation process.

Lack of Market Knowledge: Vohora et al. (2004) and Herstatt and Lettl (2004) point out that some academic entrepreneurs lack market knowledge, posing a barrier to commercializing technology. Combining experts with diverse knowledge is a potential solution, but it may lead to inefficiencies in planning and coordination (Shane, 2000).

Unstructured Ideation Process: Felkl (2013) and Kuo et al. (2011) note that successful ideation processes often rely on entrepreneurs' alertness and prior experiences, lacking systematic and structural approaches to match technology and market needs.

Challenges in Obtaining Alertness: García-Cabrera and García-Soto (2009) emphasize the importance of technological and entrepreneurial alertness. Obtaining sufficient alertness poses a challenge and requires a combination of personality traits, knowledge, experience, the search process, social networks, and the entrepreneurial environment.

Resource Constraints in the Search Process: Lim and Lee (2019) assert that entrepreneurs must be proactive and flexible in information collection. However, the challenge lies in the increasing inputs of monetary resources, time, and energy required for an effective search process (Gruber et al., 2008).

Difficulty in Exploring Multiple Applications: Scholars suggest that finding multiple applications can reduce risks, but exploring alternative applications proves extremely difficult due to environmental constraints and limited resources (Bianchi, Campodall'Orto, Frattini, & Vercesi, 2010; Gruber et al., 2008; Strøm, 2018).

Challenges in Evaluation Methods: Holzleitner (2015) highlights the importance of evaluating potential applications but notes challenges, such as needing a sufficiently diverse evaluation committee to ensure neutral and diverse assessments. Further, a challenge is that traditional methods for assessing the fit between technology and the market cannot capture the dynamic nature of markets (Herstatt & Lettl, 2004).

Identification of New Customers: Danneels (2007) identifies a challenge in addressing new customers to fully exploit technology, as a lack of competence in this area can constrain technology leveraging.

Market Centrism: Herstatt and Lettl (2004) highlight that the development of new technology tends to concentrate on a company's current market, neglecting the exploration of new service areas.

3.4 Discussion

Overall, thirteen influential factors and nine challenges were identified. In the context of influential factors for ideation processes, it is observed that the most frequently recurring factors, based on their prevalence in the literature, include prior knowledge, alertness of entrepreneurs, social network, environment, experience, and personality traits. Challenges in the TAS process are also evident, which are identified by 14 articles.

3.4.1 Influential Factors

Of the additional seven influential factors, only search process and customer inclusion were mentioned by multiple authors, while the other five were each mentioned by a single author, originating from a total of three studies. While the more prominent ones center around the individual involved in the application identification process, less emphasized factors focus on the search process itself, forming the foundation of this research. This divergence arises from the predominant focus of ideation studies on the individual, particularly personality traits, often directly linked to opportunity recognition (Sarasvathy, Dew, Velamuri, & Venkataraman, 2003). The less frequently highlighted factors, which concentrate on the process itself, are particularly intriguing for understanding application identification. These factors include the search process (Corbett, 2007; Dew, 2009; Neill et al., 2017), customer inclusion (Holzleitner, 2015), clear technological advantage (Bishop & Magleby, 2004), carefully examined alternatives (Bishop & Magleby, 2004), information transformation (Corbett, 2007), contact with the industry (Rasmussen & Wright, 2015), and contact with the scientific community (Rasmussen & Wright, 2015).

All the influential factors discussed are pivotal in the application identification process and significantly impact its outcomes. Disparities in information distribution and learning asymmetries to uneven access to prior knowledge encompassing general insights into markets, ways of serving them, and customer problems (Shane, 2000). This inequality directly influences the identification of applications. Personality traits, including activeness, creativity, optimism, self-efficacy, self-regulated learning, openness to experience, risk propensity, and self-confidence, are crucial contributors to the ideation process (Shane, 2000; Veilleux et al., 2018). These traits profoundly influence entrepreneurial alertness, a key player in scanning, association, connection, evaluation, and judgment dimensions, underscoring its vital role in linking new technologies to emerging markets (Ardichvili et al., 2003; Kirzner, 2009).

Furthermore, social networks mediate by providing additional knowledge, enhancing the leverage of prior knowledge and entrepreneurial alertness. An open environment proves indispensable for fostering diverse ideas, accentuating the significance of the business environment in identifying new applications. Consistent contact with the academic community and industry facilitates superior knowledge transfer, aligning with the influential factor emphasizing the importance of such ongoing connections.

Moreover, both commercial and technical experience are integral components of the process. Commercial experience enhances comprehension of customer needs, while technical experience aids in assessing the feasibility and potential of the technology (Conway & McGuinness, 1986; Cooper & Park, 2008; Park, 2005). Given the high fuzziness in application identification, the intentional search for connections between changes and trends becomes critical for pattern recognition and opportunity identification. Customer inclusion, particularly in technology push projects, provides valuable insights into technology innovativeness and benefits, contributing to a deeper understanding (Henkel & Jung, 2009). Active and innovative lead users offer valuable perspectives. While a clear technological advantage is beneficial, it is not always guaranteed (Bishop & Magleby, 2004). However, a meticulous examination of alternatives contributes to success by making applications unique and challenging to replicate.

Overall, the results demonstrate that diverse factors influence the ideation process. This knowledge can assist researchers and nascent spin-offs in identifying areas where external support may be needed and refining these areas, contributing to an enhanced ideation process.

3.4.2 Challenges

Fourteen studies examined challenges in ideation processes, resulting in nine findings. One to two studies addressed the highlighted challenges yet provided a comprehensive overview of the numerous obstacles researchers and nascent spin-offs encounter when identifying applications for their given technologies. The difficulties recognized in identifying applications within a technology push highlight the fundamental vagueness of this phase. They emphasize the intricate, uncertain, and ever-changing nature of linking potential applications with emerging technologies, thus underscoring the necessity for further investigation (Danneels, 2007). The subjective nature of application identification is highlighted by the cognitive challenges involved (Grégoire & Shepherd, 2012; Terzidis & Vogel, 2018). Perspectives of stakeholders heavily influence the fit between technology and market solutions, resulting in a subjective perception (Strøm, 2018). Consequently, a structured process that integrates early external feedback and customer input is necessary to overcome this ambiguity and subjectivity (Gruber et al., 2008; Lim & Lee, 2019).

The lack of a standardized process creates ambiguity, allowing for varied interpretations and approaches (Gruber et al., 2008). This adaptability may result in inferior concepts or missed opportunities for more promising applications (Bianchi et al., 2010). The associated difficulty lies in maintaining awareness, influenced by personality traits, knowledge, and social networks (García-Cabrera & García-Soto, 2009). The intricate nature stems from the multifaceted and interrelated factors, which differ for each individual and significantly impact the process of identifying applications. Additionally, the inherent challenge of inadequate market knowledge creates uncertainty around the practicality and sustainability of potential applications, leading to premature dismissal or misjudgment of identified applications and complicating the exploration of multiple options (Herstatt & Lettl, 2004; Shane, 2000; Vohora et al., 2004). The uncertain nature of discovering and evaluating new applications in a limited setting and the markets' dynamic and evolving nature is apparent (Gruber et al., 2008; Herstatt & Lettl, 2004). Market-centeredness frequently arises from a lack of market knowledge, which narrows the scope for identifying potential areas to those currently known (Herstatt & Lettl, 2004). Identifying new clientele poses hurdles given the unpredictable nature of technological advancements, hindering projections and comprehension regarding the manifold necessities and predilections of prospective customer bases (Danneels, 2007). Evaluation methods present challenges by revealing their susceptibility to subjectivity in assessing possible applications (Holzleitner, 2015). The requirement for varied assessment committees acknowledges the multifarious viewpoints conduce to this undertaking (Berggren, 2017; Holzleitner, 2015)(Berggren, 2017; Holzleitner, 2015).

These challenges portray the ambiguous initial stage of the application identification process. The absence of clear guidelines, the subjective nature of assessments, and the unpredictable dynamics of markets contribute to the inherent ambiguity, rendering the application identification phase a complex and intricate aspect of the technology push process.

3.5 Conclusion

In summary, this research contributes significantly to understanding technology commercialization, focusing on the crucial phase of application identification. Uncovering challenges, influential factors, and gaps in existing knowledge paves the way for enhanced practices and strategies in technology to push innovation. Identifying a literature gap regarding the specific focus on application identification within the context of technology push innovation underscores the need for a comprehensive investigation (Manthey et al., 2022a). The SLR method is a suitable approach to address this gap, providing an objective analysis of critical theories, influential factors, and challenges related to the ideation process.

In terms of influential factors, the most recurrent ones include prior knowledge, alertness of entrepreneurs, social networks, environment, experience, and personality traits (Ardichvili & Cardozo, 2000; Mary George et al., 2016; Shane, 2000; Veilleux et al., 2018). While studies often emphasize individual factors, the less explored but pivotal ones center on the search process. Factors such as the search process, customer inclusion, clear technological advantage, carefully examined alternatives, information transformation, contact with the industry, and contact with the scientific community are just highlighted by a few studies (Bishop & Magleby, 2004; Holzleitner, 2015; Rasmussen & Wright, 2015). Including these less frequently highlighted factors is intriguing, offering more profound insights into application identification. The study underscores the significance of various factors such as disparities in information distribution, learning asymmetries, personality traits, entrepreneurial alertness, social networks, open environments, commercial and technical experience, intentional search processes, and customer inclusion. These factors play critical roles in influencing the outcomes of the application identification process. The inclusion of various perspectives, both individual and process-oriented, contributes to a comprehensive understanding of the complex nature of application identification.

In exploring the challenges associated with the ideation process, the study identifies nine key challenges, revealing the inherent vagueness of the application identification phase. The challenges emphasize the intricate, uncertain, and evolving nature of connecting potential applications with emerging technologies. Cognitive challenges highlight the subjective nature of application identification, underscoring the influence of stakeholders on the fit between technology and market solutions (Grégoire & Shepherd, 2012). The lack of a standardized process introduces ambiguity, allowing for varied interpretations and approaches, potentially resulting in missed opportunities (Lim & Lee, 2019). Challenges related to inadequate market knowledge, exploration of multiple applications, and evaluation methods further contribute to the complexity of the identification process (Gruber et al., 2008; Holzleitner, 2015; Vohora et al., 2004).

Overall, the study provides valuable insights into the influential factors and challenges of application identification in technology push innovation processes. Nonetheless, it is essential to recognize the constraints of this study. The chosen search string and quality criteria may have narrowed the search scope, potentially omitting promising and pertinent research. Moreover, the influential factors and challenges lack empirical evaluation, and their applicability to real-world scenarios remains unexplored.

4 Investigation of TAS in Practice

4.1 Introduction

Although it is widely recognized that selecting the right product is critical to mitigating the high risk associated with commercialization (Fini, Grimaldi, Santoni, & Sobrero, 2011; Fini, Rasmussen, Wiklund, & Wright, 2019), the TAS area continues to be overlooked in practice (Manthey et al., 2022a). Meanwhile, the decision to pursue a particular identified application relies heavily on the judgement of the venture stakeholders, thereby wasting potential further opportunities that might lead to increased success (Fini et al., 2019). This might be caused by neglecting the importance of this particular phase, even though it represents a crucial role in determining the success of the transfer efforts (Zhang et al., 2019). Based on the importance of this phase and the lack of research in this area, the following research question is posed:

How does the TAS process manifest in practice?

Thus, this research aims to investigate how TAS processes are performed in a real-world context, focusing on the perspectives of researchers and their technology transfer nexus. Practical insights can be revealed by conducting an extensive series of interviews with the respective stakeholders involved. Additionally, the study aims to identify current practices, challenges faced, and the support sought for and provided within TAS processes. Lastly, the research explores the support mechanisms and strategies implemented to enhance and optimize the TAS processes. This comprehensive approach aims to contribute valuable insights to academic understanding and practical decision-making in TAS.

4.2 Research approach

Academic research has neglected the issue of application identification and selection, focusing instead on the concurrent processes and challenges of technology transfer (Kock et al., 2015; Spanjol, Mühlmeier, & Tomczak, 2012; Strøm, 2018). However, research has stated that this phase is of considerable importance (Kock et al., 2015). To achieve greater insight into the significance of this phase and its place in the stakeholder processes involved in creating nascent spin-offs, interviews are conducted to obtain practical perspectives.

To maximize the value of these interviews, four perspectives on application identification and selection are highlighted, using mostly similar but target-group-oriented semi-structured questionnaires. An inductive research approach is adopted in this study to understand the perspectives of respective target audiences, as well as the process, influencing factors, and challenges (Gioia, Corley, & Hamilton, 2013; Mayring, 2016). This approach follows an explorative approach by focusing on individual actions and perceptions of the interviewee without bias to identify new ideas that emerge during the interview (Flick, 2022). This is especially crucial in this field, given the limited theoretical basis. As such, the inductive approach examines all aspects of qualitative data (Mayring, 2016). For this purpose, 45 semi-structured interviews with experts involved in the technology transfer of nascent spin-offs were conducted. The following sections provide a detailed description of the methodology and design.

4.2.1 Research sample

To understand the topic thoroughly, two crucial stakeholder groups were recognized as the principal actors in the field: Supporters within the spin-off creation process and the actors within the spin-offs themselves. Therefore, the following target audience is established: On the one hand, the supportive aspect is represented by entrepreneurship educators and technology transfer managers; On the other hand, the executive aspect is represented by spin-offs and researchers who may be interested in spin-off ventures. This approach offers a complementary analysis of technology application identification and selection, aiming to contribute to a comprehensive understanding of the topic.

Further, concerning the technology transfer representatives, complementary industry experts were chosen based on studies indicating that university TTOs primarily concentrate on IP and licensing (Zhou & Tang, 2020). The selected industry experts have participated in comparable initiatives but within established organizations, ensuring a diverse range of perspectives. Hence, a snowballing technique was used throughout the process of identifying further interviews, where interviewees suggested others to interview (Reed et al., 2009).

Table 7: Sample Overview of the Interviewees

Target Group	Invited	Agreed	Completed	Percentage
Entrepreneurship Education	12	10	10	22%
Technology Transfer Manager	25	17	16	36%
Academic Spin-Off	23	10	9	20%
Researcher	17	10	10	22%
Total	**77**	**47**	**45**	**100%**

4.2.2 Research Method and Design

The applied methodology consisted of two phases. First, the primary data was collected through interviews with stakeholders involved in creating a spin-off, consisting of academic spin-offs (ASOs), researchers, entrepreneurship educators (EE), and technology transfer managers (TTM). Second, the data analysis took place, applying the method by Gioia et al. (2013), with elements of Mayring (2016), following an inductive approach.

The interviewees were identified by desk research, network suggestions and snowball system, mainly in Europe. A semi-structured interview schedule was used, following the approach by Döring and Bortz (2016). Interviews took an average of 40 minutes but ranged between 25 and 75 minutes. They were conducted online, as online interviews offer a more time and cost-effective option since aspects such as travel costs are eliminated, and interviews with internationally dispersed experts are possible (Kaiser, 2021). Regarding the second phase, the transcription of the audio versions of the recorded interviews follows the qualitative data analysis of such non-numerical data (Gehman et al., 2018). The Gioia method is used to analyze the data (Gioia et al., 2013). It offers an inductive approach based on the grounded theory methodology in the form of a three-level category system for coding. Thus, drawing on the concept of Mayring (2016), the categories are referred to as codes in different sublevels.

Moreover, it offers a more extensive scope for interpretations and allows the opportunity to consider different facets that are not obvious initially (Gehman et al., 2018; Gioia et al., 2013). The approach involves first-order analysis based on informant-centric codes and second-order analysis based on concepts, themes and dimensions related to the researcher (Gehman et al., 2018). The research progresses by identifying similarities and differences among the emerging categories (Gehman et al., 2018). Based on this, a data structure is developed that shows the evolution of the initial data into theoretical dimensions (Gehman et al., 2018).

4.3 Results

Based on the interview's insights into TAS practices, challenges covered and desired support mechanisms could be derived. These findings are presented in this section. First, the status quo of TAS in practice is described. Second, the mentioned challenges in TAS are represented, and third, the support in TAS is highlighted. Direct quotes were used in this section in order to illustrate the key points, with references to the interviewee and the group they belong to. The following shortcuts are used: EE (entrepreneurial educators), TTM (technology transfer managers), ASO (academic spin-off), and RE (researcher).

Table 8: Code System of the TAS Interviews

Code system of the Interviews		
Codes Level 1	**# Codes Sublevel 2**	**# Mentions**
TAS in Practice	5	37
Challenges in TAS	11	70
Support in TAS	8	122

Over 231 discrete data points were identified by transcribing the interview data into coded pieces of text. Five codes sublevel 2 were derived in TAS in Practice, 11 subcodes level 2 for Challenges in TAS and eight codes sublevel 2 for support in TAS. Several rounds of data coding were conducted to compile the primary findings.

4.3.1 TAS in Practice

The empirical results of this study show that five categories occur in the discourse surrounding the practical implementation of TAS processes. These categories include the following key dimensions: (1) following a customer-centric approach, (2) obtaining early feedback, (3) proactive opportunity identification, (4) following an iterative process, and (5) the integral role of market research (Table 9).

Within this dimension, the ASOs contributed the most statements, almost twice as many as the TTMs, who contributed the second most. In contrast, RE had no contribution in this dimension, which is a consequence of the absence of expertise in the process itself.

Table 9: Categories of TAS Processes in Practice

Category	Description
Customer-centric Approach	Emphasizes engaging closely with customers to understand needs, aligning efforts accordingly. Solutions resonant with customers prioritized, valuing feedback and interactions as crucial for shaping innovation strategies.
Early Feedback	Stresses the critical role of early feedback in innovation, urging engagement with stakeholders before significant resource commitment. Focuses on addressing core issues, gauging market receptivity, and identifying uncharted territories for innovation.
Opportunity Identification	Revolves around recognizing and pursuing innovative ideas proactively from diverse sources. Encourages a mindset open to inspiration, early feedback, technological leverage, and opportunistic action in the entrepreneurial journey.
Iterative Process	Describes an approach of continuous learning, flexibility, and rejection of rigid processes. Emphasizes niche solutions, responsiveness to market feedback, and an occasional non-linear ideation influenced by personal interests, collaboration, and market dynamics.
Market Research	Highlights diverse approaches to assessing market potential and validating product ideas. Acknowledges the challenge of the 'chicken and egg' problem. Stresses thorough market research, identifying viable markets, and validating through interactions with potential partners and assessment of development readiness. Underscores the multifaceted nature of researching and validating markets in TAS practices.

Customer-centric Approach

This category underscores the significance of engaging closely with customers, understanding their needs and priorities, and aligning innovation efforts accordingly. Interviewees emphasize the value of customer feedback and interaction as a fundamental aspect of their approach to innovation and entrepreneurship. Through conversations with customers, whether through pilot projects or direct communication, they gain valuable insights into customer preferences, pain points, and priorities. This information guides decision-making and shapes the direction of their innovation efforts. They prioritize applications and solutions that resonate with their target customers and align with their technical expertise. Furthermore, the interviewees recognize that their interactions with customers inform them about the potential for improvement and innovation. Through these customer-focused conversations, they identify opportunities to deliver better solutions and meet customer needs more effectively.

> *"Exactly, we are very close to the customer through pilot projects because that is the key."*
> *(Interviewee I41, ASO)*

In summary, this category underscores the significance of engaging with customers objectively to comprehend their requirements, prioritize innovation efforts, and acquire vital insights. The interviewees emphasized the importance of customer feedback in shaping their innovation strategy.

They highlight the need for customer interactions to guide decision-making, identify opportunities for improvement, and develop solutions that align with customer preferences and technical expertise.

Early Feedback

Early feedback is a recurring theme in the interviews and was therefore assigned as another category, reflecting recognition of its critical role in innovation. Interviewees highlight the benefits of engaging with stakeholders and potential users in the early stages of innovation initiatives before committing significant resources. They emphasize the need to go beyond the superficial and focus instead on fundamental feedback, stressing that addressing core issues rather than minor tweaks delivers incredible value. Participants also stress the importance of gauging market receptivity early by assessing customers' willingness to invest in the proposed innovations. This approach is consistent with the broader strategy of identifying market niches where innovation can flourish without intense competition, underlining the search for uncharted territory rather than crowded spaces. These findings underscore soliciting and listening to early feedback as a fundamental element in TAS practices.

> *"It has almost always been worthwhile to approach people relatively early, before elaborating too much, to obtain feedback at the foundation level and not just at the top, to change the color slightly. Rather, it is about the entire form being flawed." (Interviewee I38, ASO)*

Early feedback is a significant topic in the interviews, and its crucial role in promoting innovation is emphasized. Interviewees suggest involving stakeholders and potential users at the beginning of innovation projects to acquire essential feedback instead of superficial input. Furthermore, they underline the significance of evaluating market interest promptly and targeting unexplored niches to avoid intense competition.

Opportunity Identification

This category revolves around the spontaneous recognition and pursuit of innovative ideas from various sources, including prior professional experience, heightened situational awareness and collaborative brainstorming. This theme underlines individuals' and teams' proactive and agile mindset in recognizing and seizing potential opportunities in TAS practices. It emphasizes the importance of remaining open to diverse sources of inspiration, seeking feedback early in the ideation process, capitalizing on technological advances and seizing opportune moments for action in the entrepreneurial journey.

> *"The opportunity was simply there. We had seen that with the technologies that were still available at the time, one could build exciting solutions and that the entrepreneurial environment was quite favorable then. These were the main drivers for us to say: Okay, the opportunity is there, and if we do it, we better do it now rather than later." (Interviewee I40, ASO)*

This category centers on individuals' and teams' proactive and adaptive mindset in identifying and pursuing innovative ideas from different sources. It emphasizes the significance of being receptive to multiple sources of inspiration, seeking timely feedback, harnessing technological advances, and seizing favorable opportunities for action within TAS processes.

Iterative Process

Interviewees emphasize that their approach is characterized by continuous learning and refinement rather than a rigid and predefined process. They stress the importance of gathering insights, experiences and best practices that serve as the basis for experimentation and problem-solving. They focus on niche solutions to specific problems and iterate through different stages, responding to market feedback and opportunities. Their process involves persistence, perseverance and a commitment to iterative improvement, allowing them to evolve their ideas and solutions over time. They also acknowledge their occasional, non-linear ideation process, influenced by personal interests, collaboration and market dynamics. In summary, the “iterative process” theme reflects a flexible and adaptive approach to innovation and entrepreneurship, characterized by continuous learning and refinement through repeated cycles of experimentation and improvement.

> *"Then it is an iterative process from which these solutions emerge. That is why you can tell the great stories afterwards, that everything was clear beforehand, but it was not. It is always an iterative experimentation until you somehow get there and have something that potentially adds value." (Interviewee I40, ASO)*

In conclusion, the interviewees have emphasized the importance of an adaptive and flexible approach to TAS processes, which involves continuous learning, refinement, and problem-solving based on evidence, experience, and best practice. The outlined strategy prioritizes the development of custom solutions, responsiveness to market feedback, and a commitment to enhancing development, enabling gradual progress of ideas and solutions over time. The iterative process is not linear, and its direction is affected by individual interests, cooperation, and market dynamics.

Market Research

The interviewees highlighted entrepreneurs' and innovators' different approaches to assessing market potential and validating their product ideas. Entrepreneurs often engage in conversations with inventors, use networking events and seek opportunities for dialogue to obtain feedback and insights. However, it is recognized that defining a product when there are multiple technological possibilities can be challenging, often referred to as the “chicken and egg” problem. To overcome this, individuals seek to identify suitable markets where their innovations could thrive. While many ideas can be generated, it is essential to conduct thorough market research to determine which markets are viable and receptive to their innovations. Interviewees stress that technical feasibility alone is not enough; actual market validation is required to ensure success. This validation process involves interacting with potential partners and assessing the readiness of their development departments. While some respondents mention having a clear understanding of the problem their solution addresses, they still recognize the importance of conducting market research. Respondents also mentioned that their market research methods vary. Some rely on their professional networks and see this as an unstructured but valuable process. They iterate ideas through collaboration, recognizing the importance of engaging with potential users or partners. Overall, the "market research" category highlights the multifaceted nature of researching and validating markets as an essential aspect of TAS practices.

> *"We tried to identify in which markets all of this could work. You can always have many ideas. The problem is that you could imagine it working somewhere. Technically, you can somehow envision it and have an overview. Many markets come together, but whether something happens there or comes out of it is another story. We noticed various things where you say: Okay, first, completely open-minded people and so on. But you can quickly see that you need to do a small quantity of market research everywhere, which is really what was super important for us in the end. You talk to two or three companies, for example, and you can already see how big their development departments are." (Interviewee I42, ASO)*

In conclusion, the interviews represent inventors' different approaches to assess the market potential and validate their product ideas. The significance of interacting with inventors, networking, and obtaining feedback is highlighted to tackle the hurdle of defining a product where multiple technological possibilities exist. To achieve a productive TAS process, it is crucial to identify appropriate markets where innovations can thrive, necessitating comprehensive market research and validation. It is worth noting that the methods for conducting market research vary, including utilizing professional networks, collaborating with relevant individuals, and engaging with potential users or partners.

4.3.2 Challenges in TAS

Several challenges arise during the technology transfer process, particularly in the initial phase, explicitly identifying and selecting suitable applications to utilize the given technology. Upon reviewing interview insights, the following eleven categories of challenges were identified: (1) Assumptions and Deep Dives, (2) Communication and Engagement with Stakeholders, (3) Customer Perspective and Early Validation, (4) Knowledge Gaps and Finding the right team, (5) Market Validation and Market understanding, (6) practicability and focus on one application, (7) Problem-solution Fit and Market-centric ideation, (8) team dynamics and collaboration, (9) technical depth, (10) timing and persistence and (11) transitions from academia to entrepreneurship (Table 10). In terms of perceived challenges, ASOs contributed the most statements regarding TAS, followed by EE, similar to the previous dimension. TTM and RE also identified some difficulties.

Table 10: Categories of Challenges in TAS Processes

Category	Description
Assumptions and Deep Dives	Emphasizes the need to challenge assumptions continuously, navigate uncertainty, and adapt assumptions throughout the innovation process. Highlights the importance of balancing narrative and evidence-based approaches and the tension between attachment to ideas and early validation.
Communication and Stakeholder Engagement	Stresses effective communication with diverse stakeholders, the challenge of conveying technical benefits to non-technical individuals, and the significance of initiating industry collaborations, even through unconventional methods like cold calling.
Customer Perspective and Early Validation	Addresses the challenge of identifying relevant customers early in technology development. Highlights the importance of understanding and integrating the customer's perspective, maintaining a close relationship during the verification phase, and the potential pitfalls of overlooking the customer perspective in spin-off development.
Knowledge Gaps and Team Formation	Recognizes the challenge of knowledge gaps and the difficulty in assembling teams with the requisite skills. Emphasizes the critical role of knowledge in successful technology introduction, the underestimation of knowledge needs, and challenges related to team downsizing and trust within teams.
Market Validation and Understanding	Stresses the importance of aligning technological innovation with market realities, identifying the right audience, and conducting thorough market research. Acknowledges the challenges of market needs opacity, time-consuming technology adoption, and the necessity of continuous self-assessment and adaptability.
Practicability and Focus on One Application	Highlights the recurring theme of focusing on a single application for success. Emphasizes the need for technology to address real-world challenges, the pitfalls of pursuing multiple ideas, and the shift from an engineering mindset to a business perspective.
Problem-Solution Fit and Market-Centric Ideation	Emphasizes critical self-assessment, the importance of external perspectives, and the concept of "problem-solution fit." Highlights challenges in evaluating deep technology, the danger of excessive time investment without validation, and the need for constant evaluation and testing.
Team Dynamics and Collaboration	Emphasizes the importance of diversity in idea generation, challenges in fostering innovation within teams, and the need for patience in entrepreneurship. Recognizes the significance of recruiting individuals with specific skills and creating a corporate culture that transitions from caution to open collaboration.
Technical Depth	Points out the challenge of scientists becoming overly focused on technical details, potentially neglecting broader practical considerations. Highlights the difficulty in translating visionary ideas into effective technical solutions in the early stages of development.
Timing and Persistence	Emphasizes personal attributes such as curiosity, eccentricity, and persistence as crucial. Recognizes the significant time and dedication required for technological innovation, the paradox of balancing short-term financial gains with long-term strategies, and the underestimated importance of perseverance.
Transitions from Academia to Entrepreneurship	Highlights the challenges in transitioning from academia to entrepreneurship, particularly in adopting a business-oriented outlook. Recognizes the need for a substantial time investment, additional expertise, and the shift from academic independence to entrepreneurial fiscal responsibilities.

Assumptions and Deep Dives

Interviewees emphasize the need to continually challenge and modify assumptions while recognizing the evolving nature of this process. Navigating uncertainty in the early stages is seen as challenging and requires informed decision-making despite limited data. Throughout the transfer process, underlying assumptions are crucial for adaptability and refinement. A thorough exploration of different aspects is required. The level of analysis should be adjusted according to the stage of transfer. A balance between narrative and evidence-based approaches is emphasized, with a warning against overly fanciful justifications. Finally, there is a tension between founders' attachment to ideas and the need for early validation.

> *"You have to make somewhat sure that everything you do is assumption-based; it is okay to make assumptions. It is okay to have hypotheses. It is not set in stone; that's a little bit of the problem because you will learn over time that it will change. Moreover, you need a deep dive afterwards for some of the parts. So, let's say market attractiveness. You do not do a super-intensive market evaluation just to select the first idea. It is superficial. However, afterwards, you have to, I guess, go in again and do a deep dive. So, the question is a bit: how intensive is this first?" (Interviewee I12, EE)*

In conclusion, the importance of making assumptions about the technology, the idea and the potential applications, and of continually testing them, is emphasized in this section. Researchers tend to become fixated on the initial idea and avoid admitting its imperfections. Consequently, it is crucial to recognize underlying assumptions and the need for repeated and intensive evaluation of these assumptions.

Communication and Engagement with Stakeholders

Effective communication with diverse stakeholders, such as industry partners and managers, is critical. Researchers must demonstrate their ability to convey the technological benefits to non-technical individuals, essential for building trust and fostering collaboration. Unfortunately, researchers seldom initiate the search for potential industry collaborators through techniques like cold calling. Additionally, the difference between research and entrepreneurial approaches highlights the significance of embracing a modest and open attitude towards technology transfer.

> *"So, it is about communication with the other players and with the other stakeholders." (Interviewee I03, ASO)*

Establishing trust and promoting collaboration necessitates effective communication with non-technical stakeholders. To bridge the void between research and entrepreneurship, researchers should actively pursue industry partnerships and maintain a modest and candid approach.

Customer Perspective and Early Validation

When developing concepts based on new technologies, it can be challenging to identify the relevant customers early, but it is still essential to understand and consider the customer's perspective to integrate it into the development process. In particular, during the initial verification phase, it is crucial to maintain a close relationship with the customer. Early integration of the customer perspective is critical to validate emerging assumptions in the process. If this is not done, it is often claimed that the end product is not designed with the end user in mind.

> *"But, what would I also use and maybe on a, yeah, scientific base, but when you think about a solution for the customer, you fully need to understand the customer. So, it also makes clear that you need pretty close customer analyzers. Furthermore, most technologies are not; they are not consumer-oriented. At least in Germany not, and therefore, you need to get deep insights of your companies, and for this, you need really, to investigate very well seemed like a persona template, you need to generate a similar picture." (Interviewee I15, EE)*

> *"So, you should get out there as early as possible and validate that." (Interviewee I43, ASO)*

Generally, in the early stages of new spin-offs, the integration of the customer perspective is often overlooked. Although it is difficult to identify potential customers during this stage for early evaluation, it represents a crucial challenge that spin-offs encounter. Therefore, this challenge must be considered when diving into the TAS process.

Knowledge Gaps and Finding the Right Team

A critical issue to consider is the challenge posed by knowledge gaps and the resulting difficulty in assembling a team possessing the requisite skills. Acquiring the correct know-how is critical in successfully introducing technology to the market. However, the knowledge needed for this undertaking is frequently underestimated. To secure the necessary knowledge base, one may either acquire the knowledge itself or rectify the deficit by introducing new team members with said expertise. There are often knowledge gaps within teams, mainly when potential founders come from technical or scientific backgrounds and have limited entrepreneurial experience or skills. Further challenges arise during team downsizing in the early stages, where significant knowledge can be lost with the departure of a team member. Furthermore, trust in each other's abilities and ongoing commitment are significant factors that challenge the application identification and selection process in the initial phase.

> *"And the second is a mismatched team. But that does not have to be personal. It can be that the team gets along wonderfully, but there is a lack of know-how in the team." (Interviewee I43, ASO)*

> *"Yeah, I would say for me, it is the team. It is hard to find a good team, and it is crucial for your success. So, you need to have a kind of trust in your team that you know you can work together with them. You are going in the. Kind of the same direction. Yeah, that's that's, I would say, the most crucial point." (Interviewee I34, RE)*

Knowledge gaps are a significant hurdle in the early stages of technology transfer and spin-off development. While procuring necessary knowledge and establishing a proficient team are indispensable for success, they are often underappreciated. Teams, notably those with scientific or technical backgrounds, may be deficient in critical entrepreneurial know-how. Further challenges may arise due to reducing the team, and the significance of trust and commitment between team members must also be considered when identifying and selecting applications.

Market validation and market understanding

Lessons learned from expert experience highlight the importance of aligning technological innovation with market realities. Targeting the right audience is a fundamental challenge, as the scope of the problem is often misunderstood or overly broad. Researchers may be unaware of real production problems and not fully appreciate market issues. In addition, they may face the challenge of reconciling visionary ideas with market acceptance. The eagerness to explore new concepts may be at odds with the reality that potential customers may not share the same enthusiasm. Therefore, comprehending the market and its issues is of paramount importance. The tendency towards abstraction, which is common in academia, can also be an obstacle to resolving specific problems of external stakeholders. Market needs may not always be transparent, making it difficult to engage customers during the product'

s conceptual stage. Identifying the target audience for a technology can be time-consuming without external support or industry interest. The relevance of technology adoption depends on industry dynamics, and it is essential to assess whether the technology aligns with the company's goals and provides value to customers. Finally, there is an emphasis on a culture of continuous self-assessment and adaptability. In this constantly evolving environment, it is essential to steadily question technology solutions' applicability and maintain an open attitude to learning and development.

> *"We did not understand the market. We did not understand the problems. We made everything very abstract, as scientists do. They were always abstracting everything. However, the outsiders, the people out there, have very concrete problems. They do not have an abstract problem." (Interviewee I36, ASO)*

Experts emphasize the importance of aligning technological innovation with market realities. Identifying the appropriate audience can be challenging due to misconceptions or broad scopes. Researchers may not have sufficient insight into production issues and market concerns, and they need to balance imaginative concepts with market acceptability. The abstraction often found in academia can hinder the resolution of specific external challenges, and identifying the target audience for the technology can be time-consuming. Technology adoption depends on industry dynamics, and it is imperative to cultivate a culture of constant self-evaluation and adaptability in this ever-evolving environment.

Practicability and Focus on One Application

Another recurring theme throughout these interviews emphasizes the importance of focusing on a single application rather than being tempted to explore various avenues. Success is often tied to pursuing a clearly defined application, comparable to selecting a promising technology with significant potential impact. The interviews stated that technological advancement should have a clear purpose, focusing on addressing real-world challenges rather than merely being technology-centric. Having an outstanding technology or inventive concepts alone is insufficient for ensuring success; these must tackle authentic market demands. Departing from these requirements can hinder progress, particularly in complicated fields such as chemicals and commodities, where commercialization can be intricate. Usually, current technologies undergo gradual enhancements, resulting in minor improvements to the latest advancements. Detecting these prospects for refinement necessitates impartial analysis, culminating in copyrighting and subsequent utilization. This action might demand searching for a licensee or launching a new start-up. Emphasis is placed on transitioning from an engineering mindset to a business perspective, requiring a shift from a technology-centric approach to a comprehensive comprehension of sales strategies and market dynamics. Effective sales strategies and alignment with market realities are paramount, outweighing technological enthusiasm. The interviews highlight researchers' pragmatic approach, often resulting in partnerships with industrial collaborators who can efficiently utilize the technology. This alliance is a practical method to bridge the gap between research and market implementation.

> *"It is always the problem with the developers; they want to focus then on one application." (Interviewee I04, EE)*

> *"The first thing is practicability. They just go for that." (Interviewee I02, EE)*

Overall, interviewees consistently identified a persistent challenge concerning the difficulty concentrating on a solitary, validated notion, as shifting between various ideas can deplete resources. Furthermore, a tendency to swiftly pursue the first industry-endorsed concept often overlooks the prospect of delving more profoundly and potentially independently commercializing other valuable applications, representing a significant obstacle in the technology transfer and spin-off development process.

Problem-Solution Fit and Market-centric Ideation

The importance of critical self-assessment in the ideation process is highlighted as a key observation. It is essential to be less reliant on one's vision and more receptive to external perspectives. The focus is on acknowledging the importance of third-party evaluations and support in shaping ideas. This methodology advocates a move away from self-made ideas towards ideation motivated by market observations. It illustrates the dangers of becoming too infatuated with technology. The interviewees recognize the potential of neglecting whether the technology genuinely tackles an issue. The concept of a "problem-solution fit" is emphasized, underlining the need for the technology to resolve a tangible problem effectively. Merely discovering one supporter is inadequate; it is vital to confirm the appropriateness of the resolution by having numerous individuals with the same issue validate it. The difficulties posed by this context comprise the intricate evaluation of deep technology during workshops. It can be challenging to understand the limitations and capabilities of such complex technology, so participants must understand its scope and potential. Another challenge is the potential danger of investing excessive time in technology development without proper validation. Continuously evaluating the suitability of the solution and conducting rigorous testing is fundamental. Failure to do so could result in wasted resources and a divergence from market requirements.

> *"I have to solve a real problem. The problem has to exist, and you do not have to find just one blind person; you have to have 3-4 people who have the same problem in the form." (Interviewee I36, ASO)*

The key observations highlight the importance of moving from internally generated ideas to ideas driven by market observations, underlining the concept of “problem-solution fit”. The emphasis here is on the need to avoid over-enthusiasm about the technology and instead concentrate on whether the technology is a natural solution to a real problem. The requirement for external validation and support in shaping ideas is highlighted, as are the potential pitfalls of spending too much time on technology development without proper validation. These findings are closely linked to problem-solution fit and market-centered ideation, emphasizing the need for a precise alignment between technological solutions and real market needs while continuously evaluating and testing the solution's suitability.

Team Dynamics and Collaboration

Objectivity is a priority, but recurring patterns reveal the importance of building a diverse network of people from different fields. Grammatical correctness is ensured while maintaining a formal register and logical flow of information. This facilitates the cross-pollination of concepts and broadens technology applications. A challenge identified is the need to involve a people with diverse backgrounds, knowledge, and skills in the ideation process to generate a wide range of ideas and to avoid the risk of falling back on the inventor's preconceived ideas. Striking a balance between involving inventors and remaining open to alternative viewpoints and enquiries is crucial. Challenges in fostering innovative thinking within teams are also recognized. Teams may sometimes fail to explore the full range of possible applications, thus hindering innovative progress. Interviewees note that stagnation in technology ideation can lead to team dissolution. This can be attributed to the inherent complexity of marketing and product launches, discouraging teams from pursuing their ideas. The interviews further stress the importance of patience in entrepreneurship. Developing a product, entering the market, and generating revenue may exceed the initially expected timeframe, requiring a commitment beyond the typical 12-month period. Recruitment of individuals with precise interests and skills is critical, particularly for disruptive or innovative technologies. Everyone does not fully understand some technologies, nor can they be developed into marketable products by everyone. Challenges arise when elaborating and refining ideas, especially when dealing with rare or complex technologies. An interviewee emphasizes the difficulty in establishing a culture within a company that enables teams to advance through various stages of teamwork proficiently. This entails transitioning from cautiousness to open cooperation, undertaking accountability for individual and team-based responsibilities, and cultivating a collective sense of obligation. Conquering opposition from those who favor solving issues independently can be arduous but is fundamental for successful collaboration.

> *"The importance lies in organizing good teamwork because nobody can do it alone." (Interviewee I16, TTM)*

The key messages in this section are the importance of diversity in the idea-generation process and the need to involve a wide range of people from different backgrounds to generate inventive ideas and avoid dependence on the inventor's preconceived ideas. Achieving a balance between inventor engagement and a willingness to consider alternative perspectives is essential. The challenges of fostering innovation within teams are recognized, as stagnation in technology ideation can potentially lead to team disintegration. Entrepreneurship emphasizes patience, as product development and revenue generation often take longer than expected. Further, recruiting individuals with specific skills is essential for disruptive technologies, and creating a corporate culture that moves from caution to open collaboration is also a crucial but challenging aspect of achieving success.

Technical Depth

A key challenge highlighted is the tendency of individuals with a scientific background to be captivated by technical intricacies and minutiae. This heightened preoccupation with technical detail could lead to an obsession with nuance, potentially diverting attention from broader, practical aspects. In addition, this sub-theme highlights the challenge of translating valuable product concepts into effective technical solutions in the early stages of development. While a visionary idea may have considerable potential for a company, comprehending how to execute it correctly can be a formidable task.

> *"Once the old burdens as a scientist. One is too enamored with technical details, with trivialities, with subtleties." (Interviewee I36, ASO)*

In sum, individuals with a scientific background face the challenge of becoming overly focused on technical details, potentially at the expense of broader practical considerations. In addition, effectively translating visionary product concepts into technical solutions in the early stages of development is a significant hurdle.

Timing and Persistence

A key aspect repeatedly discussed in the interviews is the personal attributes and characteristics, such as personal curiosity, a certain level of eccentricity, and an unwavering determination to persist despite setbacks. Explanations of technical abbreviations should be provided when first used. It is also essential to ensure that clear, concise and necessary information is provided in simple sentences while maintaining a logical flow of information with causal links between statements. A crucial aspect in this context is the capacity to confront challenges and persistently experiment. The interviews highlighted that technological innovation demands a significant allocation of time. Although progress may be rapid in the early stages, it often requires years of dedication as the process progresses. Such a temporal challenge can prove daunting for companies, which may opt to relinquish promising ideas because of the protracted duration and resource expenditure. Efforts involved in technology transfer from conception to implementation pose a significant challenge. Balancing the desire for immediate business outcomes with technology's need to mature and evolve is acknowledged as a paradoxical challenge. Constantly demanding immediate financial returns may hinder the development of cutting-edge technologies that often require a more extended-term strategy. Moreover, the significance of perseverance is highlighted since it is frequently undervalued. The original romanticized idea of a start-up can diverge greatly from the practicalities of the voyage.

> *"These things are taking a long time, so and this is a challenge because in the very first phase, you are very fast for months and then you need 2 two years and this is in the company, and some companies go through this process, and other companies say. This is a nice idea, but it is. Moreover, we see the business case and so on, but it is a year's effort right now, and we do not want to spend that." (Interviewee I26, RE)*

Essentially, key attributes such as personal curiosity, extravagance, and unwavering determination are emphasized as crucial to success. When it comes to technical details such as abbreviations or information, they need to be explained in a manner that people from outside the field can understand it easily. Considering the significant time and fortitude required for technological innovation, companies seeking rapid results may find this discouraging. Overall, striking a balance between short-term financial gains and long-term technological advancement poses a challenge, and persistence is often underestimated in creating a spin-off.

Transitions from Academia to Entrepreneurship

It is worth noting that setting up a company may be a more straightforward route for individuals who wish to remain in academia. However, launching a spin-off or new enterprise requires a substantial time investment and acquiring additional expertise. Transitioning from a scientist to a businessperson's role presents a distinct challenge. The main difficulty lies in moving away from the scientific realm and adopting a business-oriented outlook, which is crucial when starting or trying to commercialize a venture. The transition can be challenging for many scientists, who must learn to negotiate the business landscape. In addition, when embarking on entrepreneurial activities, individuals may need business acumen or may need to work with those who have a business background. This transition from academic independence, where the government provides research funding, to the corporate world necessitates undertaking fiscal obligations and producing value autonomously.

> *"When you try to commercialize in your enterprise, your start up, your own spin off. The big challenge is getting out of your scientific bubble and being a businessman. This is what the most scientists struggle." (Interviewee I29, RE)*

In brief, there are challenges in transitioning from academia to entrepreneurship. Establishing a company is an alternative that demands supplementary expertise and a transformation from a scientist's outlook to a business-oriented one. This changeover can be perplexing, necessitating adaptation to the demands of the commercial sector and may require people to acquire business knowledge or work together with those possessing business expertise. This transition from the realm of academia to the business world necessitates undertaking fiscal obligations and producing value autonomously.

4.3.3 Support in TAS

The TAS process is paved with uncertainties, a lack of structure, and a lack of knowledge. Therefore, appropriate support in this area is crucial. The interviews have yielded various insights, clustered into the following six areas: (1) Coaching, (2) Entrepreneurial Ecosystem, (3) Entrepreneurial Training, (4) Financial Support, (5) Support to Network and (6) Methodological Support (Table 11). The ASOs contributed the most statements regarding support in TAS. However, TTM and RE also highlighted several aspects. In contrast, EE made few statements.

Table 11: Categories of Support Mechanisms in TAS Processes

Category	Description
Coaching	Coaching is crucial for supporting spin-offs, providing guidance, knowledge sharing, and maintaining focus. There is a call for more experienced business consultants, and suggestions include assigning dedicated persons to startups and establishing collaboration hubs.
Entrepreneurial Ecosystem	The entrepreneurial ecosystem aids spin-offs by fostering collaboration and innovation. Exposure to global ecosystems, interdisciplinary collaboration, and leveraging experienced individuals contribute to overcoming challenges.
Entrepreneurial Training	Universities play a vital role in educating aspiring entrepreneurs. Suggestions include providing opportunities for students to discuss business concepts and integrating entrepreneurship into academic programs, with challenges noted in access to training programs.
Financial Support	Diverse financial support options exist, but bureaucracy is considered a hurdle. Critics argue for more support for bootstrapping, and extension of funding schemes. There's acknowledgment of varied perspectives on bureaucratic efforts.
Support to Network	Establishing networks is vital, with universities facilitating connections. Networking assistance proves crucial, emphasizing feedback, existing connections, mentorship, and ongoing university support.
Methodological Support	Lack of structured processes for idea generation is noted. Interviews suggest the need for structured innovation workshops, tools, and a dynamic approach. There's optimism about tools like the Business Model Canvas but reservations about imposing rigid processes.

Further, the categories Raising Awareness and Lack of Support were added, as they represent interconnected categories. All these areas were examined from various perspectives, highlighting well-functioning support mechanisms on the one hand and identifying areas lacking support that need improvement on the other.

Table 12: Interconnected Categories of Support Mechanisms in TAS Processes

Category	Description
Raising Awareness	Lack of familiarity with business models is a challenge. Raising awareness involves promoting entrepreneurship concepts, transcending academic vocations, and making workshops visible. Cultural differences and simulations are recognized as factors.
Lack of Support	Perceived lack of support in the early phase, particularly for the transition from PhD to entrepreneur. Criticism includes insufficient structures for awareness and limited past university support.

Coaching

Coaching is vital in supporting spin-offs as they frequently lack entrepreneurial expertise and are unfamiliar with such procedures. Coaches can guide spin-offs according to their requirements, ensuring they remain on the correct path. By offering guidance to teams sharing knowledge and experience, coaches support spin-offs throughout their journey. They possess various tools and techniques to lead spin-offs during different phases and issues. The interviews demonstrated that coaching aided them in maintaining their focus whilst advancing technology. Coaches provided a broader perspective and a clear view of the end goal whilst teams risked getting lost in the development of technology. Thus, they enabled them to maintain a focus on the overall development of the spin-off. Overall, coaches helped them stay on track. Coaches facilitate handling of time constraints by imposing precise deadlines that incite and engage teams to maintain concentration on their assignments and enhance their strategies.

> *"There is an enormous amount of support at universities. Nearly all the companies I know have mentors. There are support groups. Often, there are people who understand the market or invest money. Advisory boards or support committees." (Interviewee I01, TTM)*

The interviews recommended establishing collaboration hubs to engage with industry-specific coaches for targeted support. Critiques noted that most spin-off coaches lack genuine business experience, which hinders progress. Criticism has been directed towards the lack of engagement with experienced business consultants. However, it has been suggested that such coaching can be made available upon commission through spin-offs' financial support.

> *"Exactly, it would already be sufficient to assign a dedicated person to each startup and say: "Look, this is your contact person." Perhaps even a business consultant whom you contact once a quarter or with whom you have a kind of regular meeting to check how things are going. But none of that exists. As I mentioned, there was one meeting in one and a half years. During that meeting, they briefly looked at the financial planning. "(Interviewee I39, ASO)*

> *"I think programs like the EXIST start-up grant are great, especially because it allowed us to conduct coaching sessions with the funds it provided." (Interviewee I37, ASO)*

In summary, coaching is indispensable for spin-offs in technology transfer. It assists by steering them in the right direction, linking them with mentors, and aiding them in overcoming obstacles. The process can be further enhanced by setting up digital hubs and providing continuous mentorship. There is a unanimous agreement that coaching is paramount for spin-offs throughout this phase.

Entrepreneurial Ecosystem

The entrepreneurial ecosystem serves as a crucial aid for spin-offs. By providing a forum for individuals to share expertise and connect with others who share their interests, spin-offs can greatly benefit from the ecosystem. Universities can play an important role in promoting innovation events by referring teams to them and acquainting them with the multitude of opportunities available. Participation within such ecosystems can substantially alter perspectives and facilitate the acquisition of innovative ideas. Universities offer tailored programmed that promote inter-disciplinary collaboration in guided settings to further facilitate this. Interviews highlight the value of taking advice from those who have directly faced similar challenges and the significance of this insight for personal development.

> *"That's why it's very good to be part of this entrepreneur, start-up and innovation ecosystem around the world because they changed my mind and allowed me to help the people working with me to have that mindset." (Interviewee I03, ASO)*

In summary, this text highlights the significance of providing researchers and students with exposure to entrepreneurial ecosystems, promoting interdisciplinary collaboration within guided frameworks, exploring the influence of global ecosystems on mindsets, and leveraging the knowledge of experienced individuals to overcome challenges.

Entrepreneurial Training

Universities have a crucial role in educating aspiring entrepreneurs. One suggestion is that universities provide students with the chance to present and discuss business concepts without imposing them as mandatory. This can encourage an interest in entrepreneurship and identify a group of students who are keen to remain involved in entrepreneurial activities. Another idea proposed is the integration of entrepreneurship into academic programs during the early stages. Every scientist joining the university ought to undertake entrepreneurship training or, at a minimum, develop the ability to monetize their research outcomes. Nonetheless, this is challenging since the capacity to do so varies among individuals. Additionally, there has been criticism that German researchers who may be interested in spin-offs are not able to access existing training programs.

> *"Every scientist coming to the university has to do training in entrepreneurship or just like to commercialize things, to getting it view just if you on your research work with maybe or can be commercialized or not, I think it's hard because it depends on the people." (Interviewee I35, RE)*

Entrepreneurial training entails incorporating entrepreneurship into established academic frameworks to alert scientists to the potential for commercialization at a young age and bolster their entrepreneurial abilities.

Financial Support

Overall, the interviewees stated that diverse options are available for financial support, but the bureaucracy is considered unpleasant. However, the funding instruments offer some respite in decreasing personal financial risk. Conversely, given the financial remunerations, other perspectives do not perceive the bureaucratic effort as high. In general, the current forms of financial support are regarded as satisfactory, although an extension would be appreciated. Furthermore, critics argued that there is limited assistance obtainable for bootstrapping, as the current aid is directed towards obtaining investors, which is inadequate for spin-offs that opt to operate without them. Additionally, it was observed that not all establishments were willing to offer financial support, and determination was essential.

> *"I might have wished back then that the EXIST phase would have lasted not just one year, but two years. That would have been, let's say, better, but it was already good in its current form." (Interviewee I37, ASO)*

In general, sufficient financial backing is available for spin-offs. However, critics argue that bureaucratic obstacles are a concern, which are considered somewhat acceptable. Moreover, the funding schemes primarily favor investments over self-financing. Furthermore, the spin-off companies demand extended financial support.

Support to Network

Further support can be provided by establishing networks, in which universities play a significant role as they can facilitate pre-existing connections and relationships. Particularly in the initial phases, beneficial contacts and networks facilitated by attending meetings or events can be advantageous, as highlighted by Davidsson and Honig (2003). Through accessing the university and its programs, these available resources can be advantageous. The spin-off project can benefit greatly from external feedback and networking opportunities. Moreover, the university remains a valuable contact throughout different phases, providing access to additional resources and prospects through sustained collaboration.

> *"A lot of what we do relies on networks. Of course, we have methods and processes in place as well. They are documented on paper, but nobody really looks at them." (Interviewee I01, TTM)*

> *"The biggest gain was simply knowing people who could help us, at least in the field of development. That was an area where we made some good progress." (Interviewee I38, ASO)*

In conclusion, networking assistance is pivotal for upcoming entrepreneurs and researchers. The guidance provides entry to the university and its amenities, emphasizes the significance of feedback from external sources and adjusting accordingly, acknowledges the importance of existing interconnections and past relationships, recognizes the worth of gatherings and meetings, highlights the necessity of mentors and knowledge exchange, and underlines the perpetuity of support from the university. Establishing and utilizing a robust support network often proves more crucial and efficient than formal procedures and methodologies. Such a network can significantly influence the triumph of new ventures and research initiatives.

Methodological Support

The interviews reveal a lack of structured processes for idea generation despite the availability of resources for idea development. Structured methods aid in organizing and mobilizing teams and participants in innovation workshops and decision-making processes. Particularly, structured innovation workshops facilitate creative thinking and employ tailored tools for the context. Furthermore, collaborative tool design often promotes interdisciplinary cooperation that is fundamental to driving innovation. A dynamic and iterative approach is typically employed in tool usage, akin to a toolbox where the tools can be creatively adapted to suit the problem. The adaptability of tools to the specific use case is emphasized in this context. Tools should be viewed as a versatile toolbox from which the most suitable tool can be chosen according to the given circumstances. Nonetheless, it is crucial to acknowledge the constraints of the prevailing tools and techniques, comprehend them, and surpass them with the help of further brainstorming.

> *"There is a complete wing of the building, three big rooms, equipped with all kinds of stuff for ideation and development of ideas. But there is no structured way, how we use that for ideation." (Interviewee I04, EE)*

> *"Of course, having a roadmap, workshops, and coaching can be helpful, similar to a soccer coach who instructs players to put on the right shoe on the right foot and the left shoe on the left foot." (Interviewee I41, ASO)*

> *"We are kind of opening in a lot of different new fields. We have a lot of brainstorming. We learn from other disciplines and so on. So, I think this is from our horizon a lot." (Interviewee I34, RE)*

Although tools can provide significant benefits and can be applied to specific projects, they should be employed in a bespoke manner, depending on the task and collaboration, and canvas and models should be adjusted as required. Generally speaking, there is optimistic sentiment towards tools such as the Business Model Canvas, which can substantiate concepts, whilst it is emphasized that using tools alone is insufficient to ensure triumph. On the flip side, there are reservations about imposing a structured approach to the inherently undefined business process. Greater emphasis is placed on direct customer contact than on rigid processes. Furthermore, there is an emphasis on the significance of external experts who provide critical perspectives and possess expertise in guiding entrepreneurs. That being said, support in brainstorming and team building is crucially important, which can be effectively facilitated through the use of appropriate tools.

> *"The challenge is always, you need to find the right level for artifacts, how to go in deep in these artifacts you need. Yeah, you need to find out what is the best level, how, what, and sometimes you have limitations of this artifact. So just as an example of Business Model Canvas helps you for some parts but doesn't give you the complete picture. So, you need to understand where the limits of artifacts are. Overcome the limits by additional artifacts or by additional brainstorming or whatever. " (Interviewee I15, EE)*

Moreover, tools can potentially foster the acquisition of entrepreneurial skills by guiding individuals and promoting a systematic approach towards processing thoughts and identifying key problems. Nevertheless, the uniformity inherent in generic techniques often fails to translate into practical applications, necessitating carefully adapting methodologies to the specific context. Furthermore, one should consider the significance of personal networks and connections in commencing and maintaining entrepreneurial activities. These networks can be utilized more effectively when combined with tools. It is important to note that subjective evaluations must be clearly marked as such.

Launching a prosperous enterprise necessitates a combination of methodical resources and malleable strategies. The proficiency to competently apply these tools and techniques in practical scenarios is pivotal to the success of entrepreneurs and researchers.

4.3.4 Interconnection of Raising Awareness and Perceived Lack of Support

The inclusion of "raising awareness" and "lack of support" as categories within the wider context of support mechanisms is founded on their interconnectedness with multiple facets of entrepreneurial activities. These categories acknowledge the comprehensive nature of support necessary for successful entrepreneurship and innovation.

Raising Awareness

The lack of familiarity with business models, entrepreneurial processes and opportunities is a major challenge. Numerous students and researchers are unaware of these possibilities, underscoring the necessity of fostering entrepreneurial and business development concepts within their mindset. Encouraging them to transcend traditional academic or scientific vocations is deemed critical. Enhancing the visibility and accessibility of entrepreneurship-related workshops, associations, and programs for students is paramount. University promotion can bridge the gap between interested individuals and relevant resources. Even if it does not traditionally pertain to business or economics education, raising awareness among students that their research or developments could hold commercial potential beyond academia is believed to be a significant endeavor. Making entrepreneurship workshops, associations, and programs visible and accessible to students is crucial. Advertising within the university community can help interested individuals connect with relevant resources.

> *"If more people know their opportunities, I would say it's more like showing them other opportunities rather than just the scientific career because if I have to say, speak the truth." (Interviewee I29, RE)*

Educators and mentors recognize the importance of providing students with information and options, enabling them to make informed decisions regarding their career paths. The emphasis is on highlighting opportunities rather than dictating a specific career path. Cultural differences may exist in how students from diverse academic backgrounds perceive entrepreneurship. Certain fields may lean towards practical applications, while others may necessitate further encouragement. Employing games or simulations that accurately reflect real-world situations aims to raise awareness of various aspects, such as entrepreneurship and can be valuable for students and researchers.

> *"Even if it's just a course on the side where students get informed, I don't want to overwhelm them with business or economics, but I do want to sensitize them to the extent that they consider whether their research or development could have potential in other areas." (Interviewee I08, TTM)*

In essence, promoting awareness within the field of entrepreneurship and business poses a vital challenge. This involves educating, motivating and sensitizing students and researchers to the potential practical application of their work beyond academic contexts. The challenge highlights the importance of incorporating entrepreneurship education, endorsing relevant resources and fostering a pragmatic outlook towards business development. Fostering entrepreneurship and innovation necessitates tackling cultural discrepancies and the inadequate comprehension of individuals from diverse academic environments.

Lack of Support

Critical voices have noted a perceived lack of support in the early phase, focusing on the absence of assistance for the bridge between researcher and entrepreneur. Various support mechanisms have been presented, but insufficient structures for raising awareness and limited past university support have contributed to the overall deficiency.

> *"Many of them didn't have any support from the universities, but support from universities would be like certainly critical." (Interviewee I31, RE)*

These statements underscore universities' need to provide more extensive and adaptable support, particularly regarding entrepreneurship and innovation, whilst acknowledging the obstacles arising from the inadequate current provision.

Fundamentally, increasing awareness and addressing the insufficiency of support are all-encompassing motifs which intersect and complement diverse support mechanisms. With the potential to enhance the effectiveness of coaching, entrepreneurial ecosystems, training, financial and network support, as well as methodological approaches, they play fundamental roles as foundational components. By addressing these broader issues objectively, the entrepreneurial ecosystem can create a concise and necessary support structure for aspiring entrepreneurs and researchers.

Importance and Interconnection

Raising awareness is crucial, as numerous students and researchers may not be aware of the entrepreneurial possibilities within their work. This may be attributed to a dearth of knowledge of business models, entrepreneurial processes and available opportunities. Demonstrating its complicated interconnection, awareness works in synergy with several support mechanisms. It aligns with entrepreneurial training, providing an educational pathway for individuals to understand the practical application of their research. Additionally, it merges with networking support to act as a bridge that connects individuals with relevant resources. Ultimately, raising awareness serves as the foundation for the inception of successful entrepreneurial journeys.

Support deficiencies are apparent throughout the identified categories but are particularly evident in interviews conducted in general. Moreover, acknowledging a perceived absence of assistance, especially during the nascent phases linking researchers and entrepreneurship, is a crucial recognition. Such realization underlines the need for all-encompassing support throughout the entire entrepreneurial path. The lack of support poses a multi-dimensional challenge interconnecting various aspects. Robust coaching is indispensable in providing valuable guidance during intricate transition phases. Additionally, financial support plays a pivotal role in overcoming obstacles encountered along the entrepreneurial path. Networking support plays a critical role in filling perceived gaps in assistance, fostering collaboration, and providing external perspectives. The acknowledgment of this absence of assistance emphasizes its importance as a significant obstacle that requires collective endeavors for rectification and advancement within the entrepreneurial environment.

4.3.5 Comparison of Covered and Desired Support Mechanisms

In dissecting the complexities of entrepreneurial support mechanisms, it is crucial to make a clear distinction between the current support available and the desired support for a nuanced comprehension of areas that require improvement.

Table 13: Comparison of Covered and Desired Support Mechanisms

Category	Available Support	Desired Support
Coaching	Coaching can assist in challenging assumptions, communication strategies, customer perspective, and team dynamics. Coaches provide external perspectives and facilitate problem-solution fit.	Continuous coaching is desired to navigate uncertainty, adapt assumptions, and ensure effective communication with diverse stakeholders. Coaches can help in validating market-centric ideation and maintaining focus.
Entrepreneurial Ecosystem	Entrepreneurial ecosystems offer a platform for networking, diverse perspectives, and external collaborations. They can assist in market validation, understanding, and provide opportunities for team formation.	Enhanced exposure to global ecosystems is desired to foster innovation, challenge assumptions, and encourage collaboration. More tailored programs within ecosystems can address specific challenges.
Entrepreneurial Training	Entrepreneurial training in universities can contribute to addressing challenges related to knowledge gaps, team dynamics, and market-centric ideation.	More emphasis on practical aspects, deep dives into market realities, and critical self-assessment is desired. Training programs need to be more accessible for researchers interested in spin-offs.
Financial Support	Financial support can aid in overcoming challenges related to knowledge gaps, team formation, market validation, and transitions from academia to entrepreneurship.	Flexibility in financial support for early-stage validation, addressing practicability challenges, and persistence in innovation. More support for bootstrapping and dealing with market uncertainties.
Support to Network	Network support through universities facilitates collaboration, provides external perspectives, and can address challenges related to team dynamics and technical depth.	More structured networking opportunities, mentorship programs, and industry-specific coaching hubs are desired. Continuous support through sustained collaboration with the university is important.
Methodological Support	Methodological support, including structured innovation workshops, can contribute to addressing challenges in problem-solution fit, market-centric ideation, and transitions from academia to entrepreneurship.	More emphasis on adapting methodologies to specific challenges, addressing technical depth concerns, and providing dynamic toolsets for continuous evaluation.

In the context of coaching, the existing mechanisms provide valuable guidance in areas like challenging assumptions and refining communication. Coaches play a vital role in aligning technological innovation with market realities. However, the desired support envisions continuous coaching to foster adaptability, validate market-centric ideas, and ensure effective stakeholder engagement. This emphasizes the evolving entrepreneurial landscape that demands ongoing refinement. Entrepreneurial ecosystems, as current pillars of support, provide a fertile ground for networking and diverse perspectives. Their role in assisting with market validation, understanding, and team formation is acknowledged. However, the desired support seeks enhanced exposure to global ecosystems, a culture encouraging collaboration, and tailored programs addressing specific challenges within the dynamic entrepreneurial milieu. Within the scope of entrepreneurial training offered by universities, current support significantly addresses challenges related to knowledge gaps, team dynamics, and market-centric ideation. The call for desired support highlights a more practical orientation, deep dives into market realities, and critical self-assessment. The need for accessibility of training programs, especially for researchers interested in spin-offs, further accentuates the desired support framework. Financial support is a critical enabler, aiding in overcoming challenges across knowledge gaps, team formation, market validation, and transitions from academia to entrepreneurship. The current support mechanisms offer a solid foundation, yet the desired landscape seeks increased flexibility, particularly for early-stage validation and navigating the intricacies of market uncertainties. Moreover, there is an amplified focus on supporting bootstrapping endeavors. Network support, facilitated through universities, is instrumental in collaboration, offering external perspectives and addressing challenges related to team dynamics and technical depth. While the current support proves valuable, the desired framework envisages more structured networking opportunities, mentorship programs, and the establishment of industry-specific coaching hubs. The emphasis on continuous support through sustained collaboration with universities underscores the enduring nature of these relationships. Methodological support, encompassing structured innovation workshops, plays a pivotal role in addressing challenges related to problem-solution fit, market-centric ideation, and transitions from academia to entrepreneurship. The current support mechanisms offer a foundation, yet the desired landscape envisions a greater emphasis on adapting methodologies to specific challenges, addressing concerns of technical depth, and providing dynamic toolsets for continuous evaluation. This underscores the dynamic nature of entrepreneurial endeavors, demanding an agile and adaptive methodological support structure.

In summary, recognizing the disparity between existing and desired support within entrepreneurial pillars is crucial for comprehending complexities and outlining pathways for enhancement. This nuanced understanding acts as a compass for establishing the foundations of effective support processes to streamline TAS operations.

4.4 Discussion

The crucial but overlooked stage of TAS in the commercialization process has only gained recognition in recent times. Within this study, the initial stage of nascent academic spin-offs is investigated by gathering input from multiple technology transfer stakeholders, such as academic spin-offs, entrepreneurial educators, technology transfer managers, and researchers. By examining current practices, challenges, and support mechanisms in the TAS area, insights were gathered into the practice of TAS.

4.4.1 Descriptive Findings

To gain a more holistic overview, the distribution of contributions is shown in percentages (Table 14) and shortly described. Further, the number of mentions per dimension is analyzed and discussed (Table 15).

Table 14: Distribution of Mentions in Percentage

Stakeholer	TAS practice*	TAS Challenges*	TAS Support*	Overall contribution*
Entrepreneurship Education	5,4%	21,4%	4,8%	9,9%
Technology Transfer Manager	27,0%	14,3%	28,0%	23,7%
Academic Spin-Off	67,6%	52,9%	40,0%	48,3%
Researcher	0,0%	11,4%	27,2%	18,1%
Overall contribution of each group*	16,0%	30,2%	53,9%	100,0%

*Mentions in Interviews

Statements on TAS practices come mainly from academic spin-offs (68%), followed by TTM (27%) and EE (5%). However, researchers did not contribute any insights. Overall, the dimension is underlined by 16% of the mentions. Insights into TAS challenges come mainly from academic spin-offs (53%), while researchers contribute the least (11%). This discrepancy may be due to the fact that spin-offs have already gone through this stage, while researchers may not priorities this aspect, considering it a subset of the overall process. The TTM and EE groups provide an external perspective based on their observations. Overall, the dimension of challenges is emphasized by 30,2% of respondents. The dimension of TAS support is mainly underlined by academic spin-offs with 40%. Researchers and TTMs contribute equally to this dimension with 27-28%, providing important insights into support mechanisms. Entrepreneurship education, on the other hand, is only briefly mentioned, accounting for a modest 4.8%. The support mechanisms highlighted reflect both the perceived provision and the perceived need for support mechanisms. All stakeholders contribute to both aspects, highlighting both existing support and perceived needs within the TAS process. Overall, mentions in this dimension accounted for 53,9% of all mentions.

When scrutinizing the outcomes of the qualitative analysis, particular emphasis is placed on the references to each level 2 process (Table 15).

Table 15: Distribution of Codes and Mentions

Main Code: TAS Interviews	
Level 1: TAS in Practice	**Mentions**
Level 2: Customer-centric Approach	8
Level 2: Early Feedback	3
Level 2: Opportunity Identification	5
Level 2: Iterative Process	12
Level 2: Market Research	9
Level 1: Challenges in TAS	**Mentions**
Level 2: Assumptions and Deep Dives	5
Level 2: Communication and Stakeholder Engagement	5
Level 2: Customer Perspective and Early Validation	5
Level 2: Knowledge Gaps and Team Formation	13
Level 2: Market Validation and Understanding	11
Level 2: Practicability and Focus on One Application	7
Level 2: Problem-Solution Fit and Market-Centric Ideation	5
Level 2: Team Dynamics and Collaboration	9
Level 2: Technical Depth	2
Level 2: Timing and Persistence	5
Level 2: Transition from Academia to Entrepreneurship	3
Level 1: Support in TAS	**Mentions**
Level 2: Coaching	14
Level 2: Entrepreneurial Ecosystem	6
Level 2: Entrepreneurial Training	8
Level 2: Financial Support	9
Level 2: Support to Network	8
Level 2: Methodological Support	47
Level 2: Raising Awareness	16
Level 2: Lack of Support	14

It is evident that within "TAS in Practice," the iterative process is notably highlighted, garnering a total of 12 mentions. Following closely are market research and the customer-centric approach. In contrast, early feedback is the least frequently cited, with only 3 mentions. Considering the low percentage of contributions in this dimension, the findings indicate that "TAS in Practice" constitutes a relatively underexplored subject, with the iterative process standing out prominently. Conversely, aspects such as early feedback and proactive processes like opportunity recognition are scarcely mentioned. Further, the dimension TAS practice reveals a relatively modest contribution, underscored by 27 of the overall mentions.

Within the “TAS challenges”, notable mentions of Level 2 codes include "Knowledge Gaps and Team Formation" and "Market Validation and Understanding," standing out with 13 and 11 mentions, respectively. Conversely, there are fewer mentions for certain Level 2 codes, such as "Technical Depth" and "Transition from Academia to Entrepreneurship." A significant range of challenges falls between 5 and 7 mentions. Surprisingly, "Customer Perspective and Early Validation" as well as "Assumptions and Deep Dives" each receive only 5 mentions, despite their substantial overlap with codes from TAS in Practice. In contrast to TAS in practice, the mentions within the challenge section reach 70, thereby more than doubling the amount. In summary, a diverse array of recognized challenges exists within the TAS process, originating from various domains. Notably, aspects such as technical depth, transition from academia to entrepreneurship, and team-related considerations are absent from the discussions in TAS in Practice

“Support in TAS” exhibits a clear leader in mentions within the domain of methodological support, totaling 47 mentions. These references equally pertain to both desired and covered support, collectively indicating that this area is most prominently perceived as a support system for the process. Additionally, coaching emerges as a relevant facet with 14 mentions, while the entrepreneurial ecosystem garners the least attention with only 6 mentions. It is noteworthy, however, that "raising awareness" with 16 mentions and "lack of support" with 14 mentions highlight criticisms of current support mechanisms, together comprising a substantial portion of the overall mentions at 30. With a total of 125 mentions, support constitutes the most extensive category. This suggests that support is a crucial aspect of the TAS process, with spin-offs and researchers requiring substantial assistance, while EE and TTM perceive this as their primary contribution.

4.4.2 Dimension-related Findings

4.4.2.1 TAS in Practice

The “customer-centric approach” category highlights the importance of close customer cooperation. This involves understanding their different needs and preferences. Innovation efforts must be aligned with these. Equally important, “early feedback” is highlighted as an essential part of the innovation process. The interviewees highlight the benefits of engaging with stakeholders and potential users early to address critical concerns and gauge the market's receptiveness. In addition, the “identifying opportunities” category underlines the proactive and vigilant exploration of innovative concepts from various sources. Respondents extol the virtues of remaining open to a wealth of inspiration, actively soliciting input during the ideation phase, and taking advantage of technological advances and opportune moments for action. The next category highlights the “iterative nature” of the innovation and entrepreneurial journey. This involves a continual process of learning, refining, and acquiring fresh insights throughout the TAS process. This iterative approach serves as the foundation for experimentation and effective problem-solving. Finally, the “market research” category is explained as a dynamic and exploratory dimension of innovation and entrepreneurship. Entrepreneurs are portrayed as actively engaging in dialogues, networking events and knowledge sharing to elicit feedback and insights. A careful approach to market research emerges as an essential prerequisite for identifying viable markets and assessing readiness to innovate.

These categories provide a comprehensive perspective on the practical implementation of TAS. They emphasize the centrality of customer engagement, continuous refinement, early validation and the fluidity inherent in entrepreneurial endeavors. These categories are closely intertwined, with Early Feedback encompassing the fundamental principles of a customer-centric approach and Opportunity Identification encompassing various categories within this domain. However, these categories retain their distinct identities. These represent the prevailing landscape of TAS practices in contemporary contexts.

4.4.2.2 Challenges in TAS Processes

The outlined challenges provide insight into the main focus of the TAS process. However, it is apparent that this process is intertwined with other stages, and the obstacles identified are also relevant to other domains. The findings comprise a comprehensive overview of challenges that can aid researchers in future commercialization projects. Assumptions pose a formidable challenge in the TAS process, necessitating the acknowledgement that they are mere assumptions to facilitate a comprehensive evaluation. Researchers often become entrenched in initial ideas, underscoring the criticality of continuously challenging and modifying assumptions to align with evolving circumstances. Striking a balance between the imperative for in-depth analysis and the practicality of early validation presents a significant challenge. Additionally, effective communication with diverse stakeholders is identified as challenging, as conveying technological benefits to non-technical individuals, building trust, and fostering collaboration require nuanced strategies. The challenge of understanding the customer's perspective and enabling early validation is crucial but intricate. Early validation and establishing close customer relationships are deemed indispensable for confirming emerging assumptions. Overcoming knowledge gaps and assembling an adept team is recognized as a substantial challenge, with the acquisition of necessary expertise and recognition of its importance being pivotal. Aligning technological innovation with market realities remains a key challenge, requiring researchers to target the right audience, comprehend production problems, and grasp market issues. Striking a balance between visionary ideas and market acceptance is a persistent challenge. Focusing on a well-defined application is deemed critical for success, emphasizing the importance of solving real-world problems rather than being solely technology-centric. Addressing existing technological challenges necessitates objective evaluation for improvement opportunities. Critical self-assessment and openness to external perspectives are deemed vital. The concept of "problem-solution fit" is emphasized as challenging, alongside the recognition that external validation and support are crucial for shaping ideas. Building a diverse network of individuals from different fields is seen as essential for generating innovative ideas, and overcoming stagnation in technology ideation requires patience and the recruitment of individuals with specific skills. The tendency of scientists to focus excessively on technical intricacies can impede attention to practical aspects, hindering a successful TAS process. Translating visionary concepts into effective technical solutions, particularly in the early stages of development, is recognized as challenging. Personal attributes such as curiosity, determination, and patience, which are critical for technological innovation, are perceived as challenging for researchers, as these attributes are not commonly associated with the academic realm. The transition from academia to entrepreneurship is acknowledged as a formidable challenge, requiring researchers to adapt to a business-oriented outlook. This shift is considered a critical hurdle for researchers navigating the business landscape and may necessitate business acumen or collaboration with business experts. In conclusion, the identified challenges significantly impact the process of identifying applications and selections for new technologies. They underscore the imperative for adaptability, effective communication, customer focus, knowledge acquisition, market alignment, practicality, and persistence. Notably, the challenges in themselves are interconnected, requiring a holistic strategy. Nevertheless, they are partly already recognized in practice. For instance, the challenge of effective communication aligns with the need for a customer-centric approach, highlighted by practice insights. Further, challenges associated with assumptions and early validation complement the iterative nature of the innovation process, which is also represented in TAS in practice. However, certain challenges, such as personal attributes critical for innovation, and the transition from academia to entrepreneurship, appear less explicitly addressed in identified TAS practices. Overall, the challenges outlined underscore the existence of numerous hurdles within the TAS process, which, in comparison to highlighted TAS practices, appear disproportionately substantial. This signifies a lack of structure in the process, a lack of clear perspectives on the significance of specific steps, and an absence of optimal strategies for addressing emerging challenges. A successful TAS process hinges on adaptability, effective communication, customer focus, knowledge acquisition, market alignment, practicality, and persistence. Addressing the entirety of the TAS process is imperative for navigating the intricacies of innovation successfully.

4.4.2.3 Support Mechanisms of TAS Processes

The findings in the dimension support emphasize the importance of coaching, entrepreneurial ecosystems, training, financial support, networking, methodological support, as well as the general recognition of the need for awareness-raising and a general lack of support. While the provided support mechanisms were acknowledged, also the desire for further support mechanisms was discussed. Universities have a crucial role in facilitating these elements to nurture entrepreneurship and innovation effectively. Coaching proves crucial in steering spin-offs, helping them maintain focus, fostering holistic thinking, and improving critical thinking skills. Nevertheless, it is imperative to emphasize that customization specific to every spin-off's needs, industry, and development stage demands attention, which is currently inconsistent. The critique about mentors' insufficient business experience has led to a craving for consultation with business consultants or skilled entrepreneurs, as they usually stem from entrepreneurial research, focusing on the theory of entrepreneurial practices and methods. Coaching is highly appreciated, yet often underutilized, indicating a demand for more bespoke support mechanisms. Entrepreneurial ecosystems are crucial to support networking with other spin-offs, affirming concepts, propelling projects, and obtaining insights from others' experiences. Experienced individuals underline the importance of entrepreneurial ecosystems and stress the need to increase awareness among researchers lacking exposure to entrepreneurial events and network formats. There is a desire for more comprehensive entrepreneurial training, which is currently believed to be inadequate. It is believed that better preparation and university support would be helpful in this regard, although not necessarily suitable for everyone. Financial backing seems adequate and is widely appreciated, although individuals may perceive bureaucratic obstacles differently. Methodological support usually entails structured processes, techniques, and tools. Even though tools are appreciated, their present usage is lacking both structure and focus. Using tools contextually and relevantly to satisfy current requirements and consider them part of a wider entrepreneurial activity context is essential. Raising awareness is important, particularly for researchers who might be oblivious to commercialization opportunities. There is a need for earlier engagement, particularly at the student level, to increase entrepreneurship awareness. Entrepreneurial simulations are encouraged as a way to introduce students to the field. Five researchers have raised the issue of inadequate support; however, TTM and EE do not make any mention of this concern. Given that these groups and spin-offs are the main focus of these support activities, it is imperative to critically examine them and use this as motivation for improvement in these areas. The overall assessment highlights the importance of different support mechanisms, including coaching, entrepreneurial ecosystems, training, financial support, networking, methodological support and awareness-raising, in the promotion of entrepreneurship and innovation. While the present mechanisms are appreciated, inadequate support is a matter of concern with scope for enhancement, especially in the domains of mentoring and early-phase support.

4.4.3 Interconnection of the Dimensions

Clearly, the dimensions of TAS processes, challenges and perceived support are closely interrelated and it is beneficial to recognize how they interact. As we examine present-day TAS processes, it is apparent that challenges surpass perceived support mechanisms. Nonetheless, specific challenges that arise in the context of TAS processes may not be directly tackled by support mechanisms, such as technical depth or timing issues, and it is worth noting this. Depicting precise relationships can be challenging. Figure 3 offers an abstract view, exhibiting directly observable connections.

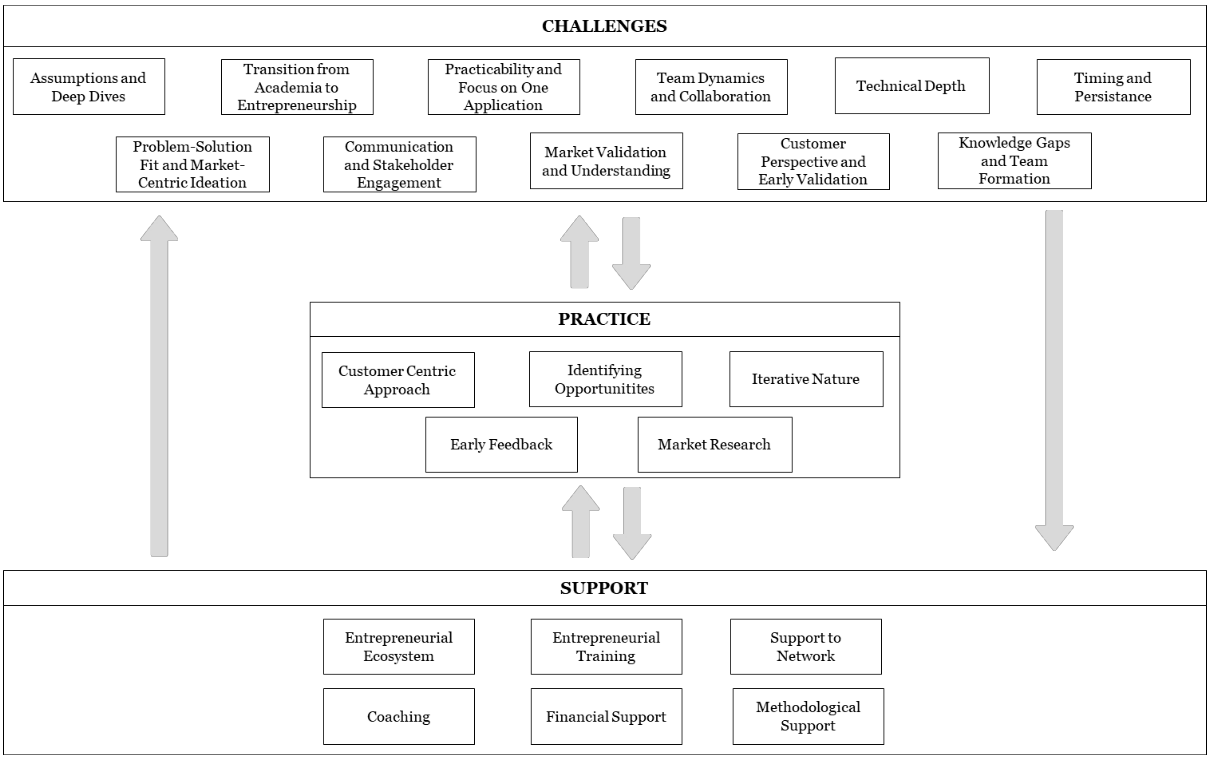

Figure 3: Abstract Representation of the Interconnection of the Dimensions (Own Illustration)

Several noteworthy overlaps and interconnections emerge between these dimensions of TAS in Practice, related challenges and support in TAS. The "customer-centric approach" highlighted in TAS in Practice aligns closely with challenges related to effective communication, understanding the customer perspective, and early validation. It also intersects with support regarding raising awareness about the importance of customer engagement and feedback. Further, the emphasis on early feedback, representing another category in TAS in Practice, connects directly with challenges, particularly those related to effective communication, customer perspective, and early validation, also representing an overlap with the above alignment. Additionally, it aligns with the support dimension by emphasizing the role of coaching and awareness-raising in facilitating early feedback mechanisms. The category of "identifying opportunities" encompasses proactive exploration of innovative concepts and aligns with the iterative nature of TAS practices. Challenges related to visionary ideas, problem-solution fit, and knowledge gaps are intertwined with this dimension. Support mechanisms such as training and methodological support also contribute to enhancing opportunity identification. The iterative nature of TAS practices, as highlighted, underpins the importance of continuous refinement and adaptation. This aspect aligns with various challenges, such as balancing visionary ideas with market acceptance and translating concepts into technical solutions. It also correlates with support, where coaching and training are essential in guiding iterative improvement. The dimension of market research, discussed in TAS in Practice, directly relates to Challenges associated with market alignment and the need to target the right audience. Support mechanisms, including networking and methodological support, also facilitate effective market research practices. These interconnections emphasize that these dimensions are not isolated but rather form a cohesive ecosystem within technology transfer and entrepreneurship. Successful TAS practices require addressing challenges, leveraging support, and integrating customer-centric approaches, early feedback mechanisms, opportunity identification, and iterative refinement into the overall process.

Table 16: Division of the Respective Codes Showing their Representation in the Other Dimensions

TAS in Practice	**Code**	**Challenges in TAS**	**Support in TAS**
Customer-centric Approach	P1	C1, C2, C3,	S1, S3, S5, S6
Early Feedback	P2	C1, C3, C4, C6, C7	S1, S2, S5
Opportunity Identification	P3	C2, C3, C6	S1, S2, S3, S5, S6
Iterative Process	P4	C1, C2, C3, C5, C7, C10	S1, S2, S3, S5, S6
Market Research	P5	C5, C7	S1, S3, S6
TAS Challenges	**Code**	**TAS in Practice**	**Support in TAS**
Assumptions and Deep Dives	C1	P1, P2, P4	S1, S2, S3, S5, S6
Communication and Stakeholder Engagement	C2	P1, P3, P4	S2, S5
Customer Perspective and Early Validation	C3	P1, P2, P3, P4	S1, S2, S5, S6
Knowledge Gaps and Team Formation	C4	P2	S1, S5, S6
Market Validation and Understanding	C5	P4, P5	S1, S2, S3, S5, S6
Practicability and Focus on One Application	C6	P2, P3	S1, S6
Problem-Solution Fit and Market-Centric Ideation	C7	P2, P4, P5	S1, S2, S3, S5, S6
Team Dynamics and Collaboration	C8	-	S1, S6
Technical Depth	C9	-	-
Timing and Persistence	C10	P4	S1, S6
Transition from Academia to Entrepreneurship	C11	-	S1
TAS Support	**Code**	**TAS in Practice**	**Challenges in TAS**
Coaching	S1	P1, P2, P3, P4, P5	C1, C3, C4, C5, C6, C7, C8, C10, C11
Entrepreneurial Ecosystem	S2	P2, P3, P4	C1, C2, C3, C5, C7
Entrepreneurial Training	S3	P1, P3, P4, P5	C1, C5, C7
Financial Support	S4	-	-
Support to Network	S5	P1, P2, P3, P4	C1, C2, C3, C5, C7
Methodological Support	S6	P1, P3, P4, P5	C1, C3 C4, C5, C6, C7, C8, C10
Raising Awareness	*S7*	-	-
Lack of Support	*S8*	-	-

Although this figure provides only a broad overview of the interconnections, it offers a quick glimpse into the diversity of perceived challenges in contrast to support mechanisms and representations of TAS in practice. Additionally, it becomes apparent that not all challenges are recognizable in practice, and certainly, not all challenges are addressed by support mechanisms. The division of the respective associated challenges, support mechanisms, and recognized practices in TAS in Table 16 reveals, for instance, that C8, C9, and C11 are not mentioned at all in TAS in Practice. Regarding support mechanisms, the financial aspect is not mentioned in either TAS in Practice or the challenges. "Raising Awareness" and "Lack of Support" are shaded, signifying them as general exceptions.

By examining the number of reflected codes in each area, one can discern which challenges have already been addressed and where more attention is needed. Particularly, C2, C6, and C10 should receive more attention. Even though other highly relevant areas highlighted in both TAS in Practice and the challenges, such as Problem-Solution Fit and Customer Perspective and Early Validation, should not be neglected, they should be systematically integrated into the TAS in Practice process.

4.5 Conclusion

Within this study, the early phase of technology commercialization, precisely the application identification and selection of technologies, was investigated by conducting 45 semi-structured interviews with various stakeholders involved in the technology transfer process to answer the proposed research question. To gain a broad picture, two perspectives were incorporated, including the support side, represented by entrepreneurship educators and technology transfer managers and the executive side, represented by spin-offs and researchers who may be interested in spin-off ventures. By inductively analyzing the interviews (Gioia et al., 2013), 24 second-order categories were derived, leading to the final set of insights of this study.

The research focuses on the early stages of nascent spin-offs and revealed different findings on how the TAS process manifests in practice. First, the study shows that the practical implementation of TAS has been somewhat neglected, with more emphasis on problem-solving and support. Second, key sections such as “customer-centric approach”, “iterative process”, “early feedback”, “opportunity recognition” and “market research” provide a comprehensive overview of TAS practices, highlighting the importance of customer engagement, continuous improvement, rapid review, and adaptability. Third, key challenges influencing the TAS process in practice are: Including assumptions, effective communication, the customer perspective, initial validation, knowledge gaps, market alignment and balancing innovative proposals with market acceptance. Adapting to a business-oriented mentality is a significant barrier for researchers to realize the transition from academia to entrepreneurship. Coaching, entrepreneurial ecosystems, training, financial support, networking, methodological support, and awareness raising are among the support mechanisms for TAS. These mechanisms are valued. However, there is room for improvement, particularly in mentoring and early-stage support. The linkages between these dimensions are evidence of their coherence in the context of technology transfer and entrepreneurship. The successful implementation of TAS requires the management of challenges, the use of support and the integration of customer-centric approaches, early feedback mechanisms, the identification of opportunities and iterative refinement in the overall process.

By elucidating the practical manifestation of the TAS process, the study findings reveal the presence of TAS recognition in the technology commercialization process. Despite indications in the literature suggesting a lack of research attention to this aspect, our findings underscore its actual existence in practical scenarios. Consequently, it is evident that further theoretical examination of the issue is warranted. Thus, this research serves to address and contribute to the identified gap in the existing literature.

Certainly, this study faces limitations. One is that it is based on qualitative data collected through a series of interviews. While qualitative research provides valuable insights, it may not capture quantitative or statistical patterns, which limits our ability to make broader empirical claims. In addition, this research is a single, narrowly focused study. It does not explore the long-term consequences or effects of TAS practices, leaving this as an area for future investigation. Furthermore, despite including diverse perspectives in the sample, each stakeholder category was represented by a small sample size, raising the possibility of bias due to limited sample representation.

Future research could include investigations into effective education and training initiatives to support researchers in their transition to entrepreneurship. This may increase their readiness to tackle the challenges associated with TAS. In addition, there is potential for research to explore TAS practices, challenges, and support mechanisms in different technology transfer settings. Such a broader approach could lead to more comprehensive findings, thereby increasing the potential for generalization and wider applicability.

5 Investigation of TAS Processes

5.1 Introduction

Although the relevance for a systematic TAS processes was identified (Kuo et al., 2011; Platzek, Pretorius, & Winzker, 2012), only isolated or no systematic approaches are prevalent in practice. Especially, actors in the area of academic spin-offs expressed high interest in a structured approach to transform the technology developed in research institutions into a consumable product or service (Djokovic & Souitaris, 2008; Rothaermel & Boeker, 2008). Pattern analysis and the characterization of existing TAS approaches can provide a valuable understanding of their relevant contents and guide the compilation of a systematic approach. Manthey et al. (2022a) addressed this gap with an SLR and identified 17 TAS tools (Table 17) designed for stakeholders to extract value from technology by identifying and selecting suitable applications that stimulate further development. These approaches were tailored to technology managers, companies of different sizes, and individuals (Manthey et al., 2022a).

Table 17: Identified TAS approaches by Manthey et al. (2022a)

Authors	Year	Titles
Bianchi et al.	**2010**	Enabling Open Innovation in Small and Medium-Sized Enterprises: How to Find Alternative Applications for Your Technologies
Bishop	**2004**	A Comprehensive Model for Technology Push Product Development
Conway and McGuiness	**1986**	Idea Generation in Technology-Based Firms
Daneels	**2007**	The Process of Technological Competence Leveraging
Evans et al.	**2010**	Seeding and Harvesting the Innovation Gap: Linking Technology to Spcial and Market Needs
Felkl	**2013**	Advanced Technology Innovation Mapping Tool to Support Technology Commercialization
Henkel and Jung	**2009**	The Technology-Push Lead User Concept: A New Tool for Application Identification
Holzleitner	**2015**	A Comprehensive Framework for Successful Commercialization of Technology Push Group
Kuo et al.	**2011**	Reconsidering the Role of Brainstorming in the Marketing of Technology-Driven Innovation
Lynn and Heintz	**1992**	From Experience: Where Does Your new Technology fit Into the Marketplace?
Maarse and Bogers	**2012**	An Integrative Model for Technology-Driven Innovation and External Technology Commercialization
Moncada-Paternò-Castello et al.	**2003**	Early Identification and Marketing of Innovative Technologies: A Case Study of RTD Result Valorisation at the European Comission's Joint Research Centre
Nelson	**2005**	A Detailed Approach for Concept Generation and Evaluation in a Technology Push Product Development Environment
Roberson and Weijo	**1988**	Using Market Research to Convert Federal Technology into Marketable Products
Souder	**1989**	Improving Productivity Through Technology Push
Strøm	**2018**	Identification of Applications to Technology in the CERN Knowledge Transfer Group
Terzidis and Vogel	**2018**	A Unified Model of the Technology Push Process and Ist Application in a Workshop Setting

Furthermore, the conceptualization of a TAS process involves delineating six distinct clusters deemed foundational elements. These clusters include Technology Characterization, Trend Assessment, Market Assessment, Customer Integration, Value Analysis and Evaluation. Technology Characterization is conducted by closely examining basic functional and situational characteristics. Trend Assessment entails exploring related trends and changes, while Market Assessment involves delving into the associated market and industry dynamics. Customer Integration focuses on understanding the needs of the customer. Value Analysis encompasses the assessment of market and customer value. Lastly, Evaluation involves assessing the application against defined criteria. Notably, as Manthey et al. (2022a) highlighted the identified approaches exhibit an average coverage of approximately 3-5 of these clusters, with none encompassing all of them.

However, the study does not provide a detailed account of the building blocks and the interconnectedness of these, as well as how these building blocks are specifically interpreted in each study and where potential commonalities exist. Therefore, the study by Manthey et al. (2022a) serves as a valid starting point. To ensure scientific rigor, further research is necessary. Thus, this research aims to delineate the key attributes of a successful TAS process in the context of technology push, focusing on its application to the technology commercialization efforts of spin-offs, leading to the overall research question:

How should an ideal TAS process be conceptualized?

By identifying common methodologies and process steps through a comprehensive analysis of existing TAS processes/frameworks, insights can be drawn from the comparisons. Consequently, the research lays the foundation for the construction of a theoretical model for a systematic and successful TAS framework. This model is intended to be applicable across different scientific fields, ensuring generalizability in terms of given technologies beyond its specific context.

5.2 Research Approach

By applying an SLR, following the methodology proposed by Kitchenham and Charters (2007), this research aims to provide insights into existing approaches within the field of TAS to support researchers in the fuzzy front end of the innovation process. This review specifically targets identifying existing processes, methods, and tools employed in the context of TAS for spinoffs. The synthesis of this information contributes to a comprehensive understanding of the landscape, thereby offering valuable insights into the requirements of such an approach. A diverse range of electronic databases and academic repositories will be thoroughly examined to ensure inclusivity. The review will extend beyond journal articles to encompass various forms of literature. The inclusion criteria will be based on the significance of the literature in relation to the entrepreneurial aspects of the posed TAS process.

The data identified through the SLR will serve as input for the subsequent approach, structured as follows:

1. **Gathering Approaches:** Collecting a comprehensive set of approaches described in research for finding and selecting applications for newly developed technologies.
2. **Determinant Selection:** Identifying and selecting crucial determinants to characterize these approaches.
3. **Analysis:** Systematically analyzing the identified approaches by determining their strengths, weaknesses, limitations, challenges, unique features, and success factors, culminating in the compilation of an overview.
4. **Pattern Recognition:** Recognizing patterns and regularities within the analyzed approaches, facilitating comparability and clustering. Concluding various aspects of these approaches.
5. **Theoretical Model Construction:** Utilizing the insights gained from the analysis to construct a theoretical model for a TAS Process specifically tailored for push innovations. This theoretical model aims to provide a structured framework for effectively identifying and selecting applications for newly developed technologies.

The SLR adhered to the model outlined by Kitchenham and Charters (2007), comprising three key phases: Planning the review, conducting the review, and reporting on the results.

Concerning the first phase, defining Research Questions and Objectives, the research questions were set centered on identifying various TAS processes documented in the literature. The overarching objective was to compile and understand relevant TAS processes to derive the requirements of a theoretical TAS model, supporting spin-off commercialization in the FFE best. Inherent with developing a search strategy, a diverse set of databases was selected: Web of Science, Scopus, IEEE Xplore, ProQuest and PubMed. This diverse database selection strategy ensures a comprehensive exploration of TAS processes across interdisciplinary and specialized domains. The search string used for the TAS process exploration was defined as follows, consisting of several synonyms in terms of field, topic and aspect, arousing around the main terms “Technology push”, “Application identification and selection”, and “approach”. The findings were selected based on predefined inclusion and exclusion criteria (Table 19). No date limitation is set in this study, which will allow for a comprehensive and historical examination of the topics, contributing to a richer and more complete literature review. Also, the studies identified by Manthey et al. (2022a) varies between 1989 and 2018, reasoning a wide data range.

Table 18: Core Concepts of the Research Questions and Derived Keywords for Search Query

Core Concepts	Keywords
Technology Push	technology push, technology transfer, technology commercial*, research commercial*, spin$off, academic entrepreneur*, technology entrepreneur*, nascent entrepreneur*, university entrepreneur*, research entrepreneur*, fuzzy front end
Application Identification and Selection	application identif*, application select*, application ideat* application prospect*, technology prospect*, opportunity recogni*, opportunity identif*, opportunity discover*, opportunity develop*, innovation diffus*
Approach	framework, model, method, approach, process, guide, tool, artifact, artefact

Table 19: Study Selection Criteria Applied in SLR

Inclusion Criteria	Exclusion Criteria
Research study creates or covers TAS approaches	Not available in English
Practical contribution	Not peer-reviewed
	Access to full paper not available
	Niche topic

The third phase of the review resulted in a total of 504 identified papers. After eliminating duplicates (459), the results were reduced by title and abstract screening (23). Further, inclusion and exclusion criteria were set, resulting in a final of 3 papers. No further sources were identified through the application of forward and backward citation searches. In conclusion, the literature search yielded three significant results of TAS processes.

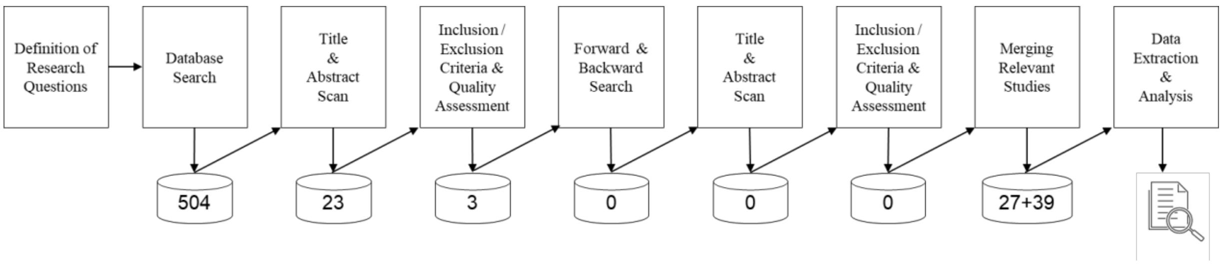

Figure 4: SLR Process: Visualization (adapted from Petersen et al., 2008)

Two of them (Linton & Walsh, 2008; Terzidis & Vogel, 2018) were previously identified by Manthey et al. (2022a), validating the findings of prior research. However, the third result, a study by Russo et al. (2020), emerged as a particularly interesting process, distinctively divergent from the previously identified methods. The inclusion of this third process for further analysis will augment the comprehensiveness and depth of this study, potentially offering insights and perspectives into the objectives being explored**.**

5.3 Results

Building upon the findings of Manthey et al. (2022a), the identified processes are compared and merged, resulting in a total of 18 processes taken for further analysis (Table 20). In pursuit of addressing the research questions and developing a conceptual theory-based model for a systematic TAS process, a thorough understanding of the structure of TAS processes is essential. This understanding is critical for systematically uncovering the construction and operation of these processes step by step. It involves identifying the specific functions of each part of the process, making inferences about necessary resources, and evaluating advantages and disadvantages. By this analysis, insights into the required clusters and their functionalities can be derived, contributing to a nuanced exploration of the TAS process.

Table 20: Identified TAS Processes

Authors	Year	Titles
Bianchi et al.	**2010**	Enabling open innovation in small- and medium-sized enterprises: how to find alternative applications for your technologies
Bishop	**2004**	A comprehensive model for technology push product development
Conway and McGuinness	**1986**	Idea Generation in Technology-Based Firms
Danneels	**2007**	The process of technological competence leveraging
Evans et al.	**2010**	Seeding and Harvesting the Innovation Gap: Linking Technology to Social and Market Needs
Felkl	**2013**	Advanced Technology Innovation Mapping Tool to Support Technology Commercialization
Henkel and Jung	**2009**	The Technology-Push Lead User Concept: A New Tool for Application Identification
Holzleitner	**2015**	A comprehensive framework for successful commercialization of technology push innovations
Kuo et al.	**2011**	Reconsidering the Role of Brainstorming in the Marketing of Technology-Driven Innovation
Lynn and Heintz	**1992**	From Experience: Where Does Your New Technology Fit into the Marketplace?
Maarse and Bogers	**2012**	An Integrative Model for Technology-Driven Innovation and External Technology Commercialization
Moncada-Paterno-Castello et al.	**2003**	Early identification and marketing of innovative technologies: a case study of RTD result valorisation at the European Commission's Joint Research Centre
Nelson	**2005**	A detailed approach for concept generation and evaluation in a technology push product development environment
Roberson and Weijo	**1988**	Using market research to convert federal technology into marketable products
Russo et al.	**2020**	Discovering new business opportunities with dependent semantic parsers
Souder	**1989**	Improving productivity through technology push
Strøm	**2018**	Identification of Applications to Technology in the CERN Knowledge Transfer Group
Terzidis and Vogel	**2018**	A Unified Model of the Technology Push Process and Its Application in a Workshop Setting

5.3.1 Characterization of TAS processes

The following aspects have been selected for the detailed characterization in this study: Aim of the process, object, process itself, building blocks, resources, advantages and disadvantages, and validation strategy, represented in Table 21. The choice of these specific elements ensures an extensive and nuanced understanding of the processes under examination.

Table 21: Objects of Study of Respective TAS Processes

Object of Study	Description
Aim of the Work	This aspect involves understanding the specific environment for which the process is defined. Providing a conclusion on the intended use of the process.
Object	Conclude as what the process is defined (e. g. framework, tool). This allows for the understanding of how the author(s) intend the process to be utilized.
Process	This represents the most critical segment, necessitating precise execution. It entails deconstructing the process to enhance its comprehensibility, examining the functions, their sequence, and the objectives pursued throughout the process. This detailed description facilitates clear understanding and identification of the clustering and the building blocks inherent within the process.
TAS Building Blocks	Clustering the processes provides answers and insights into their construction. It allows for a comparative analysis, identifying commonalities and differences in functions, and highlights the essential aspects of a Technology Assessment Strategy (TAS) process. As certain identified processes address multiple phases of the technology commercialisation process only the building blocks pertinent to the relevant stages of the TAS processes were defined, recognizing that not all processes are exclusively TAS processes.
Resources	Identifying the necessary resources is crucial for understanding how to execute the process effectively. This offers insights into the requirements and provides a perspective on the associated expenses, giving an understanding of both the organizational and financial aspects involved.
Advantages and Disadvantages	Evaluating what elements contribute to or obstruct the effectiveness of the process is essential. Analysing the factors of success and limitations provides insight into the reliability of the process, offering a comprehensive view of its potential benefits and constraints, and enabling a more informed assessment.
Validation	Analysing the validation of the process determines the level of confidence in its effectiveness under real-life conditions or according to expert opinion. This assessment aims to evaluate the practical functionality and reliability of the process beyond theoretical assumptions, ensuring its applicability and efficacy in actual operational contexts.

The outcomes of the systematic characterization are outlined below, serving as the groundwork for constructing building blocks and subsequently conceptualizing the TAS Model. Each study underwent meticulous analysis and evaluation to ensure the accuracy and comprehensiveness of the presented information.

The evolution of processes from Conway and McGuinness (1986) to Russo et al. (2020) has yielded diverse methodologies for technology commercialization and TAS. While these processes differ in stages and validation types, they consistently embody a structured approach involving idea generation, technology characterization, and market research, ultimately leading to commercialization. The active involvement of multiple stakeholders is pivotal in refining and evaluating concepts and technologies.

Processes outlined by Bishop (2004), Nelson (2005) and Terzidis and Vogel (2018) place significant emphasis on detailed technology characterization, aligning technology with market and user demands through extensive research and evaluation. The number of stages varies, ranging from three in Conway and McGuinness (1986) to seven in Roberson and Weijo (1988). However, various processes exhibit limitations such as potential biases, resource intensiveness, and overemphasis on specific aspects. Most prioritize elements like market alignment or technological potential, culminating in practical applications.

Evaluation methods span a spectrum from expert feedback (Conway & McGuinness, 1986) to user-centric guidelines (Kuo et al., 2011) and tools such as TRIZ (Bianchi et al., 2010) or T-PLUC (Henkel & Jung, 2009), highlighting diversity. Despite these varied approaches, common limitations persist across processes, including management complexity and a lack of specific tools, impacting the discovery and evaluation of applications.

5.3.2 Building Blocks of TAS Processes

Drawing upon a comprehensive understanding of existing processes, critical insights into their construction and operation have been acquired. This understanding clarifies key elements, their roles, and necessary capabilities. Acknowledging how these processes function, the sequence of operations, and common stages is essential for guiding the construction of an effective TAS model, with these stages serving as foundational building blocks. The identification of these building blocks involved clustering processes to distil essential steps. These identified building blocks informed the construction and structuring of the model's stages, ensuring the incorporation of all vital components. A summarized table below indicates each block, the corresponding papers in which they appear, and the total number of appearances across the identified 18 processes. Despite diverse process designs, the definition of nine clusters reveals consistent underlying principles. These building blocks establish a fundamental base, facilitating the construction of a robust TAS process in alignment with the current state of the art.

Table 22: Building Blocks of TAS Processes with Respective Authors

Building Blocks	**Authors**	**#**
Application identification	Conway and McGuinness (1986), Roberson and Weijo (1988), Souder (1989), Moncada-Paterno-Castello et Al. (2003), Bishop (2004), Nelson (2005), Danneels (2007), Henkel and Jung (2009), Bianchi et Al. (2010), Kuo et Al. (2011), Maarse and Bogers (2012), Felkl (2013), Holzleitner (2015), Strøm (2018), Terzidis and Vogel (2018), Russo et Al. (2020)	16
Market research	Conway and McGuinness (1986), Roberson and Weijo (1988), Souder (1989), Lynn and Heintz (1992), Moncada-Paterno-Castello et Al. (2003), Bishop (2004), Nelson (2005), Danneels (2007), Henkel and Jung (2009), Evans et Al. (2010), Kuo et Al. (2011), Maarse and Bogers (2012), Felkl (2013), Holzleitner (2015), Strøm (2018), Terzidis and Vogel (2018)	16
Product conception	Conway and McGuinness (1986), Roberson and Weijo (1988), Souder (1989), Lynn and Heintz (1992), Moncada-Paterno-Castello et Al. (2003), Bishop (2004), Danneels (2007), Henkel and Jung (2009), Evans et Al. (2010), Kuo et Al. (2011), Maarse and Bogers (2012), Holzleitner (2015), Strøm (2018)	13
Technology characterization	Souder (1989), Lynn and Heintz (1992), Moncada-Paterno-Castello et Al. (2003), Bishop (2004), Nelson (2005), Danneels (2007), Henkel and Jung (2009), Bianchi et Al. (2010), Evans et Al. (2010), Felkl (2013), Strøm (2018), Terzidis and Vogel (2018), Russo et Al. (2020)	13
Evaluation	Conway and McGuinness (1986), Lynn and Heintz (1992), Moncada-Paterno-Castello et Al. (2003), Bishop (2004), Nelson (2005), Bianchi et Al. (2010), Maarse and Bogers (2012), Felkl (2013), Holzleitner (2015), Strøm (2018), Terzidis and Vogel (2018), Russo et Al. (2020)	12
Expert evaluation	Conway and McGuinness (1986), Roberson and Weijo (1988), Souder (1989), Kuo et Al. (2011), Maarse and Bogers (2012), Strøm (2018), Russo et Al. (2020)	7
Application selection	Roberson and Weijo (1988), Souder (1989), Moncada-Paterno-Castello et Al. (2003), Maarse and Bogers (2012), Terzidis and Vogel (2018)	5
User evaluation	Roberson and Weijo (1988), Souder (1989), Moncada-Paterno-Castello et Al. (2003), Henkel and Jung (2009), Kuo et Al. (2011)	5
Prototyping	Roberson and Weijo (1988), Souder (1989), Bishop (2004), Maarse and Bogers (2012)	4

The identified building blocks display interconnectivity, evident in examples such as Application Selection and Evaluation. They lack consistent outlining, as illustrated by Conway and McGuinness (1986), and their dynamic nature is highlighted by simultaneous occurrences like User Evaluation and Product Conception (Henkel & Jung, 2009). Notably, several blocks interrelate and support each other, comprising market research and assessment, evaluation and selection of applications, and characterization of technology and identification of applications. This interaction underscores the collaborative essence of these components in shaping a consistent TAS process.

Among the processes, Roberson and Weijo (1988) comprise the most sections - seven out of nine - omitting only the evaluation from non-experts and users and technology characterization. This technique is demanding in resources, requiring manifold rounds of evaluation and refinement. Conversely, Bianchi et al. (2010) and Evans et al. (2010) consist of only three sections out of nine, conveying a resource-conserving strategy. On average, processes typically consist of five to six clusters, with Market Research and Application Identification being the most prevalent, featured in 16 out of the 18 processes. In contrast, the processes of prototyping, user evaluation, and application selection are mentioned the least in the identified papers.

The regular inclusion of the most frequently included steps - market research and identification of applications - is a consistent approach. As market research is a critical function in identifying potential technology positions and providing direction for evaluation, in line with the overarching goal of technology commercialization, its frequent inclusion is justified. Similarly, the frequent occurrence of application identification is legitimate as it represents the fundamental aspect of this stage and recognizes the importance of timing and methodology during this step. It is worth noting that prototyping and user evaluation are the least frequent stages in the processes studied, presumably because of their high cost. Despite their crucial role in ensuring the feasibility and acceptance of new technologies, their limited integration is noteworthy, which could be attributed to financial and resource constraints. This illustrates that frequency of occurrence does not necessarily reflect importance. The limited representation of application selection within processes can be explained by the fact that many processes either exclude a selection process or priorities the development of a single idea at any given time.

5.3.3 Comparison to Previous Studies

The cluster categorization presented by Manthey et al. (2022a) emphasizes five clusters: Technology Characterization, Trend Assessment, Market Assessment, Customer Integration, Value Analysis, and Evaluation. Although these clusters may initially appear to diverge from those derived in the present study, a closer examination reveals certain similarities.

In the underlying studies, Technology Characterization and Evaluation appear to be given elements within the TAS process. Trend Assessment can be categorized under either Market Research or Technology Characterization, thus representing an integrated building block within the derived blocks. Market Assessment is a fusion of Market Research and Evaluation, while Customer Integration closely aligns with User Evaluation. Additionally, Value Analysis relates to Market Research and Evaluation of Product Concepts.

However, distinctions emerge in elements such as Application Identification, Application Selection, the differentiation between consulting experts and non-experts for evaluation, Product Conception, and Prototyping, which were introduced throughout this review. The notable disparity between these sets of clusters centers around the emphasis on the actual application and product. This suggests that various approaches to clustering can yield different yet similar outcomes. Therefore, the characterization laid out provides a foundation for diverse interpretations.

An additional but logical observation due to the nature of technology push, corroborated by the characterization, is that all processes commence with technology (Manthey et al., 2022a). The majority of the processes initiate the process with Technology Characterization to enable a deep understanding of the given technology. Further exploration of this observation reveals that five processes commence with Application Identification (Conway & McGuinness, 1986; Holzleitner, 2015; Kuo et al., 2011; Maarse & Bogers, 2012; Roberson & Weijo, 1988), assuming a valid understanding of the technology, and the remaining one begins with Technology Characterization. One exception is Felkl (2013), who initiates the process with Market Research to identify the demands and desired benefits of a somewhat vague market idea. However, Felkl (2013) asserts that a basic understanding of the technology is essential to begin, with Technology Characterization as the subsequent step, thereby representing a process in between.

5.4 Discussion

The primary objective of this study is to identify key characteristics of TAS processes, with a focus on enhancing existing processes and deriving fundamental building blocks. The study aims to conceptualize a successful TAS process within the context of technology push, particularly in supporting the technology commercialization efforts of spin-offs. Through a comprehensive analysis of existing TAS processes, including their practical applications, strengths, weaknesses, limitations, challenges, and unique features, a comprehensive understanding of the TAS process landscape was obtained.

Despite the initial analysis yielding only three results based on the SLR, the inclusion of processes identified by Manthey et al. (2022a) expanded the scope to examine a total of 18 processes. Subsequently, nine building blocks were identified and assessed based on frequency, applicability, potential duplication, and necessity. Notably, these building blocks align with the three segments of the second phase in the Technology Push model by Terzidis and Vogel (2018), dividing the conceptual model into the steps of "Technology Characterization," "Application Identification," and "Application Selection." It is important to highlight the interconnected nature of these steps, where the evaluation can loop back to application identification.

5.4.1 TAS Conceptualization

In developing a theoretical model for the TAS processes, understanding not just the steps and phases but also the functions they perform, and the individuals involved is crucial. This comprehensive insight is essential for determining the capabilities and operators of every building block in the process. For this purpose, various activities and participants were extracted for each building block.

Table 23: Building Blocks of TAS Processes

Building Blocks	Description
Application Identification	Individual judgments, expert sessions, technology characterization, market exploration, networking, user input, and patent searches are crucial. It involves identifying potential applications for a technology.
Application Selection	Decisions, often made by managers or technology experts, are supported by workshops and evaluations. This phase involves selecting specific applications based on various criteria.
Evaluation	Focus on assessing feasibility and economic viability through workshop design, strategic positioning, technology-needs alignment, testing, market impact evaluation, benefits assessment, and product prioritization.
Expert Evaluation	Technical experts, managers, scientists, externs, and industry experts contribute insights. Coordination of a multidisciplinary team is essential to thoroughly evaluate the technology's potential.
User Evaluation	Techniques such as focus groups, product testing, evaluations in minor markets, surveys, lead user involvement, and brainstorming sessions are employed to gather user feedback and preferences.
Market Research	Refining product concepts and identifying target markets or buyers by scanning for developments, analyzing competitors, understanding customer needs, identifying lead users, and assessing market potential.
Product Conception	Focus on devising a primary solution, refining based on feedback and market research, and creating a practical business plan. User involvement in certain aspects is highlighted.
Prototyping	Utilized for user testing, expert evaluation, and product refinement. It ensures that the final product meets the expected standards and requirements.
Technology Characterization	Scrutinizing various aspects of technology, including benefits, limitations, strengths, functional and situational characteristics, core competencies, supported trends, and unique elements. The use of patent keywords aids in streamlining the process.

In the **Application Identification** phase, individual judgments (Conway & McGuinness, 1986; Strøm, 2018) and sessions with experts (Bishop, 2004; Holzleitner, 2015; Roberson & Weijo, 1988; Strøm, 2018) play a significant role. The technology characterization connecting demands is acknowledged (Bianchi et al., 2010; Felkl, 2013; Maarse & Bogers, 2012; Nelson, 2005; Souder, 1989; Terzidis & Vogel, 2018), complemented by market exploration activities (Holzleitner, 2015; Moncada-Paternò-Castello, Rojo, Bellido, Fiore, & Tübke, 2003; Strøm, 2018; Terzidis & Vogel, 2018) and networking (Danneels, 2007). Input from users (Henkel & Jung, 2009; Kuo et al., 2011) is also critical, along with conducting a patent search (Russo et al., 2020; Strøm, 2018).

Moving to **Application Selection**, decisions are often in the hands of managers (Roberson & Weijo, 1988; Souder, 1989) or experts in the technology (Maarse & Bogers, 2012). Workshops (Terzidis & Vogel, 2018) are common platforms for these decisions, which are typically made after one or multiple evaluations to support the decision.

In the **Evaluation** block, an assessment of feasibility and economic viability is paramount(Conway & McGuinness, 1986; Lynn & Heintz, 1992)(Conway & McGuinness, 1986; Lynn & Heintz, 1992; Maarse & Bogers, 2012; Moncada-Paternò-Castello et al., 2003; Terzidis & Vogel, 2018). The use of workshop design (Bishop, 2004; Terzidis & Vogel, 2018), strategic positioning (Bianchi et al., 2010; Maarse & Bogers, 2012; Nelson, 2005), and connecting technology and needs (Felkl, 2013; Russo et al., 2020) are common approaches. Additional activities include testing (Holzleitner, 2015), assessing the impact on the market (Strøm, 2018), evaluating benefits (Roberson & Weijo, 1988), and prioritizing products (Roberson & Weijo, 1988).

Expert Evaluation involves the insights of technical experts (Conway & McGuinness, 1986; Strøm, 2018) and includes the coordination of a multidisciplinary team or representatives from all affected departments (Conway & McGuinness, 1986; Maarse & Bogers, 2012). Managers (Roberson & Weijo, 1988) and scientists (Roberson & Weijo, 1988; Strøm, 2018) also contribute, along with externs (Souder, 1989) and industry experts (Russo et al., 2020; Strøm, 2018).

In **User Evaluation**, focus groups (Kuo et al., 2011; Roberson & Weijo, 1988) are a common technique, together with testing product concepts or prototypes (Roberson & Weijo, 1988; Souder, 1989). Evaluations in minor markets (Souder, 1989), surveys (Moncada-Paternò-Castello et al., 2003), and lead user involvement (Henkel & Jung, 2009; Kuo et al., 2011) are also employed, along with brainstorming sessions (Kuo et al., 2011).

Market Research serves to refine the product concept (Conway & McGuinness, 1986; Maarse & Bogers, 2012; Souder, 1989) and identify target markets or buyers (Bishop, 2004; Evans et al., 2010; Felkl, 2013; Holzleitner, 2015; Lynn & Heintz, 1992; Maarse & Bogers, 2012; Moncada-Paternò-Castello et al., 2003; Nelson, 2005; Roberson & Weijo, 1988; Terzidis & Vogel, 2018). Activities in this phase include scanning for developments (Souder, 1989), analyzing competitors (Moncada-Paternò-Castello et al., 2003), and trends (Henkel & Jung, 2009; Moncada-Paternò-Castello et al., 2003), and developing marketing strategies (Danneels, 2007; Evans et al., 2010). This phase also involves understanding customer needs (Danneels, 2007; Felkl, 2013; Holzleitner, 2015; Terzidis & Vogel, 2018), identifying lead users (Kuo et al., 2011), and assessing market potential (Strøm, 2018).

In the **Product Conception** stage, the focus is on devising a primary solution (Conway & McGuinness, 1986; Roberson & Weijo, 1988). Further refinement based on feedback is essential (Conway & McGuinness, 1986; Kuo et al., 2011; Roberson & Weijo, 1988; Souder, 1989; Strøm, 2018), as is refinement based on market research (Bishop, 2004; Evans et al., 2010; Holzleitner, 2015; Lynn & Heintz, 1992; Souder, 1989). A practical business plan can be created at this stage (Conway & McGuinness, 1986; Danneels, 2007; Kuo et al., 2011; Lynn & Heintz, 1992; Maarse & Bogers, 2012; Moncada-Paternò-Castello et al., 2003) and certain aspects can be handled by users (Henkel & Jung, 2009).

Moving on to **Prototyping**, it is utilized for user testing (Roberson & Weijo, 1988; Souder, 1989), expert evaluation (Bishop, 2004), and product refinement (Maarse & Bogers, 2012), ensuring the final product will meet the expected standards and requirements.

During **Technology Characterization**, various aspects such as benefits, limitations, and strengths of the technology or for the user are scrutinized (Evans et al., 2010; Lynn & Heintz, 1992; Strøm, 2018; Terzidis & Vogel, 2018). An understanding of the technology is emphasized (Moncada-Paternò-Castello et al., 2003; Nelson, 2005; Terzidis & Vogel, 2018), as well as identifying functional and situational characteristics (Bianchi et al., 2010; Bishop, 2004; Nelson, 2005; Terzidis & Vogel, 2018). Understanding core competencies (Bianchi et al., 2010; Felkl, 2013; Nelson, 2005) is also vital, along with recognizing supported trends (Henkel & Jung, 2009) and unique elements (Felkl, 2013). The characterization process can be aided by patent keywords (Russo et al., 2020), helping to streamline and focus the effort for maximum efficiency and effectiveness.

These outlined steps, characterized by specific activities, methods and participants, form the foundation for building a robust and effective model for technology application selection processes.

5.4.2 Building a Concept

A comprehensive evaluation of the TAS process requires not only an understanding of the functions and methods inherent in each building block but also an examination of their arrangement, interrelationships, potential synergies and the inclusion of optional building blocks tailored to specific application areas. Several influential factors determine this arrangement and choice of links: First, identifying steps that either enable or constrain others is critical to orchestrating a seamless flow within the process. Second, understanding which steps can effectively leverage the results of preceding or analogous steps increases efficiency and influences the effectiveness of subsequent activities. Third, considering the resource intensity of each step is essential. Strategically placing resource-intensive steps ensures optimal resource utilization, while steps with lower resource requirements may be appropriate for early exploration. In addition, recognizing the iterative nature of connections between building blocks is fundamental. Incorporating feedback loops and the ability to revisit and refine certain steps based on ongoing insights contributes to the adaptability and robustness of the process. Finally, assessing the scalability of the links is crucial for adapting the process to different scales of application, both for small-scale projects and large-scale initiatives.

The overall aim of this evaluation exercise is to formulate a well-structured and flexible framework. This framework is designed to maximize the utility of each building block, minimize resource inefficiencies and skillfully navigate the dynamic and iterative nature inherent in technology application processes. By carefully considering these factors, the TAS can be tailored to specific application domains, ensuring both effectiveness and efficiency in technology application and selection.

Introducing the TAS process with technology characterization is proving to be strategically advantageous: 17 out of the 18 processes analyzed use this approach, and the majority of them start directly with this step. This autonomous, technology-focused starting point lays the groundwork for subsequent phases such as prototyping, application identification and market research. Alternatively, Application Identification serves as another viable initial step that aligns seamlessly with common practices.

The phase between technology characterization and application selection is characterized by high fuzziness and interconnectedness, usually defined by technology application identification. An iterative approach involving testing, ideation, research and interviews is considered essential due to the exploratory nature of the field. This dynamic process recognizes the need for continuous refinement and adaptation as evidence evolves. The prototyping stage, informed by the prior technology characterization, facilitates the creation of an initial, basic prototype that demonstrates technology attributes and contributes to tangible aspects. However, due to its resource intensity, it remains an optional stage to ensure that it does not overly restrict creative exploration. Similar to the first step, prototyping drives the market research phase - a versatile step that allows revisits to the technology characterization, ensuring continuous alignment with evolving market insights. Seamless identification of a suitable market, where technology functionality matches market needs, accelerates the transition to the Application Selection phase. The Evaluation phase, in conjunction with market research, provides robust support for product evaluation. Extensive use of both expert and user evaluation, with a preference for cost-effective and insightful expert evaluation where resources permit, is critical. Following evaluation, the product concept stage requires extensive evaluation coupled with market research before the final transition to application selection. If the evaluation fails, the concept circles back to application identification, accompanied by detailed feedback. This joint relationship ensures continuous refinement of the product concept, supported by prototyping and market analysis. This dynamic interplay between the stages ensures an iterative, adaptive and effective TAS process. Concluding with Application Selection, this step brings together the insights from all the previous stages to make a holistic, informed decision for product development. This cumulative insight ensures that Application Selection stands as the final step in each scenario, reinforcing the structured and systematic layout of the model and ensuring an optimized, insightful and effective product development pathway.

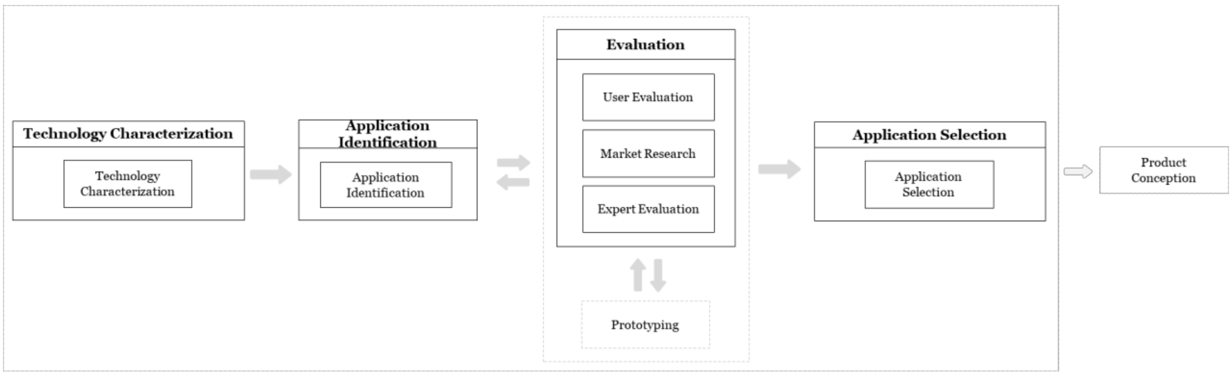

Figure 5: Conceptualization of a systematic TAS Model (Own Illustration)

In summary, as seen in the conceptual model (Figure 5), the typical procedure of the model initiates with technology characterization unless a compelling application idea is present, in which case it may directly begin with application identification. Subsequently, the evaluation of the identified applications is forced. While this is represented after the application identification, it is interconnected with the phase. Within the evaluation phase, a prototype, while optional, could be created. Within this stage, market research and user and expert evaluation are focused upon, providing varied viewpoints that might lead back to application identification. Overall, the identified application undergoes evaluation through three-step methods, ideally conducted sequentially. If necessary, the process may revert to the application identification stage for refinement. Upon successful evaluation, the application is selected, marking the conclusion of the process. Consequently, the product conception can be addressed, which is mentioned by various sources to come into play after selecting the final application. Thus, it is considered to be the next step after the TAS process.

In conclusion, the TAS Process follows the structure enhanced by Terzidis and Vogel (2018), highlighting three segments: Technology Characterization, Application Identification and Application selection. As the evaluation is an iterative evaluation process that takes place in the interplay between the application identification and selection phases, the model still represents the three segments of Terzidis and Vogel's (2018) TAS process.

5.5 Conclusion

The goal of this study was to identify existing TAS approaches in order to derive a conceptual model of a systematic TAS process, building the foundation for the design of a TAS framework. Through an SLR, existing TAS approaches were assessed, leading to the derivation of building blocks and the design of a conceptual TAS model. This model serves as a foundation to empower spinoffs to successfully identify promising applications for their technology, marking a crucial step in the journey toward technology commercialization.

By precisely characterizing 18 processes identified in the SLR, this examination aimed to discern their structure and functionality, providing insights into their operational patterns. The analytical approach facilitated the construction of a conceptual model derived from identified clusters or building blocks and the observed functions and arrangements within the processes. A noteworthy finding was the substantial similarity across the processes in terms of construction and operation, coherently clustered into nine distinct building blocks, assigned to three segments: Technology Characterization, Application Identification, and Application Selection. While the segments Technology Characterization and Application Identification also represent the respective phases undergone, the transition to the segment Application Selection involves further interconnected evaluation steps, which cannot directly be assigned to one of the steps. Furthermore, two steps, the product conception and the prototyping, are seen as optional. Overall, this research significantly enhances the understanding of TAS processes, especially regarding their structural composition and the underlying foundation.

In summary, this research not only advances the understanding of TAS processes but also emphasizes the vital impact of a model's foundational design in contributing substantially to technology application selection. The exploration and elucidation of building blocks and operational paradigms within this work offer a robust framework for further research and practical application in the field.

While providing valuable insights into TAS processes, it is subject to certain limitations that warrant consideration. Hence, the identified building blocks, derived from the analysis of existing processes, present a static representation. TAS processes are inherently dynamic and susceptible to changes driven by technological advancements and market dynamics. Consequently, the identified building blocks may not comprehensively capture the evolving nature of TAS processes over time. Additionally, the overemphasis on academic literature as the primary information source introduces potential limitations. Relying predominantly on academic sources might result in a skewed perspective, as academic literature may not fully encapsulate industry-specific practices or recent advancements in the field. To achieve a more holistic understanding, incorporating practical insights from industry experts and practitioners would be imperative.

6 Design of a Systematic TAS Framework

In the current dynamic global environment, a constant stream of revolutionary ideas is emerging that have the potential to alter the global scenario significantly. This trend is particularly evident in technological advances, which offer immense opportunities for significant change (Saari, Damberg, Frömbling, & Ringle, 2021; Wolff, 2021). However, to realize this transformative potential that bears technological innovations, it is crucial to address the critical task of commercialization, which can be a significant challenge for new and developing technologies (Maier et al., 2016). Addressing the slow transformation of emerging technologies into practical products or services, which results in hidden societal and economic losses, is an urgent priority as it is essential to unlock the full potential benefits of technological innovation (Budi & Aldianto, 2020). In the rapidly evolving landscape of technological advancements, the increasing pace of innovation suggests a parallel rise in missed opportunities and untapped potential for technology transfer (Bozeman et al., 2015). Addressing existing obstacles in technological exploitation signifies a need for process optimization to unlock innovation's full potential. Successful outcomes in technological innovation hinge on strategically selecting and implementing appropriate commercialization mechanisms for new technologies (Andersson, Hellsmark, & Sandén, 2021; Cheah & Ho, 2021).

While various commercialization mechanisms exist, creating new ventures or spin-offs stands out as a valid approach. However, while studies focus on the development and the challenges of academic spin-offs, the complexities of spin-off commercialization processes remain underexplored in the literature (Seguí-Mas, Oltra, Tormo-Carbó, & Sarrión-Viñes, 2018). As stated in chapter 2.2, researchers, who typically represent the founders of those spinoffs, face numerous challenges in navigating these processes and transforming emerging technologies into marketable products or services (Djokovic & Souitaris, 2008; Rothaermel & Boeker, 2008). In particular, the nascent stage of a spin-off, where researchers try to navigate the fuzzy front end of the innovation process, is pivotal for subsequent success or failure (Kock et al., 2015). Therefore, formulating a well-defined strategy during this early phase is imperative (Zhang & Doll, 2001). Particularly crucial in the early phase is identifying the correct application for the given technology (Spanjol et al., 2012). Despite its critical importance, this aspect has been neglected in research, with limited exploration of effective strategies for identifying and selecting promising applications for novel technologies (Terzidis & Vogel, 2018). Researchers and academic spin-offs play a crucial role in addressing this gap and enhancing understanding of the challenges and strategies involved in the early phases of spin-off development and technology application identification (Seguí-Mas et al., 2018).

Due to the primary focus on research within universities, institutes, and R&D departments, early-stage implementation considerations are often neglected (Caetano & Amaral, 2011). The research-oriented environment prioritizes theoretical advancements and knowledge generation, possibly overlooking the practical aspects associated with the initial phases of translating research into tangible applications or products (Al-Jedaiah, 2020). Further, even dedicated entities like technology transfer offices, established to support commercialization efforts, tend to be focused mainly on guiding Intellectual Property (IP) matters and activities related to securing funding (Siegel, Waldman, & Link, 2003). Research from the previous chapters indicated that these offices might not sufficiently address or provide comprehensive support for the broader spectrum of challenges encountered during the early stages of technology commercialization. Further, previous research primarily focused on disclosed activities, leading to an underestimation of academics' overall engagement in technology and knowledge transfer (Grimaldi, Kenney, Siegel, & Wright, 2011). This imbalance in focus may leave researchers and nascent spin-offs without adequate guidance or resources in critical areas such as identifying suitable applications, selecting promising ones, and navigating the intricacies of the early commercialization process (Manthey et al., 2022a). Furthermore, researchers may not possess a comprehensive understanding of the broader real-world implications or commercial prospects of their endeavors, as they are often situated within scientific or technical domains (Berggren, 2017; Gosens et al., 2018; Qian, Xia, Liu, & Tsai, 2018). Researchers typically have constrained entrepreneurial skills and experiences, given their predominant backgrounds in scientific or technical fields (Kalar & Antoncic, 2015). Recognizing this gap, targeted efforts become imperative (Krabel & Mueller, 2009), considering that conventional training and education in scientific disciplines do not inherently furnish researchers with the business-oriented mindset and skills requisite for proficient technology commercialization (Kalar & Antoncic, 2015). The essential nature of these targeted efforts lies in providing specific training programs, workshops, or initiatives tailored to heighten awareness among researchers regarding the potential practical applications of their work and augment their entrepreneurial competencies (Salisu, 2020). The findings of chapter 4 signify a deficiency in entrepreneurial training offerings and activities directed at raising awareness within this context. This deficiency suggests that existing support mechanisms may not adequately address the crucial requirement for entrepreneurial training and awareness-building among researchers. Consequently, this shortfall in support mechanisms can impede the successful commercialization of technologies originating from academic research.

Presently, the state-of-the-art reveals that technology transfer offices predominantly focus on the later stages of the technology commercialization journey (see 4.4.2.1). What often remains overlooked is the critical phase of identifying suitable applications and selecting the most promising ones (Terzidis & Vogel, 2018). Despite the widely acknowledged understanding that the ideation process constitutes only a quarter of the available time, its pivotal role in determining the success of subsequent stages is recognized (Kock et al., 2015; Spanjol et al., 2012). However, the current approach typically involves connecting researchers within networks to independently explore potential applications, a process marked by a lack of structuredness and uncertainty (4.3.1). Despite alternative support mechanisms being available to researchers, they are frequently underutilized due to a lack of awareness and resistance from uncertainty about their effectiveness (Hou, Qi, Su, Wu, & Tang, 2023).

Consequently, there is a dearth of precise guidance through the application identification process. Researchers, often lacking entrepreneurial training, experience, and awareness, find their initiatives stalling or fixating on initially identified applications (Kalar & Antoncic, 2015). Collaborations with corporate partners may occur, but these more often lead to licensing agreements or researchers transitioning to the corporate sector rather than establishing spin-offs (Siegel et al., 2003).

This system, seemingly deficient in fostering technology commercialization and spin-offs, manifests several issues. Firstly, existing support formats often fail to align with researchers' needs, primarily attributed to resource constraints rather than unwillingness. Secondly, researchers encounter challenges in navigating the application identification process. Additionally, researchers contemplating entrepreneurship face scarce resources, as universities or research institutions seldom allocate additional time for such activities (Djokovic & Souitaris, 2008; Kalar & Antoncic, 2015). The historical lack of emphasis on the application identification process further exacerbates the problem, as it is perceived as less critical compared to other challenges researchers face, contributing to a sense of numbness amid information overload and stress (Finner & Manthey, 2023; Manthey et al., 2022a; Terzidis & Vogel, 2018; Wohlfeil & Terzidis, 2015). Addressing this situation necessitates raising awareness, enhancing institutional support in terms of time and attention to entrepreneurship, and providing evidence of the utility of support formats for improving application identification. In conjunction with the lack of theory research, these factors significantly impede the application identification and selection process.

To support the early stage of this process, Manthey et al. (2022a) argue that researchers can be assisted in identifying, evaluating, and selecting a suitable application for their technology, overcoming the challenges of the early phase while highlighting the need for a target-oriented, systematic technology application identification and selection process. For that purpose, a design science research (DSR) project that addresses the development of such a tool is pursued. To this end, the following research question is investigated:

How to design a systematic process for researchers to improve the identification and selection of technology application?

In three design cycles, a structured framework has been developed for researchers aiming to identify and select potential applications for their technology, facilitating its commercialization. The proposed solution advocates for the adoption of a user-centric framework to guide researchers systematically through the process of application identification and selection. This framework incorporates essential entrepreneurial knowledge, facilitating the efficient identification of potential applications and offering guidelines for researchers. Empowering researchers to navigate this process autonomously aims to reduce ambiguity and enhance technology commercialization. The user-centric framework is designed to streamline decision-making, impart entrepreneurial insights, and ultimately contribute to successful technology commercialization.

6.1 Design Science Research

DSR originated in information systems and has become well-established in that research area, assisting in emerging knowledge processes (vom Brocke et al., 2020). The target of DSR is to develop new artifacts or optimize existing artifacts to increase and use the efficiency and effectiveness of groups or individuals in a customized and innovative way (Baskerville et al., 2018). Meanwhile, DSR is also an established approach in entrepreneurship to implement practical knowledge with scientific precision. Seckler et al. (2021) metaphorically describe design science as a bridge connecting basic science to entrepreneurship practice. Basic science in entrepreneurship means the development of explanatory knowledge through scientific methods. This has, above all, the goal of producing facts, whereas design science emphasizes usability. In entrepreneurship, usability also has a high value, but the practice differs from design science in terms of knowledge base and application (Seckler et al., 2021).

6.1.1 DSR in Entrepreneurship

The applicability has extended to entrepreneurship, representing a relatively new domain within DSR. As a research paradigm centered on creating and evaluating artifacts to address tangible real-world problems, DSR aligns seamlessly with the objectives of entrepreneurship (Dimov, 2016; Romme & Reymen, 2018). Entrepreneurship, driven by the pursuit of innovative solutions to relevant challenges, finds DSR a valuable tool. Scholars are displaying a growing interest in diverse artifacts associated with entrepreneurial practice (Berglund, Bousfiha, & Mansoori, 2020). In the realm of entrepreneurship research situated at the intersection of design and science (Romme & Reymen, 2018), a proposed research framework integrates design activities (creation and evaluation) and validation activities (justification and theorization), offering a structured approach for the synthesis of theoretical and practical insights. Thus, the value of DSR has recently been recognized in entrepreneurship (Berglund & Dimov, 2021).

DSR serves entrepreneurs by assisting in identifying and defining significant problems within the market and society (Voss, 2020). Leveraging existing or novel theories and knowledge, entrepreneurs can utilize DSR to craft robust solutions for emerging issues, aligning with the overarching goal of entrepreneurship (Romme & Reymen, 2018). Moreover, DSR supports entrepreneurs in proposing and developing solutions that are not only feasible but also novel and useful. To ensure, that in entrepreneurship no less artifacts are designed without proper evaluation or testing, DSR can address this gap by facilitating the rigorous testing and evaluation of entrepreneurial solutions in realistic or simulated environments, employing suitable methodologies and metrics (Dimov, 2016; Seckler et al., 2021). In conclusion, DSR emerges as an invaluable approach for entrepreneurs, aiding in solving real-world problems and enriching entrepreneurship research (Romme et al., 2018). It provides systematic frameworks, diverse research patterns, and a pathway for the effective integration of theory and practice, thereby contributing significantly to the evolution and advancement of entrepreneurship as a research domain (Romme & Reymen, 2018; Terzidis, Gutmann, & Ziegler, 2023).

Despite the inherent compatibility of entrepreneurship with DSR, essential entrepreneurial artifacts like pitches and business plans have been relatively overlooked in this evolving domain (Berglund & Glaser, 2022). Still, several impactful theories and tools developed in the entrepreneurship domain, such as effectuation theory (Sarasvathy et al., 2003; Zhang & van Burg, 2020) and the business model canvas (Osterwalder, 2004; Osterwalder & Pigneur, 2010; Osterwalder & Pigneur, 2013), have emerged from doctoral dissertations informed by Design Science (Romme & Reymen, 2018). Further, within the last few years, numerous tools have emerged, as Romme and Reymen (2018) noted. Besides the business model canvas and its toolbox (Osterwalder, 2004; Osterwalder & Pigneur, 2010), Baldassarre et al. (2020) have developed a noteworthy tool that facilitates the creation of sustainable business models through a framework that links conceptualization and implementation. Further, Hyytinen (2021) introduce a machine learning tool that predicts high-growth enterprises by employing algorithms to identify startups with considerable growth potential, and Talmar et al. (2020) have introduced the Ecosystem Pie Model to facilitate the mapping and analysis of innovation ecosystems. Also, tools based on existing tools have emerged, like the tool that connects the Value Proposition tool with SDGs (Schutselaars, Romme, Bell, Bobelyn, & van Scheijndel, 2023).

In summary, there is a notable opportunity to enhance the connection between theory and practice in entrepreneurship research by further developing practical tools using Design Science (DS). The richness and variety of DS-based artifacts in entrepreneurship research are evident, as highlighted by Romme and Reymen (2018). It is observed that many tools, often generated in practice, are not solely based on theories. While practicality is emphasized in enumerated studies, some also integrate design theories in their development, such as the Theory of Change within the Value Proposition SDG tool (Schutselaars et al., 2023). Other studies focus on theory building, like Sarasvathy's (2008) work on effectuation or van Burg et al.'s (2008) study on university-based spinoff creation. However, it is noted that these studies, as well as the practical based studies, are informed by different DS frameworks, indicating a lack of a unified DS framework for the entrepreneurship field.

Romme and Reymen (2018) have introduced a methodological framework that bridges design and science in entrepreneurship for this purpose (Figure 6). This framework aims to foster collaboration, connecting theory and practice through a systematic integration of rigor and relevance. The authors argue that the interplay between creative design and scientific validation can continuously revitalize the entrepreneurship field, unlocking a comprehensive body of rigorous and relevant knowledge. The framework's value lies in providing a comprehensive approach to exploring the intersection of design and science, facilitating innovative and successful entrepreneurship ventures.

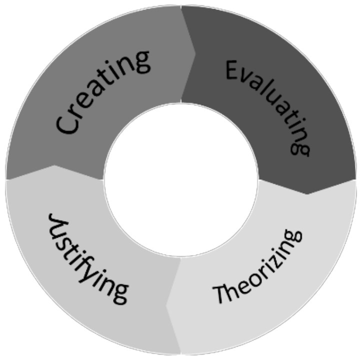

Figure 6: Methodological Framework for DSR in Entrepreneurship (Romme & Reymen, 2018)

An alternative perspective on delineating the role of the design scientist and offering explicit guidelines for entrepreneurship research through the design science lens has been presented by Terzidis et al. (2023). Their proposed framework involves five core activities: (i) Heuristic Front-end, (ii) Requirement Definition, (iii) Artifact Design, (iv) Artifact Validation, and (v) Reflection and Communication to the scientific and practitioner communities (Figure 7).

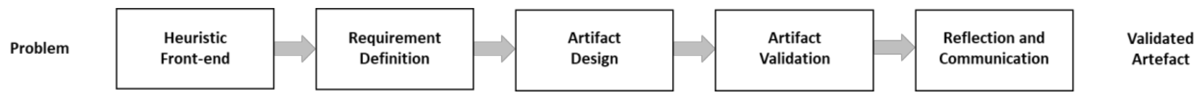

Figure 7: The Idealized Procedure of the Design Science Researcher (adapted from Terzidis et al., 2023)

The guidelines from Terzidis et al. (2023) aims to assist academic researchers in crafting useful, grounded, and validated artifacts, positioning DSR as a promising avenue for advancing scientific knowledge and effective entrepreneurial practices.

Despite the upsurge of increased DS-based artifacts in entrepreneurship and the development of frameworks (Romme & Reymen, 2018; Terzidis et al., 2023) to aid the DS process, there is no unanimous agreement on which design theories to build upon or patterns to recognize. Consequently, no general requirements are established as the foundation for such artifacts, making it contingent on the intended artifact and its impact.

6.1.2 DSR Process

The DSR approach is used as a guideline for developing a usable artifact in the form of a construct, model, method, or instantiation that supports the innovation process (Hevner, March, Park, & Ram, 2004a). Table 24 lists the different types of artifacts, of which entrepreneurship artifacts like the Business Model Canvas (Osterwalder, 2004) or the Competitor Analysis Framework (Hatzijordanou, 2019) are regarded as methods as they are expressing “prescriptive knowledge by defining guidelines and processes for how to solve problems and achieve goals” (Johannesson and Perjons, 2021, p. 31).

Table 24: List of types of a DSR artifact (adapted from Hevner et al., 2004a)

Type of artifact	Definition
Construct	Provide the language in which problems and solutions are defined and communicated.
Models	Use constructs to represent a real-world situation – the design problem and its solution space.
Methods	Define processes and guide how to solve problems (how to search the solution space).
Instantiations	Show that constructs, models, or methods can be implemented in a working system.

DSR generates prescriptive knowledge for systematically designing artifacts, aiding research and practice (Hevner et al., 2004a). To contribute meaningfully to problem-solving, novel solutions must be designed, and their impacts on the application domain must be elucidated, demonstrating rigor and relevance in DSR (vom Brocke, Winter, Hevner, & Maedche, 2020). The execution of a design science project typically involves iterative processes, moving between problem analysis, requirement definition, design, and evaluation activities (Johannesson & Perjons, 2014). Various DSR processes exist, such as Peffers et al. (2007) and the DSR process by Kuechler and Vaishnavi (2008), all of which follow an iterative approach, highlighting the inherent complexity of DSR processes.

Hevner et al. (2004a) emphasize evaluating the artifact as crucial in a DSR approach. Evaluation of a designed artifact is necessary to verify its utility, quality, and effectiveness and, thus, fulfil the artifact's stated requirements. In addition to a better understanding of the artifact, evaluation provides feedback through which both the quality of the artifact and the design process can be improved. Evaluation thus justifies the artifact by demonstrating the added value that the artifact contributes (Hevner et al., 2004a).

DSR operates within the interplay of three interdependent cycles: the relevance cycle, the rigor cycle, and the design cycle (Hevner et al., 2004a). The Relevance Cycle ensures that the addressed problem is pertinent to business practice, establishing connections between the environmental context and research activities, and specifying the problems and requirements addressed by the artifact (Hevner, 2007). The Rigor Cycle establishes a solid scientific foundation for the artifact, ensuring that artifacts are developed and evaluated in accordance with natural laws or behavioral theories, drawing upon an existing knowledge base rigorously (Baskerville, R., Baiyere, A., Gregor, S., Hevner, A., & Rossi, M., 2018; van Aken & Romme, 2012). The Design Cycle integrates practical design with the validation of effectiveness against defined requirements, involving a creative and iterative construction of an artifact based on insights derived from the other two cycles (Hevner et al., 2004a; Hevner, 2007). The amalgamation of these cycles aims to secure both relevance and scientific grounding in artifact design within the DSR context.

Moreover, as previously noted, there is no standardized process for developing DS-based artifacts in entrepreneurship. Different processes can be employed for DSR, of which two notable approaches are highlighted. The research process outlined by Kuechler and Vaishnavi (2008) comprises five stages—Awareness of Problem, Suggestion, Development, Evaluation, and Conclusion—and strongly emphasizes a theoretical foundation. In contrast, the process delineated by Peffers et al. (2007) is more practically oriented, with a reduced emphasis on theory. It involves six steps: Problem Identification and Motivation, Define the Objectives for a Solution, Design and Development, Demonstration, Evaluation, and Communication.

While the steps in both processes share similarities, distinctions exist. For instance, the Suggestion phase in Peffers et al. (2007) integrates goal definition and artifact design, whereas Peffers et al. (2007) separate these aspects into distinct steps. Kuechler and Vaishnavi (2008) underscore the importance of iteration and feedback loops between stages, suggesting a flexible and adaptable nature, particularly in the face of evolving requirements or contexts. In contrast, Peffers et al. (2007) structure their process more linearly and sequentially. The Kuechler and Vaishnavi (2008) process leans towards generating design knowledge, while Peffers et al. (2007) emphasize communicating results to fellow researchers and practitioners. This implies that the Kuechler and Vaishnavi (2008) process may yield, more profound insights into design theory, whereas the Peffers et al. (2007) process facilitates broader dissemination and acceptance of artifacts.

While previous research has predominantly relied on the process outlined by Peffers et al. (2007), exemplified in the design of frameworks like the competitor framework (Hatzijordanou, 2019) and the systematic business model framework (Lau, 2022), the approach by Kuechler and Vaishnavi (2008) presents a structured method enabling the generation of design knowledge. Notably, it strongly emphasizes practical implementation and effective communication of the artifact. Given the inherent fuzziness of the research focus and the lack of explicit guidance on design theories and requirements in the context of DSR and entrepreneurship, the more flexible and adaptable process by Kuechler and Vaishnavi (2008) serves as a robust foundation for this research (Figure *8*). Elaborating further on the processes, the five-step process will be represented in each design cycle.

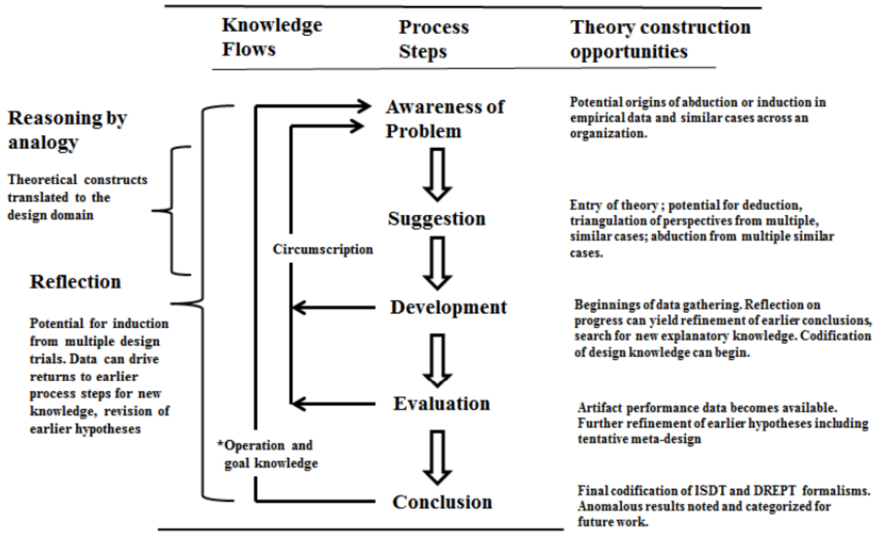

Figure 8: Reasoning in the Design Research Cycle (adapted from Kuechler & Vaishnavi, 2012)

In the Awareness of Problem phase, a relevant issue in Information Systems aligned with stakeholder concerns is identified, grounded in literature and practical considerations. Clear goals, objectives, and criteria for evaluating the artifact are defined. During Suggestion, a feasible and innovative solution is proposed, drawing upon existing or novel kernel theories if applicable. The Development phase realizes the solution into an artifact, adhering to operationalization standards and design principles. Evaluation involves rigorous testing, providing empirical evidence of the artifact's utility and efficacy. In the Conclusion phase, principal findings are summarized, acknowledging limitations, and proposing future research avenues. These design cycles are iterative and shaped by diverse perspectives, offering a robust framework for entrepreneurship research in DSR. (Kuechler & Vaishnavi, 2008)

6.1.3 DSR Guidelines

In their seminal work, Hevner et al. (2004a) articulate seven guidelines crucial for the execution and evaluation of robust DSR. This DSR Project, titled "Systematic TAS process," follows these guidelines:

Firstly, the project aligns with the principle of **Artifact Production (Guideline 1),** ensuring the creation of an artifact—in this case, the TAS process—categorized as a design instrument, method, or tool. Secondly, the guideline of **Problem Relevance and Importance (Guideline 2)** is upheld through thorough scrutiny of problem relevance and significance, achieved via systematic literature analysis and expert interviews. The third guideline, **Artifact Evaluation (Guideline 3),** directs the evaluation of the artifact, utilizing scientifically recognized methods and standards that align with the derived requirements. **Research Contributions (Guideline 4)** are distinctly outlined in chapter 7, encompassing theoretical and practical implications. This includes the presentation of a solution approach to existing problems, the creation of a framework, the establishment of a knowledge base on the TAS process, and the augmentation of methodological knowledge through DSR application in the entrepreneurship context. Rigor is a cornerstone, as emphasized in **Research Rigor (Guideline 5).** Rigor is maintained through the rigorous selection and application of scientific methods across problem understanding, knowledge base construction, and artifact development and evaluation. The guideline of **Design Process Iterations (Guideline 6)** directs the design process through multiple iterations, with interruptions occurring only when further relevant improvement is not anticipated, and theoretical saturation is achieved. Lastly, **Communication of Research (Guideline 7)** is integral. Results and interim findings are disseminated at academic conferences, innovation events, and to relevant stakeholders and users. Additionally, the research is shared in various Entrepreneurship and Intrapreneurship projects, fostering collaborations with researchers and spinoffs.

The comprehensive implementation of these guidelines within the project's context is succinctly summarized in Table 25, offering a detailed overview of their application in the research framework.

Table 25: DSR Guidelines and their Implementation

Guidelines for Design Science Research

Guideline	Justification
1. *Design as an Artifact:* Design-science research must produce a viable artifact in the form of a construct, a model, a method, or an instantiation.	Development of a framework, consisting of several methods.
2. *Problem Relevance:* The objective of design-science research is to develop technology-based solutions to important and relevant business problems.	The relevance and importance of TAS for researchers is ensured theoretically (previous studies) as well as through practical evidence (interviews).
3. *Design Evaluation:* The utility, quality, and efficacy of a design artifact must be rigorously demonstrated via well-executed evaluation methods.	Evaluation is performed following the FEDS framework along the derived requirements.
4. *Research Contributions* : Effective design-science research must provide clear and verifiable contributions in the areas of the design artifact, design foundations, and/or design methodologies.	The work derives and addresses research gaps in both theory and practice, which are specifically addresses with the developed artifact. It contributes to a better understanding of the TAS process for researchers, providing a practical solution approach for its effective implementation. DPs and DRs are derived, enhancing the body of design knowledge at the interplay of entrepreneurship and technology innovation.
5. *Research Rigor:* Design-science research relies upon the application of rigorous methods in both the construction and evaluation of the design artifact.	The design of the artifact is grounded on a sound knowledge base, as well as its evaluation. The scientific methods used and rigorously applied are literature reviews, questionnaires, semi-structured interviews, focus groups and qualitative content analysis.
6. *Design as a Search Process:* The search for an effective artifact requires utilizing available means to reach desired ends while satisfying laws in the problem environment.	The artifact was developed in three design cycles.
7. *Communication of Research:* Design-science research must be presented effectively both to technology-oriented as well as management-oriented audiences.	The research results are presented at academic conferences, innovation events and to relevant stakeholders and users. Shared in various Entrepreneurship and Intrapreneurship projects, including collaborations with researchers and innovation managers.

Consequently, the research strategy of the present study adheres to the guidelines of an effective DSR process, both in its context of discovery — addressing the question of what should be investigated — and in its explanatory context — delineating how the investigation should be conducted.

6.2 Overview of DSR Project

Working towards the goal of designing a process to assist researcher in identifying and selecting technologies for their applications, a DSR approach is adopted, aiming to systematically design and develop artifacts to solve real-world problems using an iterative approach to achieve an optimized artifact instantiation (Hevner et al., 2004a). In accordance with the iterative and participatory nature of the fuzzy front end in which TAS operates, the research employs the five-step process delineated by Kuechler and Vaishnavi (2008) across three consecutive design cycles. This iterative approach facilitates a comprehensive collection of relevant data, refining the understanding of the underlying problem and integrating the expertise and experiences of pertinent stakeholders. Each design cycle adheres to the build-and-evaluation loop framework (Hevner et al., 2004a): Design Requirements (DR) are initially established for a solution. Subsequently, provisional solution prototypes manifest these, enabling their evaluation within an application context. Insights garnered from the dedicated evaluation phase then inform the subsequent DSR cycle. Figure 9 delineates the adaptation of this procedure, providing a detailed overview of the research activities conducted in each step. The subsequent section delves into these specifics by introducing the instantiation domain (6.2.1) employed within the DSR procedure, elucidating the theoretical underpinnings (6.2.2), evaluation strategy (6.2.3), and offering insights into the iterative construction of the three consecutive DSR cycles (6.2.4).

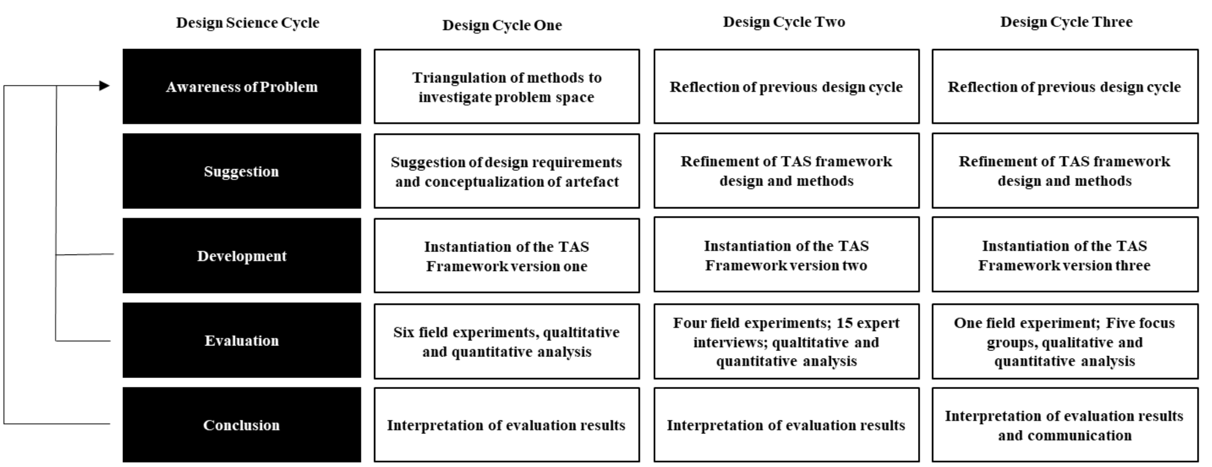

Figure 9: Overview of Design Science Cycles 1-3 of the Thesis (Own Illustration)

6.2.1 Instantiation Domain

The instantiation domain or instance domain is a critical aspect of DSR on the practical application of a solution to address specific problems (Lee, Pries-Heje, & Baskerville, 2011). By instantiating the artifact, the DSR approach allows to verify whether the use of the artifact provides an effective solution to the specific problem (Sordi, 2021). It represents one of the theorizing domains in DSR, providing a platform for researchers to test and validate their theories in real-world settings. Whether it's a developed model or an initial version, it is crucial to emphasize the practical value of the proposed artifact. What matters most is its functionality and usability for practitioners. By applying their solutions to concrete problems, researchers can assess the effectiveness of their theories, leading to refinement and ensuring that the resulting artifacts are practical and helpful in solving real-world problems (Sordi, 2021).

Building on the importance of the instantiation domain, the proposed approach recognizes that practical applications benefit from structured and visually accessible frameworks to be applied in practice. This perspective is inspired by proven tools such as the Business Model Canvas (Osterwalder, 2004), which forms the basis of the current initiative. Thus, the proposal is to create a graphical framework that integrates insights from the Business Model Canvas (Osterwalder & Pigneur, 2013), Lau's systematic business model (2022) and Hatzijordanou's competitor framework (2019). Designed as a holistic overview, the framework facilitates team communication, encourages creativity during discussions, and addresses the need for effective time management (Lukas, 2018). Thus, the framework can be used individually, similar to further entrepreneurial approaches. The choice of a framework format, including supporting methods, is consistent with recognizing the creative and uncertain nature of the TAS process. This format ensures a straightforward and practitioner-friendly working through the TAS process by introducing a novel framework, consisting of several methods, to provide structure, encourage interactive collaboration, and facilitate a systematic approach. While this framework can be applied in a facilitated workshop setting, it also ensures autonomous usage.

The instantiation takes the form of a pen and paper-based framework based on different methods. Inspired by Lau (2022) and Terzidis and Vogel (2018), the framework includes different methodologies in segments dedicated to technology characterization, application identification and selection. The building blocks, derived from an analysis of existing TAS approaches (see 5.4.1), serve as structural phases. Each phase integrates practical and theoretically derived methods from entrepreneurship practice while maintaining clarity through guiding questions, objectives and user-friendly features. This approach ensures that practitioners can systematically navigate through the TAS framework and ultimately work towards the goal of TAS.

6.2.2 Theoretical Framework

The design of a systematic TAS framework can be built upon two theoretical foundations: the Task-technology fit model (TTF) by Goodhue and Thompson (1995) and the dual process theory (DPT), based on Evans (2003).

The DPT distinguishes between System 1, which is intuitive and automatic, and System 2, which is analytical and controlled. This theory provides a cognitive foundation for decision-making. In the context of TAS, individuals can use both intuitive judgments (System 1) to quickly identify suitable technology and analytical assessments (System 2) for a more deliberate analysis of compatibility. By systematically integrating these dual processes, a comprehensive and efficient TAS framework can be created. (Evans, 2003; Evans, 2008; Evans & Stanovich, 2013)

The TTF model emphasizes the importance of aligning technology characteristics with task requirements to facilitate successful adoption. By incorporating TTF principles into the TAS framework, a systematic consideration of how well a technology aligns with specific tasks is ensured. This alignment, congruent with the more analytical System 2 processing in DPT, involves deliberate and analytical thinking about the compatibility of the technology with user needs.

The combination of DPT's two cognitive processes and the TTF model's emphasis on alignment contributes to a systematic and comprehensive design of a TAS framework. Systematic processing ensures a thorough evaluation, taking into account both intuitive judgments and analytical assessments, thereby reducing the risk of overlooking critical factors in the selection process. DPT provides insight into the potential influences on decision making, including task-technology mismatches. Both theories advocate for adaptability and iterative processes, focusing on integrating intuitive and analytical processes to foster a balanced and thorough assessment while countering biases. The TTF model prioritizes task-technology alignment to minimize misalignments, enhancing the overall effectiveness of the selection process. A systematic framework for TAS, based on the principles of DPT and TTF, should be designed to allow for feedback, adjustments, and continuous improvement. This aligns with the recognition that decision-making processes should be flexible and evolve over time.

In summary, the integration of the Dual Process Theory and the Task-Technology Fit model provides complementary insights, forming the basis for a systematic TAS framework. Utilizing both theories helps to create a comprehensive and rigorous approach that addresses the complexities and challenges associated with identifying and selecting technology applications. This ensures that the technology is relevant to the tasks at hand, contributing to optimal performance and successful commercialization outcomes. Therefore, this approach provides a comprehensive and effective strategy for navigating the complexities of the TAS process.

6.2.2.1 Task-Technology Fit Theory

The TTF model, as described Goodhue and Thompson (1995), proposes that the adoption of information technology depends on its seamless integration with users' tasks and its ability to improve performance. This conceptualization highlights the connection between a technology's characteristics and the task requirements of users, which shapes their adoption decisions (Zhou, Lu, & Wang, 2010). Therefore, the TAS process is crucial in the technology implementation trajectory. Decisions made during TAS, which include characterizing technology attributes, identifying applications, and making subsequent selections, have a direct influence on how well the technology aligns with user tasks.

Although users may understand the complexity of a technology and recognize its advanced features, the TTF model warns that adoption is not guaranteed if users perceive the technology as unsuitable for their tasks or incapable of delivering noticeable performance improvements (Afshan & Sharif, 2016). Therefore, the TAS process becomes a crucial mechanism, ensuring that the chosen technology, in addition to its advanced capabilities, is closely aligned with the specific operational requirements at hand. The TTF model advocates for an alignment that establishes a synergistic relationship, which is conducive to user adoption (Afshan & Sharif, 2016). In line with current academic discourse emphasizing the importance of decisions made during the TAS stage, it is clear that this phase plays a crucial role in effectively integrating technology into user workflows. The TTF model highlights the connection between technology characteristics and task requirements (Khan et al., 2018), providing a theoretical basis for the need to promote and improve the TAS process. Through such efforts, organizations can ensure that the technologies they select are not only sophisticated but also attuned to the practical needs of users. This maximizes the likelihood of successful adoption and implementation.

6.2.2.2 Dual Process Theory

The DPT is a psychological framework that proposes two types of cognitive processes: System 1 and System 2 (Evans, 2003; Evans, 2008; Evans & Stanovich, 2013). System 1 is fast, intuitive, and emotional, while System 2 is slow, analytical, and logical. Dual process theory suggests that both systems work together, and their interaction influences decision-making and behavior. Thus, the DPT help explain how people make decisions, solve problems, and evaluate information in different situations. The TAS framework aims to guide researchers through technology understanding, identifying applications, and selecting the most promising one. The TAS framework can help researchers to apply both System 1 and System 2 processes in a balanced way, depending on the stage and the objective of the process. For example, in the application identification phase, the researcher can use System 1 to generate creative ideas based on the technology features. In the technology application selection phase, the researcher can use System 1 and System 2 to evaluate based on rational factors and integrate individual preferences. The dual process theory aligns with the goal of the TAS framework by providing a theoretical foundation and a practical tool for researchers to make informed and rational decisions in the technology application selection process. By applying both System 1 and System 2 processes in a balanced way, researchers can enhance their creativity, efficiency, and effectiveness in developing new products or services based on novel technologies.

6.2.3 Evaluation Strategy

In a DSR approach, evaluating the artifact is imperative (Hevner et al., 2004a) to verify its utility, quality, and effectiveness, ensuring the fulfilment of stated requirements. Beyond enhancing understanding, evaluation serves as feedback for improving the artifact's quality and the design process. The artifact's added value is demonstrated through evaluation, justifying its contribution (Hevner et al., 2004a). The evaluation activity in a DSR project is crucial, as it provides evidence that the artifact solves the problem or improves the situation. It provides feedback for the next artifact iteration and assures the research's rigor part (Prat, Comyn-Wattiau, & Akoka, 2015). The artifact is evaluated to answer the research questions: “Is the developed artifact supporting the application identification and selection of technologies?" and "How can the developed artifact be further improved, if necessary?" Therefore, an evaluation strategy was developed based on the existing FEDS framework by Venable et al. (2016) applying the Human Risk and effectiveness approach as the primary strategy. This approach was chosen due to its solid formative and naturalistic character while being feasible to evaluate with real users in their real application context (Figure 10). While the first Evaluation Episode (EE1) and the second Evaluation Episode (EE2) were considered as naturalistic, but still had a artificial character to some extend within their field experiments, the final evaluation episode (EE3) was completely assigned to naturalistic character. Also, to ensure a summative evaluation, the Focus group in EE3 were used, to gather a final and comprehensive overview about the evaluation of the TAS framework.

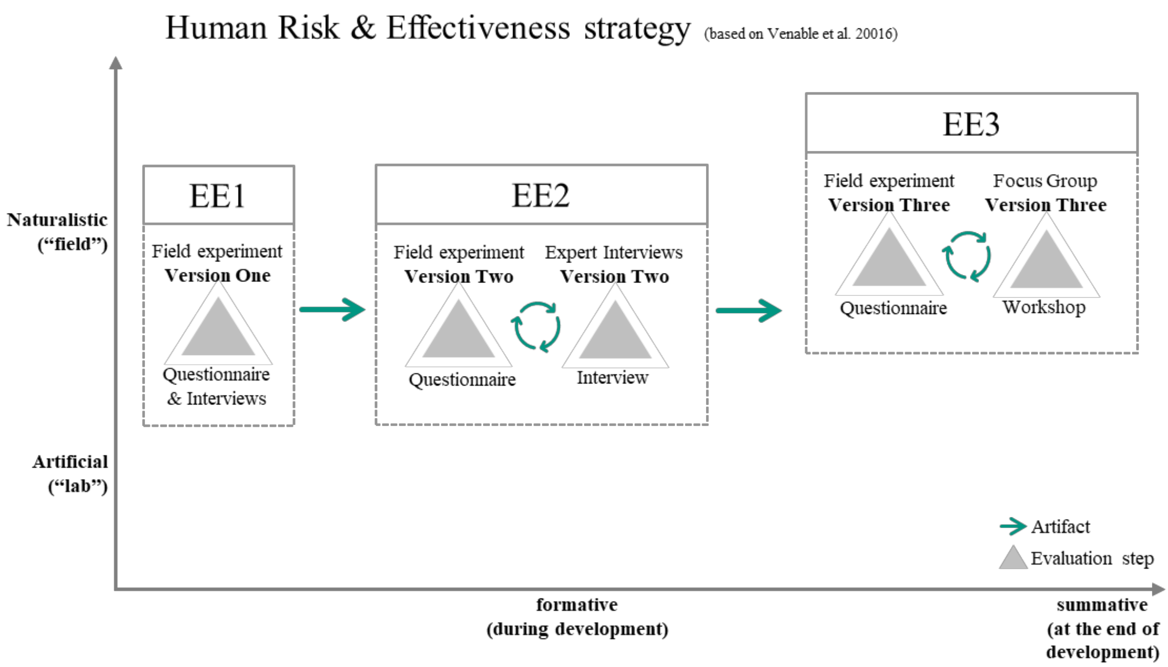

Figure 10: Evaluation Strategy for the TAS Framework (Own Illustration)

Evaluation Episode 1

In an extensive series of six field experiments, graduate students specializing in electrical, mechanical, and industrial engineering actively participate in a workshop series that integrates the TAS framework. The workshops unfold across multiple sessions, providing an extended timeframe for team collaborative work. Participants immerse themselves in the entrepreneurial experience, navigating the startup process, including idea development and business pitching, accompanied by the TAS framework. Adhering to an action-based approach (Rasmussen & Sørheim, 2006), the workshops seamlessly merge theoretical input on the TAS process with practical group work phases conducted online using a digital whiteboard. A designated moderator guides the process, ensuring clarity and usability. Post-workshop interviews with several team members delve into the utility of employing the TAS framework for generating novel technology-based ideas. Additionally, questionnaires distributed to participants after completing the TAS framework contribute valuable anonymized insights.

The evaluation embraces a naturalistic character, involving students instead of researchers or nascent spin-offs. This approach effectively addresses potential difficulties and challenges, allowing the practical application of the TAS framework to be thoroughly tested without causing frustration or confusion among participants. The framework could be used by integrating it into a workshop setting to allow for an initial evaluation, although it is intended to be used autonomously. Using patent descriptions from the university adds a practical yet stimulated dimension to the evaluation, crucial for bridging the gap between theoretical knowledge and practical application. This is particularly relevant as researchers, while not initially aware of the TAS framework's utility in generating promising applications, may be hesitant to test a purely theoretical framework. Consequently, the evaluation is positioned in-between artificial and naturalistic realms, providing a pragmatic and insightful exploration of the TAS framework within an educational context, supported by robust data collection methods.

Evaluation Episode 2

Employing a distinct evaluation episode, the second evaluation strategy unfolds as a continuation of the former approach. Five workshops, adopting the same practical yet stimulated methodology, were conducted. Of these, two followed the structure of the initial Evaluation Episode (EE1), while the remaining two were collaboratively conducted with researchers. Despite the collaborative workshops involving researchers, the target group remained students, primarily due to time constraints faced by the researchers within the workshop format. In these collaborative workshops, the researchers integrated their developed technology as the given technology for the TAS framework. The collaborative approach involved presenting the technology, providing all relevant data for a comprehensive understanding, and being available as technical consultants throughout the TAS framework. While researchers were engaged in the process, they did not actively execute the TAS process steps. The overarching goal of these collaborative sessions was to identify applications for potential commercialization. Post-workshop interviews were conducted with participants and researchers to understand the technology's usage within the workshop setting comprehensively.

Additionally, questionnaires similar to EE1 were distributed to participants. To enrich the evaluation's naturalistic aspect, 15 technology innovation managers were interviewed in semi-structured interviews, providing insights into the TAS framework's real-world implications and potential applications. The ongoing TAS projects provide a rich context for empirical exploration.

Evaluation Episode 3

To obtain extensive knowledge, focus group sessions implementing a systematic Strengths-Weaknesses-Opportunities-Threats (SWOT) analysis format were arranged. These sessions were aimed to foster contemplation amidst various stakeholder clusters and investigate the feasibility of independent usage. Further, a within a survey, the participants of the focus group workshops were asked to rate the perceived fulfilment of the requirements. Additionally, one workshop was held with 17 researchers and assessed using a questionnaire. This mixed-methods approach improves the evaluation by capturing qualitative reflections and quantitative metrics. As a result, this allows for a summative evaluation, capturing feedback on the final version of the TAS framework and the Design Cycles.

6.2.4 Design Cycles

In the initial cycle, the emphasis was on understanding design requirements and formalizing seven functional requirements through literature reviews, 45 stakeholder interviews and an investigation of existing TAS processes. Further, the goal theory was identified and applied to address the fuzzy nature of the research field. Environmental, user, and structural requirements were also defined based on prior entrepreneurial studies designing artifacts. These DRs were instantiated into an artifact and evaluated in entrepreneurship workshops with students. Building on cycle 1, the second cycle aimed to refine requirements, gather in-depth knowledge, and improve the artifact. The updated artifact underwent evaluation in five field experiments with students, simulations with researchers, and interviews with 15 innovation managers, validating proposed requirements and suggesting improvements. The third cycle focused on further refining the requirements and the artifact. A final evaluation occurred in one focus group workshop with researchers and five focus groups involving stakeholders within the technology transfer nexus of researchers.

DSR Cycle 1

The first design cycle directed attention toward comprehending the DRs. A literature review was initiated to explore challenges related to the identification and selection of applications of technologies. Concurrently, 45 interviews were conducted to glean insights from the real world regarding the process, potential barriers, and areas requiring improvement in identifying and selecting applications and technologies. Respondents were selected from four related areas of experience: 1) technology transfer innovation managers, 2) academic researchers, 3) academic entrepreneurs, and 4) entrepreneurship education researchers. The interviews sought to understand the interviewees' roles in the technology transfer ecosystem, their experiences and involvement in technology identification and selection, and the strategies and techniques employed or known during their careers. Following the methodology of Gioia et al. (2013), interviews were recorded, transcribed, and analyzed using qualitative content analysis, employing an inductive coding approach to maintain impartiality. Existing procedures were also examined to support identifying relevant components of a promising approach and any limiting factors. Thus, existing TAS processes were identified and analyzed, leading to an initial set of building blocks for an effective TAS. Based on these findings, an initial set of seven functional DRs was formalized, outlining the inherent objective of the (future) artifact (Gregor, S., & Hevner, A. R., 2013;

Kuechler & Vaishnavi, 2008). Together with environmental, user and structural requirements, these were instantiated in a tentative artifact and evaluated in six field experiments conducted in entrepreneurial workshops with students. These studies provided an opportunity to assess the TAS framework in a practical but stimulated setting, utilizing patent descriptions from the university as given technologies. This approach aimed to prevent potential difficulties and challenges from causing frustration or misguidance for researchers and nascent spin-offs, ensuring that practical applications could be effectively tested. The conclusion of cycle 1 identified the need for further refinement, serving as the basis for cycle 2.

DSR Cycle 2

The initiation of the second design cycle involved a comprehensive review of the field experiment analysis within the context of the problem understanding. Consequently, an updated and enhanced artifact was developed and evaluated in five distinct field experiments. Although all field experiments adhered to the same practical yet stimulated approach of EE1, two differed as they were conducted in collaboration with researchers. These researchers provided their patented technology as the foundational basis for the process, leveraging their expertise in the respective field to identify applications suitable for commercialization. Despite the simulated nature of these studies, the intent was to derive results applicable to practical scenarios.

Moreover, we conducted semi-structured interviews and user tests with 15 innovation managers actively engaged in identifying and selecting technology applications. These innovation managers were purposively selected based on their extensive professional experience in technology transfer and innovation management, averaging ten years of expertise. The outcomes of the field experiments analysis and the interviews validated the proposed requirements and revealed opportunities for further enhancements in the artifact.

DSR Cycle 3

The previous design cycles had the primary objective of ensuring that the design and content of the TAs framework fulfilled the specified requirements. Accordingly, the framework underwent testing under controlled conditions. To achieve the ultimate goal of enabling researchers to work independently on TAS, it is critical to ensure that the user experience remains optimal. Thus, the emphasis of the third design cycle was placed on further refinement of the design requirements, focusing on the user experience of the artifact. Guided by the outcomes of the field study results and the insights gathered from the interviews conducted during the second design cycle, the need for an enhanced UX became permanent. Thus, the artifact was refined accordingly, laying on the human-centered design process.

Consequently, the further developed artifact was evaluated within two settings: First, a field experiment was conducted with researchers. Secondly, five focus group workshops were conducted with stakeholders deeply engaged in the technology transfer and management process. The results from the culmination of the three design cycles will be elaborated upon below.

The development and evaluation process in the three design cycles are introduced separately in detail in Chapter 6.3 (Cycle 1), Chapter 6.4 (Cycle 2), and Chapter 6.5 (Cycle 3).

6.3 Design Cycle 1

The chapter follows the structure of the DSR cycle introduced by Kuechler and Vaishnavi (2008), following the five-step approach (Figure 11). The Problem Awareness phase centers on the findings of the studies presented in chapter 3, 4 and 5, translating them into design requirements in the Suggestion phase, supported by conceptual foundations for the proposed artifact. The instantiation of the TAS framework occurs in the Development phase. Consequently, the artifact is evaluated in the Evaluation phase, and the results are discussed in the Conclusion phase, marking the culmination of the first design cycle.

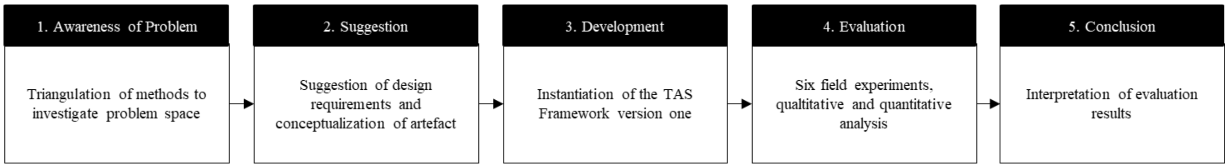

Figure 11: Design Cycle One (Own Illustration)

6.3.1 Problem Awareness

Three research activities were outlined to gain an initial understanding of the challenges, relevance, and existing processes in the area of TAS (see 3, 4 and 5). The results of the research activities, including an interview series, a systematic literature review, and an in-depth analysis of existing processes, serve as a basis to generate initial design knowledge for assisting the technology application selection process among nascent spin-offs. Triangulation was employed in this research to enhance the credibility and validity of the findings. Triangulation involves using diverse data sources, methods, or researchers to address the same question, leading to a more comprehensive understanding and improved generalizability of the results, ultimately increasing research quality and relevance (Bans-Akutey & Tiimub, 2021).

Reviewing the literature on influential factors and challenges associated with identifying and selecting applications for technologies provided an initial general impression of the obstacles and environmental conditions. Delving deeper into the problem space, an interview series with 45 stakeholders involved in the process comprised of researchers, academic spin-offs, entrepreneurial educators, and technology transfer managers. This approach facilitated a comprehensive understanding of the current process, its perception, perceived challenges, and the offered and desired support mechanisms. Further, by scrutinizing existing TAS processes, their respective characteristics could be identified, and a conceptual model for a systematic TAS framework could be derived. This systematic approach, encompassing diverse research activities and sources, contributes to a robust foundation for designing a practical TAS framework tailored to the specific needs of researchers and nascent spin-offs.

6.3.1.1 Description of the Problem

In this chapter, the findings from the expert interviews, the literature reviews, and the analysis of existing processes are summarized and analyzed to derive the proposed requirements for the artifact.

6.3.1.2 Findings of the Systematic Literature Review

The investigation into influential factors and challenges in technology-based ideation processes resulted in an overview of thirteen influential factors and nine challenges. It was noteworthy that literature density decreased as the focus shifted to technology-based ideation, with the most frequent factors centering around individual prerequisites, also evident in non-technology ideation processes. These include personality traits (Abd Rahim et al., 2021), prior knowledge (Frishammar et al., 2012; Park, 2005), experience (Gruber et al., 2008), and alertness (Veilleux et al., 2018). External influences were highlighted, significantly impacting the identification process, as indicated by using social networks (Corbett, 2007; Mary George et al., 2016) and the influence of the environment (Junglas, Abraham, & Watson, 2008; Maier et al., 2016). Rasmussen and Wright (2015) also emphasize this, focusing on contact with industry and the scientific community. These factors should be considered when designing a TAS framework, as they represent a crucial source of knowledge and exchange essential for a solid process framework. While a one-day workshop cannot cover this comprehensively, it should be considered during planning.

Consequently, influences occurring within the TAS process, despite their infrequent mention, are highlighted as fundamental aspects to consider in designing a valid TAS framework. While several studies discuss the necessity of a systematic search process for successful ideation (Corbett, 2007; Dew, 2009; Neill et al., 2017), additional factors need integration into the process to enhance its success. These include customer inclusion (Holzleitner, 2015), having a clear advantage of technology (Bishop, 2004), generating carefully examined alternatives (Bishop, 2004), and information transformation, referring to how an individual transforms new information and combines it with existing knowledge, affecting opportunity identification from technology to market (Corbett, 2007).

While the frequency of the identified nine challenges was consistently low, each represents significant importance for a successful TAS framework. Notably, they are also interconnected with the identified influential factors. Felkl (2013) and Kuo et al. (2011) generally highlight the challenge of an unstructured ideation process, aligning with the resource constraints within this process mentioned by Lim and Lee (2019) and Gruber et al. (2008). Diving deeper, the challenges differentiate between the diverge and converge phases of the process. Within the diverge process, representing a phase of expansive thinking and creative exploration, the difficulty of exploring multiple applications (Bianchi et al., 2010; Gruber et al., 2008; Strøm, 2018), cognitive challenges (Grégoire & Shepherd, 2012; Terzidis & Vogel, 2018), and challenges in obtaining alertness (García-Cabrera & García-Soto, 2009) are highlighted. Having a limited capability of imagination and utilization of creative thinking decreases the chances of discovering an original and new application for the given technology, representing an essential factor for successful technology commercialization. Further, the unknown customer and respective market are stated as challenging, as, on the one hand, a lack of market knowledge (Herstatt & Lettl, 2004; Shane & Venkataraman, 2000; Vohora et al., 2004) hinders the exploration of further possibilities in other markets, and on the other hand, the often-occurring market centrism on the known market (Herstatt & Lettl, 2004) limits the exploration space. In addition, identifying new customers is challenging (Danneels, 2007) due to the lack of market knowledge and the fuzzy nature of the ideation process on technologies. Within the converge phase, a challenge is using appropriate and suitable evaluation methods, resulting from a lack of knowledge about their existence and applicability (Herstatt & Lettl, 2004; Holzleitner, 2015).

Based on the derived insights, a structured process guiding the identification and selection of potential applications for technologies can address the identified influential factors and challenges. Various methods should support this process to guide the user through the respective steps and provide instructions to overcome the challenges. The process should instruct the user to deploy and expand existing knowledge strategically to identify potential applications for the technology. A focus should be placed on supporting the connection of technology to new (and unknown) markets and identifying potential customers and their needs. Additionally, the utilization of social networks should be encouraged.

6.3.1.3 Findings of the Interviews

While the analysis of the interviews has revealed a limited focus on the domain of application identification and selection, the identified categories and their interconnectedness have uncovered relevant insights. The fuzzy nature of the TAS process became apparent through the limited descriptions of the TAS processes in practice. Interviewees particularly emphasized the iterative nature, the necessity of customer integration, the importance of obtaining early feedback for timely adjustments, and the need for market research and proactive exploration of potential applications.

The customer-centric approach prioritizes customer needs and preferences when selecting technology applications. Through early feedback gathered during the TAS process, applications can be evaluated and adapted early on, helping to identify weaknesses and align with user needs. By proactively exploring inventive ideas, potential applications are opened up, presenting opportunities for authentic, valuable applications that can benefit business. The iterative nature of the TAS practice suggests that identifying applications is an ongoing process, encouraging continuous learning, refinement, and adaptation to evolving market conditions. The role of market research is fundamental in selecting appropriate applications by providing a comprehensive understanding of the market and competing entities.

The challenges in the TAS process, some directly related to process execution and others representing influencing factors, such as team dynamics or prior knowledge, were frequently mentioned. A highlighted aspect was understanding and validating the market, working with assumptions that need early validation through constant feedback and testing. Communication within networks emerged as a crucial area for testing and validating assumptions, gathering feedback, and filling knowledge gaps. Other challenges, while not specific tasks within the TAS process, nonetheless have an impact, such as the transition from academia to entrepreneurship and the technical depth and perseverance required.

The support domain revealed two aspects: existing support mechanisms and desired ones. Adequate training is lacking to build knowledge and experience and raise awareness for these areas. This underscores the need to be aware, that researchers lack prior knowledge. Coaching was prominently acknowledged, particularly in providing guidance, setting instructions, deliveries, and timeframes, and expanding networks within entrepreneurial ecosystems. Criticism was directed at the lack of customized support. Methodological support was also discussed, with criticism about unclear guidelines on when and how to apply methods and their perceived value. A systematic TAS framework can integrate the highlighted attributes of coaching, provide clear instructions, and incorporate methodological supports for optimal user assistance. However, it remains the users' responsibility to utilize these resources based on their needs.

In conclusion, a structured guide can assist in navigating the fuzziness of the TAS process. As highlighted in practice, the proactive search for suitable applications can be embedded in a corresponding framework and the necessary support mechanisms. Attributes mentioned in coaching and methodological support can be integrated into the framework, offering assistance in areas revealed by the interviews, including constant validation, external feedback, market research, customer understanding, and dealing with knowledge gaps. While network utilization may not be directly reflected in a framework, it can be encouraged and supported. Overall, it can be inferred that, at least within the sampled responses, no TAS framework or similar approaches are known to offer such support and guidance, emphasizing the need for such a framework to address the identified issues.

6.3.1.4 Findings of the Process Review

The review of existing TAS processes identified 18 processes that resulted in nine building blocks incorporated into existing processes. Thus, based on a conceptual model, the structure and interconnectedness of the respective building blocks could be drawn. Still, the building blocks derived should be carefully analyzed to consider them for the design of a TAS process, as well as compared to insights of theory and practice on the topic of TAS.

Following the proposed structure of the conceptual model, the building blocks are separated into three segments (technology characterization, application identification, and application selection). Thus, the segments represent two of the outlined building blocks, the technology characterization and the application identification. The remaining building blocks are posed in the application selection segment.

Consequently, the blocks of market research, user evaluation, expert evaluation, product conception and prototyping remain.

The building blocks essentially represent the challenges identified in the literature (2.1.2) and the interviews (6.3.1.3). Exceptions to this are the product conception and prototyping, which were not explicitly mentioned but can be considered subcategories in early validation and feedback. Since prototyping is typically used to gather feedback and present the product idea to potential customers, it is viewed more as a methodology than a building block. This aligns with the conceptual model of the TAS framework, which integrates prototyping as an optional block.

The remaining blocks serve as representations of insights found in previous studies: Market research was mentioned multiple times, a customer-centric approach and the need of understanding the customer represent user evaluation, expert evaluation is integrated through networking contact with industry and academia, and evaluation was emphasized in terms of the need for suitable methods and corresponding support in their utilization. Although not explicitly mentioned, a factor of immense relevance for the TAS process is the technological characterization. This step is positioned as the first in almost all identified analysis processes, as it provides a comprehensive understanding of the technology and reveals all potential possibilities. However, since this can be seen as a fundamental prerequisite, its necessity is not questioned.

6.3.1.5 Summary of the Findings

A triangulated research methodology was implemented to comprehend the challenges, significance, and current procedures in the field of TAS. This involved conducting a series of interviews, performing a systematic literature review, and comprehensively analyzing existing TAS processes. The use of triangulation, which combined various data sources and methods, enhanced the credibility and validity of the research findings. The main aim of this research was to establish fundamental design knowledge to guide researchers in the selection of technology applications. The investigation into the influential factors and challenges linked with technology-driven ideation procedures identified thirteen influential factors and nine challenges. These factors ranged across personal preconditions, external influences, and internal processes, emphasizing the intricate nature of technology ideation. Challenges comprised unstructured ideation processes, cognitive hurdles, market knowledge gaps, and complexities during the convergence phase. An analysis of TAS procedures in practice underscored the iterative nature of the process. The examination emphasized the importance of customer-centric approaches, early obtaining of feedback, proactive exploration, and market research. Challenges arose during the TAS process, both in terms of procedures and contexts, highlighting the importance of comprehending and validating the market, effective communication within networks, and navigating the shift from academia to entrepreneurship. Furthermore, an exploration of the support domain revealed both current and desired mechanisms for support, identifying gaps in training, coaching requirements, and methodological assistance. The interviews uncovered a noticeable lack of a structured TAS framework in both research and practice. The analysis of current TAS procedures revealed 18 processes that led to nine crucial components encompassed within present-day operations. These components are categorized into three distinct segments: technology characterization, application identification, and application selection. These building blocks effectively tackle obstacles uncovered during literature research and interviews, excluding product conception and prototyping which are considered to be methodologies rather than explicit building blocks. The components correspond with prior research findings, including the significance of conducting market research, implementing a consumer-focused strategy, connecting with industry experts for evaluation, and prioritizing suitable evaluation techniques. The evaluation of technology is considered a crucial prerequisite for gaining a comprehensive grasp of technology and is often regarded as the initial step in most analytical processes.

Table 26: Identified Issues within the TAS Process

Identified Issues	Sources	Theories
Researchers need to improve their market knowledge.	Ardichvili & Cardozo (2000); Shane et al. (2002); Vohora et al. (2004); Liao et al. (2010); Siegel, et al. (2012); Xie et al. (2018); Sanchez-Gutierrez et al. (2019); Choi & Storr (2021); Wang & Gao (2021)	Absorptive Capacity Theory (Cohen & Levinthal, 1990)
Researchers need to gain a versatile understanding of the technology.	Bishop & Magleby (2004); Corbett (2007); Grégoire & Shepherd (2012); Rogers et al. (2014); Terzidis & Vogel (2018); Manthey et al. (2022); Manthey (2023)	Diffusion of Innovation Theory (Rogers, 1962)
Researcher need to understand the worth and leverage social capital.	Elfring & Hulsink (2003); Franzoni (2006); Rasmussen & Wright (2015); HakemZadeh & Baba (2016); Perry-Smith & Mannucci (2017); Lim & Lee (2019)	Collaboration Theory (Vygotsky, 1934; Colbry et al., 2014)
Researcher need assistance in identifying various alternatives and multiple applications.	Cziko (1998); Bianchi et al. (2010); Girotra et al. (2010); Strøm (2018); Benedek et al. (2020)	Theory of Blind Variation and Selective Storage (Campbell, 1960)
Researcher seek guidance in evaluating the identified applications.	Cooper (1999); Koen et al. (2001); Herstatt & Sandau (2006); Cooper et al. (2002) ;Girotra et al. (2010); Stevanovic et al. (2012); Csaszar & Eggers (2013), Magnusson et al. (2014); Zhu et al. (2017); Manthey et al. (2022)	Rational decision making theory (Simon, 1947)
Researchers need structured guidance for a purposeful and efficient utilization of resources in conducting TAS.	Shane (2002); Baron (2006); Gruber et al. (2008); Dew (2009); García-Cabrera & García-Soto (2009); Felkl (2013); Strøm (2018); Assensoh-Kodua (2019)	Resource-Based View (Wernerfelt, 1984)
Researchers require guidance to comprehend potential customers and their needs.	Henkel & Jung (2009); Colbry et al. (2014); Holzleitner (2015); Chang (2019)	Collaboration Theory (Vygotsky, 1934; Colbry et al., 2014)

Issue#1: Researchers need to improve their market knowledge

The literature review highlights the significant role of market knowledge, the interviews, and the review of the existing process. It is acknowledged that a deficit of market knowledge impedes their ability to grasp the dynamics and the demands of the market, leading to difficulties in market understanding and validation. As it supports the search for new applications for innovations in several ways, market knowledge is an essential catalyst for technology-centered ideation processes (Ardichvili & Cardozo, 2000; Siegel & Renko, 2012). Understanding the transformation of the market and the future needs of potential customers can lead to the discovery of relevant and resonant solutions that can be solved by the given technology (Sánchez-Gutiérrez, Cabanelas, Lampón, & González-Alvarado, 2019). To complement existing solutions or address unmet needs, the competitive landscape can provide insights leading to new technological innovations (Wang & Gao, 2021).

Furthermore, it identifies promising segments and potential hurdles, ensuring targeted development and adaption of the technological application (Choi & Storr, 2021). Moreover, knowing the market allows for understanding the feasibility and economic potential, which is crucial for technological innovation. A lack of relevant market knowledge can hinder identifying, assimilating, transforming and exploiting external information relevant to identifying promising applications, thereby wasting opportunities (Shane, 2002; Vohora et al., 2004). Furthermore, market knowledge is required to identify potential innovation areas for the given technology (Liao, Wu, Hu, & Tsui, 2010), as absorptive capacity theory suggests. Increasing users' knowledge of markets can increase their potential and actual absorptive capacity. This ultimately leads to further innovation and value creation (Xie, Zou, & Qi, 2018).

Issue#2: Researchers need to gain a versatile understanding of the technology.

Further, a versatile comprehension of the given technology is required to navigate the intricacies associated with its development and application. This is represented by the integration of the step “technology characterization” in the building blocks and by the challenge “technological depth” highlighted in the interviews. The adoption and diffusion of new technologies depend on several factors. One of these is the characteristics of the technology as described by the diffusion of innovation theory (Rogers, Singhal, & Quinlan, 2014). The relative advantage of the technology, i.e. the extent to which it is perceived to be superior to existing alternatives, as described by (Bishop & Magleby, 2004), is a crucial feature to consider. To assess the desirability of a technology, users must have a clear understanding of how it works and the benefits it can offer in varying contexts and situations, as indicated by Terzidis and Vogel (2018). Understanding how a technology works can seem daunting, especially if it involves unfamiliar or complicated concepts, mechanisms, or components. Particular unique benefits of technology are vital in identifying applications (Manthey, 2023). Still, this presents a cognitive hurdle for users, requiring them to go beyond their current mental models and schemas and assimilate new information and knowledge, as recognized by Grégoire and Shepherd (2012). To address this cognitive challenge, structural alignments can help users understand the technology comprehensively, allowing them to identify novel connections and potential applications that are not immediately apparent. In addition, understanding the function of the technology can be hampered by the complexity of information transformation, which involves converting information from one format or representation to another (Corbett, 2007). For this reason, experts recommend thoroughly examining the given technologies, as a deeper understanding of the technology can prevent the loss of unexplored opportunities (Manthey et al., 2022a).

Issue#3: Researchers need to understand the worth and leverage social capital.

Maintaining contact with industry and the scientific community is essential for application identification, which is also highlighted by the identified influential factors “contact to industry” and “contact to scientists” (Rasmussen & Wright, 2015). This keeps users informed of the latest developments, innovations, and challenges in various fields while also assisting users in comprehending potential customers' and stakeholders' needs and preferences (Rasmussen & Wright, 2015). This information can act as a valuable inspiration for ideation. All in all, social networks provide a convenient platform for knowledge sharing, thereby increasing the probability of identifying potential opportunities (Lim & Lee, 2019). The identified influential factors also acknowledge the relevance of social networks and the environment. Using social networks can aid users in utilizing and extending their social capital by uncovering new or latent market needs, problems, or trends while acquiring suitable and timely information about existing solutions. Besides that, the information can usually be acquired in less time and costs.

Moreover, social networks can help evaluate the feasibility and profitability of potential applications or be used to exploit further opportunities, emphasizing the necessity of actively utilizing the network (Franzoni, 2006). A fascinating aspect of exploring social networks is the differentiation between strong and weak connections, facilitating the recognizing of technological applications. Weak ties formed with individuals of differing backgrounds and interests tend to assist users in accessing innovative and diverse knowledge, evoking new ideas (Elfring & Hulsink, 2003b). On the other hand, strong ties formed with friends or colleagues of similar backgrounds provide access to reliable knowledge, enabling exploration (Elfring & Hulsink, 2003b). These findings can be related to collaboration theory (HakemZadeh & Baba, 2016), which depicts working collaboratively to achieve common goals, generate new knowledge and address problems. Collaboration through social networks permits users to extend and enhance their social capital by learning from each other's experiences, expertise, and perspectives, fostering creativity, innovation and sharing of diversified information. Furthermore, it is also associated with increased motivation and commitment, essential resources for the team (Perry-Smith & Mannucci, 2017). In conclusion, by guiding users to utilize and improve their social capital, this process can help them accomplish superior performance, innovation, and competitiveness outcomes.

Issue#4: Researchers need assistance in identifying various alternatives and multiple applications.

The interviews revealed that identifying various alternative and multiple applications is a critical hurdle in practice, posing a barrier to exploring diverse opportunities. Creating new and original technological applications that can resolve problems, satisfy needs, or create value is crucial in the desired process. Ideation defines the process of generating, developing, and communicating ideas and relies on creativity, which is fundamental in identifying applications as it can enhance ideas' flexibility, originality and quality (Benedek, Jurisch, Koschutnig, Fink, & Beaty, 2020). A lack of creativity would limit ideation to existing knowledge, assumptions, or expectations. Following the theory of blind variation and selective storage (BVSR), creativity is a two-step process: Blind variation is the generation of a wide range of diverse and innovative ideas without regard to their usefulness or feasibility, while selective storage defines the evaluation phase (Cziko, 1998). By generating a wide range of potential applications for a given technology without being constrained by existing knowledge, assumptions or expectations, the high risk of failure is mitigated, as the likelihood of developing valid applications is higher. Creativity is, therefore, built into the process (Bianchi et al., 2010). This approach can also overcome the cognitive challenges that develop in this process. These refer to the obstructions that users encounter while creating or assessing new ideas, for instance, mental fixation, functional fixedness, or confirmation bias (Strøm, 2018). Therefore, guiding users to explore different and alternative applications can enhance their creativity and improve their decision-making abilities. Further, conducting ideation within a team can enhance the generated quality, thereby increasing the probability of identifying a promising application (Girotra, Terwiesch, & Ulrich, 2010).

Issue#5: Researchers seek guidance in evaluating the identified applications.

Moreover, findings from the research underscore the challenges associated with evaluating identified applications, indicative of a constrained comprehension regarding the pertinent criteria and methodologies integral to this pivotal assessment. Evaluating and selecting ideas is one of the most critical steps in the new product development process (Stevanovic, Marjanovic, & Štorga, 2012a), as it provides immense business value when making the right decision (Koen et al., 2001). Further, it coins the future shape of the company's success (Cooper, 1999). Still, despite the criticality of this phase, companies regularly resort to intuition instead of making fundamental future-determining decisions based on sound, objective criteria and methods (Herstatt & Sandau, 2006; Magnusson, Netz, & Wästlund, 2014; Manthey et al., 2022a). Although clear criteria can be established beforehand, the selection task is complex and laborious. That is because the more ideas available, the more complex the selection, the more chaotic the process, and the less attention is paid to specific criteria (Csaszar & Eggers, 2013; Girotra et al., 2010). Despite methods and criteria, it remains a predictive activity with high uncertainty and risk (Cooper, Edgett, & Kleinschmidt, 2002; Zhu, Ritter, Müller, & Dijksterhuis, 2017).

Issue#6: Researchers need structured guidance for a purposeful and efficient utilization of resources in conducting TAS.

The research reveals a notable lack of structured framework or guidance in this domain. Despite various TAS approaches, as underscored by identifying 18 processes (6.3.1.4), none of these approaches are accentuated in either research or practical contexts. Nonetheless, a discernible need for a structured approach is evident, aligning with the challenges of limited resource availability faced by researchers and spin-offs. Besides the number of applications found through spontaneous recognition (Shane, 2002), systematic opportunity-seeking is essential in the technological innovation field (Baron, 2006). Entrepreneurs can even achieve serendipity (Dew, 2009) by linking changes and trends to the market, customers and technology. In addition, active search strengthens opportunity development skills and deepens attention, knowledge, and experience. These contribute to application identification (García-Cabrera & García-Soto, 2009).

Nevertheless, systematic approaches supporting matching technology and a market are missing (Felkl, 2013). Furthermore, especially in the case of research-emerging technologies or technological knowledge, systematic search processes can help users use their resources effectively and efficiently to achieve their goals. This is in line with the resource-based view (Assensoh-Kodua, 2019). Since resources are scarce in all areas, whether due to a lack of time, energy or financial capital, they need to be used efficiently, this can be facilitated by setting up a clear structure for identifying and selecting applications for technologies (Gruber et al., 2008; Strøm, 2018).

Issue#7: Researchers require guidance to comprehend potential customers and their needs.

Even though technology-based ideation starts with the technology, there is still a need for customer involvement in the process (Holzleitner, 2015). The challenges evolving around market knowledge, market understanding, and market validation also highlight the deficiency in understanding the market's demands and customer preferences. This aligns with the challenge of gathering insights into potential customers and their needs. According to collaborative theory, learning from the feedback and suggestions of potential customers, understanding their pain points and expectations, and aligning the final solution with these requirements can enhance the final application by dealing with customers and their needs and desires (Colbry, Hurwitz, & Adair, 2014). Their involvement in the development of the application can also have a mitigating effect on the risk of failure (Henkel & Jung, 2009). Segmentation of the target and customer groups and identifying the underlying needs without asking the customers is crucial for involving them in the innovation process (Chang, 2019).

Discussion

In synthesizing the research findings, it becomes evident that market knowledge plays a pivotal role in identifying and selecting applications. This connection is intertwined with the issue of inadequate customer understanding, emphasizing the interdependence of market knowledge and customer comprehension. Moreover, a versatile understanding of technology is imperative for facilitating an effective TAS process. The underappreciation of the value of social capital represents an untapped area crucial for application identification and selection. Identifying alternative applications poses a significant challenge, limiting the exploration of unique and original solutions technology offers. Evaluating these alternatives is equally challenging, requiring specific knowledge and methods. Overall, there is an absence of approaches in research and practical applications. This gap is further underscored by limited resources' constraints, amplifying the need for a structured approach. Finally, identifying building blocks in existing TAS processes revealed nine interrelated elements, including technology characterization, application identification and application selection. These blocks, derived from the investigation of the TAS processes (6.3.1.4) reflect the challenges identified in the literature and interviews. The recognition of technology characterization as a fundamental requirement for TAS processes is highlighted. By deliberately concentrating the interviews on the technology transfer nexus surrounding the researcher, the implications derived from triangulated research are customized to address the unique requirements of the researchers. In summary, the research has established a robust groundwork for designing a systematic TAS framework, tackling the identified issues. These serve as the basis for articulating the functional requirements of the upcoming artifact.

6.3.1.6 Derivation of Requirements

The requirements of the framework, rooted in the outcome of the DSR process, form the basis of an articulated requirements set that is outlined to form the base for the design of the TAS framework. These requirements, synonymous with evaluation criteria in DSR, are defined as statements expressing the desirability of specific artifact properties by stakeholders (Johannesson & Perjons, 2021). As specific objectives, these requirements guide researchers in transitioning from problem identification to solution development within the DSR process. Validation of artifact quality and fulfilment of requirements are essential considerations (Johannesson & Perjons, 2021).

To assure that users get the most out of the TAS framework, the design of the framework is essential. The DSR process necessitates that the design is created and tested against specific design requirements to achieve an optimal outcome. Complying with these requirements ensures that the framework is both theoretically and methodologically sound as well as useful in practice. The derivation of DSR requirements stems from challenges identified through literature (6.3.1.2), the review of existing processes (6.3.1.4), empirical studies (6.3.1.3) and design theory (6.2.2), and is tailored to the specific application of the artifact (Stockmann & Meyer, 2014). In the absence of a uniform standard for DSR requirements, the approach of Johannesson and Perjons (2021) is adopted, distinguishing between functional, structural and environmental requirements, aligning with previous research in the adoption of DSR processes in entrepreneurship (Hatzijordanou, 2019; Lau, 2022).

Functional requirements pertain to artifact functions, representing the artifact's usefulness (Hatzijordanou, 2019), structural requirements address properties like coherence and conciseness, and environmental requirements consider contextual framing properties (Johannesson & Perjons, 2014). This approach facilitates a systematic TAS process by incorporating diverse requirements and perspectives. In addition, a user-centric section is integrated to address the needs of individuals employing the TAS framework. While some DSR research includes user-centric aspects within meta-requirements, this study distinguishes and evaluates them individually. Users, herein referred to as researchers, seek guidance in identifying applications for given technologies within a heterogeneous group.

The TAS Framework's task is to guide users in identifying suitable applications, providing clear instructions, highlighting objectives, and assisting in further investigations. Users, working individually or in teams with varying ages and skills, are motivated to identify applications. The framework simplifies the complexity of the process, offering comprehensive support through methods, information sources, and visual aids. Users have diverse tools, choosing between analogue or digital platforms based on preferences and application conditions. General conditions, including the application's digital or analogue form, distinguish between externally guided and self-directed applications. External guidance allows instructor support like a workshop, while self-directed applications rely solely on user-selected influences.

Functional, structural, and environmental requirements are identified from this usage context. Functional requirements stem from explicit challenges in the TAS process. Structural requirements are derived based on prior effectiveness investigations, particularly in DSR processes designing entrepreneurial artifacts (Hatzijordanou, 2019; Lau, 2022), and environmental requirements are directly derived from Johannesson and Perjons (2014).

Table 27: Set of Functional Requirements of the TAS Framework

Functional requirements	
Requirements	**Description**
The TAS process must facilitate the improvement of researchers' market knowledge.	Researchers need to improve their market knowledge.
The TAS process must support researchers in gaining a versatile understanding of the technology.	Researchers need to gain a versatile understanding of the technology.
The TAS process must enable researchers to comprehend the worth of social capital and leverage it effectively.	Researcher need to understand the worth and leverage social capital.
The TAS process must provide assistance to researchers in identifying various alternatives and multiple applications.	Researcher need assistance in identifying various alternatives and multiple applications.
The TAS process must offer guidance to researchers in evaluating the identified applications.	Researcher seek guidance in evaluating the identified applications.
The TAS process must provide structured guidance to ensure the purposeful and efficient utilization of resources in conducting TAS.	Researchers need structured guidance for a purposeful and efficient utilization of resources in conducting TAS.
The TAS process must offer guidance to help researchers comprehend potential customers and their needs.	Researchers require guidance to comprehend potential customers and their needs.

Environmental and structural requirements are typically more general and not specific to the situation. The environmental requirements concern the artifact's interactivity within its environment and are not explicitly individualized for each artifact. Therefore, the environmental requirements of the TAS framework refer to the environmental requirements of DSR artifacts as defined by Johannesson and Perjons (2021). Table 28 lists the environmental requirements and explains their objectives and motives.

Table 28: Set of Environmental Requirements of the TAS Framework

Environmental requirement	
Requirements	**Description**
Usability (Easy to use)	The ease with which a user can use an artifact to achieve a particular goal.
Comprehensibility (Easy to learn)	The ease with which an artifact can be understood or comprehended by a user (also called understandability).
Completeness	The degree to which the artefact includes all components required for addressing the problem for which it was created.
With adequate complexity	The degree to which an artefact's complexity is still adequate.
Efficiency	The degree to which an artefact is effective without wasting time, effort, or expense.
Suitability	The degree to which an artefact is tailored to a specific practice, focusing only on its essential aspects (also called inherence or precision).
Customizability	The degree to which an artefact can be adapted to the specific needs of a local practice or user.

Structural requirements concern the structure of an artifact and are relevant to almost any artifact. The structural requirements considered by the TAS framework in Table 29 are inspired by Johannesson and Perjons (2021) structural qualities, also taken into account in the DSR studies of Hatzijordanou (2019) and Lau (2022).

Table 29: Set of Structural Requirements of the TAS Framework

Structural requirement	
Requirements	**Description**
Coherence	The degree to which the parts of an artefact are logically, orderly and consistently related.
Conciseness	The absence of redundant components in an artefact, i.e., components the functions of which can be provided by other components.

A primary objective of DSR artifacts is usability. As per ISO 9241-11 (DIN-NAErg 2018), usability is defined as "the extent to which specified users can use a product to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use." User requirements describe the framework's application and are, therefore, situation-specific. In his thesis, Lau (2022) provided comparable user experience definitions, which can be adopted for the TAS framework and are detailed in Table 30.

Table 30: Set of User Requirements of the TAS Framework

User requirement	
Requirements	**Description**
Comprehensive process and method description	The artefact needs to have a comprehensive process and method description for users.
Guiding poster (Canvas-like structure)	The artefact needs to be a guiding poster i.e., have a canvas-like structure.
Include supporting methods for each component	The artefact needs to include supporting methods for each component of the TAS process.
Prioritization of components possible	The artefact needs to make prioritization of components possible.
Usable without external guidance	The artefact needs to be usable without direct external guidance e.g., from workshop leaders.

While Johannesson and Perjons (2021) also stress the need for the artifact to have a positive impact, providing an advantage over the current situation (Hatzijordanou, 2019), this requirement will not apply to the upcoming DSR project. Studies suggest that researchers are unaware of how to organize their TAS process and are unaccustomed to employing any tool to identify and select applications for their technologies (6.3.1.3). As no pre-existing standard can be built upon or compared to, the effectiveness requirement is not included in the list of criteria.

6.3.2 Suggestion

The suggestion phase is closely linked to problem awareness, involving generating potential solutions or ideas to address the identified problem. Suggestions may draw from existing theories, frameworks, models, methods, or techniques relevant to the problem domain. The output of the suggestion phase is a preliminary design of an artifact, which can take the form of a construct, model, method, or instantiation. This artifact is envisioned to address the identified problem or fulfil the requirements. This chapter's proposed set of requirements is shaped to a tentative design. This tentative design builds the basis for the subsequent Development phase of the first DSR cycle.

6.3.2.1 Foundations of the Design

The development of the TAS Framework involves a structured process derived from identified requirements in the problem awareness phase. The design process, crucial for the artifact's functionality, includes collaboration with a second researcher and the founder of an academic spin-off. This multi-perspective approach incorporates both the lens of the supportive but also the executive area. The initial design involves discussing the TAS Framework outline, integrating building blocks based on identified TAS processes and the conceptual model. Interviews and systematic literature findings are summarized, and ideas for steps and supporting methods are collected, drawing from previous research in similar practices (see Table 31). Derived from the technology push process model Terzidis and Vogel (2018), the TAS aligns with the second phase of this model, encompassing the segments of "Technology Characterization," "Application Identification," and "Application Selection." Consequently, the name is also adopted to refer to the framework.

These segments were chosen as the basis for clustering the building blocks, as examining processes and building blocks revealed significant overlaps. Design considerations are thoroughly discussed, and decisions are justified and reflected upon after the process. Following the design guidelines proposed by Johannesson and Perjons (2014), each component of the artifact is described clearly, justified, and its intended use is outlined. The design sources include findings from the systematic literature review, insights from interviews, and additional research on current TAS practices. Methods are identified, and design options are discussed in design sessions, considering their usefulness for researchers and nascent spin-offs. Selected design options are sketched, re-evaluated in subsequent sessions, and refined until an agreement is reached for version one to be evaluated. This iterative design process ensures that the TAS framework meets the identified requirements and effectively supports researchers and nascent spin-offs in their technology application identification and selection processes.

Table 31: Exemplary Methods Derived of the TAS Processes, Clustered in the TAS Segments

Segment	Building Blocks		Exemplary methods
Technology Characterization	Technology Characterization		Technology Function Map (Felkl, 2013) Technology Description (TD); Technology Watch (TW); Test Market Survey (MS); Scoring Table (ST (Moncada-Paternò-Castello, 2003) Talking to Inventor (Strom, 2018) Technology Description (Linton & Walsh, 2008) Technology Canvas (Terzidis & Vogel, 2018) TRIZ Based analysis of technology (Bianchi et al., 2010) Function Analysis and Evolution potential Analysis (Bianchi et al, 2010)
Application Identification	Application Identification		Hybrid 6-3-5/C-sketch Ideation (Linsey et al., 2011) Creativity workshops (Maier et al., 2016) Industry domains (Terzidis and Vogel, 2018) Technology trends (Gardner Hype) (Terzidis and Vogel, 2018) Detection of trends and changes (Conway and McGuiness, 1986) Tie-based and non-tie-based Ideation (Veilleux et al., 2018)
Application Selection	Evaluation; Market Research; Expert Evaluation; User Evaluation; Application Selection	Evaluation based on criteria	Screening by pre-selected criteria to fit the companys purpose; 1. by internal team, 2. by external team (Maarse et al., 2012) Assess by given criteria (Bianchi et al, 2010) Decision matrix (Terzidis and Vogel, 2018) Trend analysis based on characteristics (Henkel and Jung, 2009)
		Customer Evaluation	Serving new customer with same technology by De-Linking (Danneels, 2007) Integration of lead users (Henkel & Jung, 2009) Customer Buy Decision Map (Felkl, 2013) Value adding functions (Felkl, 2013) Customer Buy Decision Map (Felkl, 2013)
		Market Evaluation	Pre-assessment of the market value (Moncada-Paternò-Castello, 2003) Value adding functions (Felkl, 2013) Value-Profile (Terzidis and Vogel, 2018) Analyse Value-Chain-Customer (Evans et al., 2003 Market analysis (Moncada-Paternò-Castello, 2003) Assessment of potential markets market where trends works (Henkel and Jung, 2009)

The research suggests that TAS artifacts have not been implemented by researchers to structure their application identification and selection processes. Neither the supporting actors, such as entrepreneurial educators and technology transfer managers, nor the executors, researchers and academic spinoffs, are aware of or intentionally use these artifacts. Furthermore, canvas navigation is not a common practice amongst researchers in this area, as it stems from the entrepreneurial field. Considering the importance of a user-focused solution in this context, these findings call for greater awareness and intentional use of TAS artifacts. Thus, the Goal Setting Theory (GST), in addition to the already defined requirements, is chosen to underpin the design and structure it according to the theory (Locke, 2013).

This theory is a motivational psychological strategy suggesting that individuals' motivation and performance are influenced by the goals and feedback they receive. Therefore, it presents a suitable design theory for the TAS Framework, building upon the adapted TTF Theory and the dual process theory (6.2.2). The theory proposes that setting clear, challenging, and attainable goals can enhance performance and satisfaction across various domains, such as work, education, and sports. Consequently, this contributes to increasing the motivation of researchers to use the TAS Framework.

Goal-setting can improve motivation, effort, persistence, direction, and strategy (Locke, 2013), and it can be integrated into the process by following five steps, shown in Table 32.

Table 32: Goal-Setting Theory

Goal Setting Theory
Steps
1. Define clear and specific criteria for evaluating new technologies.
2. Set challenging and attainable goals for each phase of the process.
3. Ensure commitment and participation from all stakeholders involved.
4. Provide regular and constructive feedback on the progress and performance of the process.
5. Manage task complexity by breaking down the process into manageable subtasks.

By applying the GST to the design of the TAS Framework, user satisfaction with its use and, consequently, the likelihood of identifying innovative and valuable applications for the given technology can be increased.

6.3.2.2 Design Decisions for the TAS Framework

To establish the different phases in the TAS process, we considered various methods and theories based on the three segments identified in the technology push process by Terzidis and Vogel (2018). As such, we assigned the initial two segments specific 'tasks', while aligning the segment titles with the ultimate objective of the phase: Characterizing the technology and identifying potential applications. Nevertheless, the third segment poses challenges. Following an analysis of the building blocks of TAS processes, it has been determined that the Application Selection stage comprises five blocks. These blocks pertain to the evaluation of potential applications. Subsequently, following design discussions, three of the blocks were included in the segment, whilst the remaining two were integrated into their supporting methods.

Finally, the third segment was ultimately divided into three phases: criteria-based evaluation, customers-based evaluation, and market-based evaluation, which are logically sequential. After this division, the identified methods were scrutinized, and supplementary techniques were created with the support of the practical and methodological experience of the second researcher and the founder. Each phase was meticulously examined, and appropriate methods were selected to achieve their respective objectives. Ultimately, this led to the derivation of a total of five phases within the three segments of TAS (Figure 12).

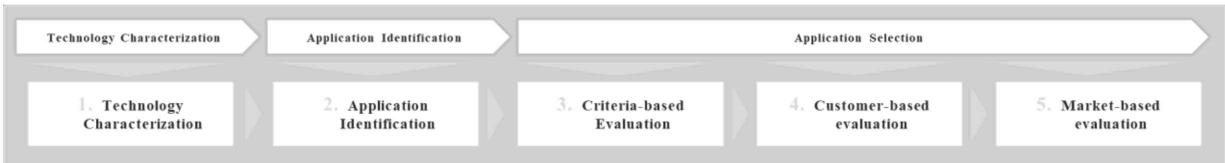

Figure 12: Segmentation of TAS into Five Phases (Own Illustration)

Technology Characterization

The objective is to gain a versatile understanding of the given technology in segment one, Technology Characterization. Since the TAS framework is not user-restrictive, it is essential at this stage to ensure that those who may not be the inventors themselves and may not have a technical background can understand the technology. Therefore, it is critical to break down the different parts of the technology in a way that promotes a shared yet complete understanding. While some approaches recommend approaches such as "Speaking with the Inventor" (Strøm, 2018), other studies suggest techniques such as the Technology Canvas (Terzidis & Vogel, 2018) or the Technology Description (Linton & Walsh, 2008; Moncada-Paternò-Castello et al., 2003). The discussion revealed that the Technology Canvas technique developed by Terzidis and Vogel (2018) obtained the most consensus. However, some parts required modifications, drawing from further techniques and the hands-on know-how of the developers. Precisely, maturity is aligned with the Technology Readiness Level Scale to determine readiness for use, which is commonly used to describe technologies. Furthermore, we implemented methods such as speaking with the inventor (if not part of the team) to guide users to relevant sources of information and motivate them to use these resources.

Application Identification

The second segment, Application Identification, constitutes a pivotal aspect of the entire framework. The objective here is to identify as many ideas as possible and collect them without immediate evaluation. This aligns with the intention to encourage users to be highly creative, as a lack of creativity would confine ideation to existing knowledge, assumptions, or expectations. Under the theory of Blind Variation and Selective Storage (BVSR), this phase emphasizes the first step of creativity, focusing on generating a wide range of diverse and innovative ideas without considering their immediate usefulness or feasibility. As per BVSR, selective storage is reserved for the subsequent evaluation phase (Cziko, 1998). The advantage of generating many initial ideas is recognized as essential for a robust ideation process (Kornish & Ulrich, 2011). While various ideation methods are available in the literature (e.g., the Hybrid 6-3-5 method by Linsey et al. (2011)), it is highly relevant to guide users through the ideation process without limiting their creativity.

Consequently, the fundamental approach of brainstorming is chosen, complemented by using ideation anchors. Ideation anchors stimulate creativity through specific prompts or questions, facilitating the generation of diverse and novel ideas. Following the theory of Creative Problem Solving by Santanen et al. (2004), it is recommended to balance cognitive processes such as divergence, convergence, and suppression for optimal ideation results. In summary, constraining the ideation area can lead to superior outcomes. Thus, based on the TAS process of Terzidis and Vogel (2018), the ideation anchors "Complementary technology" and "industry domain" are selected. This is complemented by integrating sustainability pillars, reflecting the growing need and research in this field (Kivimaa et al., 2017).

Furthermore, the intention is to work through the TAS framework in a team is possible, facilitating more significant ideation (Girotra et al., 2010).

Application Selection

Based on design choices and the inclusion of building blocks, the application selection process is divided into three distinct phases: Criteria Based Evaluation, Customer Based Evaluation, and market-based evaluation.

Criteria-based evaluation

Situated in the last segment, the Application Selection, the first evaluation phase represents the initial evaluation stage, informed by underlying methods identified in the processes and involves criterion-based assessment. This phase addresses the dual challenge entrepreneurs face, as Grimes (2018) highlighted, wherein maintaining distinctiveness while demonstrating responsiveness to external feedback is crucial. In this context, the phase aims to establish a shared understanding of the underlying evaluation criteria and identify potentially optimal ideas. The criterion-based evaluation approach aligns with the methodologies of Maarse and Bogers (2012), Bianchi et al. (2010), and Terzidis and Vogel (2018). Based on criteria utilized in those studies and discussions within the design team, five predefined criteria were defined, with the option to establish custom criteria, recognizing variability depending on the technology and objectives. These criteria encompass Technical Feasibility, Profitability, Market Attractiveness, Team Commitment, Sustainable Value, and an optional criterion. To facilitate ranking, an evaluation system ranging from -2 to +2 is integrated for user-friendly assessment. Users are encouraged to leverage their social capital by consulting experts from diverse fields, aligning with the practice suggested by Grimes (2018) and McDonald and Gao (2019). This external input supports the distillation of potentially optimal ideas. Recognizing the iterative nature of the evaluation process, wherein the top-identified idea may not necessarily prevail in subsequent rounds, the top three ideas are outlined. This approach allows for seamless progression to another highly rated idea if needed. Users articulate their thoughts around the top idea through an idea sketch, prompting documentation of the addressed problem, the presented solution, and the presumed Unique Selling Proposition (USP). This process of putting ideas into writing enhances understanding among team members, facilitates effective communication, and encourages targeted feedback.

Customer-Based Evaluation

The fourth phase, still within the evaluation segment, is centered on comprehending the customer and their needs. Literature offers various methods aligned with this goal, such as Felkl (2013) value-adding functions, the integration of lead users proposed by Henkel and Jung (2009) or Felkl (2013) Customer Buy Decision Map. However, based on the insights of the design team, the initial requirement for understanding the customer is established as the comprehension of the customer segment. Subsequently, the process involves humanizing the customer by utilizing the persona canvas. Following this, the Jobs-to-be-Done method (Ulwick & Hamilton, 2016) is implemented, as it represents a practical and valid approach aiming to understand the core job the customer is trying to accomplish when using the product. This method contributes to a profound understanding of the needs and desires of the customer. Acknowledging that these understandings are often rooted in assumptions initially, a section is integrated to reflect on and test critical hypotheses. This aspect aims to guide users of the TAS framework in identifying hypotheses critical to the further development and potential success of their identified idea, providing a means to validate these hypotheses. Consequently, at this stage, it is possible to revisit the previous phase, leveraging the second top idea and continuing the TAS framework.

Market-Based Evaluation

Hence, the ultimate and subsequent phase within the application selection segment is devoted to market evaluation. In this phase, the goal is to comprehend the competitive landscape surrounding the identified application to pinpoint key factors that distinguish the idea from existing alternatives. Methods and theories relevant to competitive dynamics are crucial in the market understanding phase. Additionally, this process is fortified by completing the value proposition canvas, which is an evaluated DSR artifact widely employed among practitioners (Osterwalder & Pigneur, 2010).

6.3.2.3 Incorporation of Design Requirements into the Design

The fundamental structure of the artifact follows a canvas-like design, aligning with common frameworks in entrepreneurial practices, meeting the user requirement. This canvas visualizes the TAS process components, providing a visual guide for researchers. The first version of the TAS Framework serves as a process designed to facilitate the systematic identification and selection of promising applications for a given technology. It is organized into three main categories: Technology Characterization (1), Application Identification (2) and Application Selection (3). These categories are subdivided into five phases, with the last category (3) comprising three phases and the others comprising a single phase. Adhering to the predefined design requirements, the framework integrates guidance and methods aligned with the goals and motives specified in the functional requirements. Consequently, the segments are constructed sequentially, ensuring that each phase builds upon the previous one, contributing to fulfilling the requirements and effectively guiding the user through the entire process.

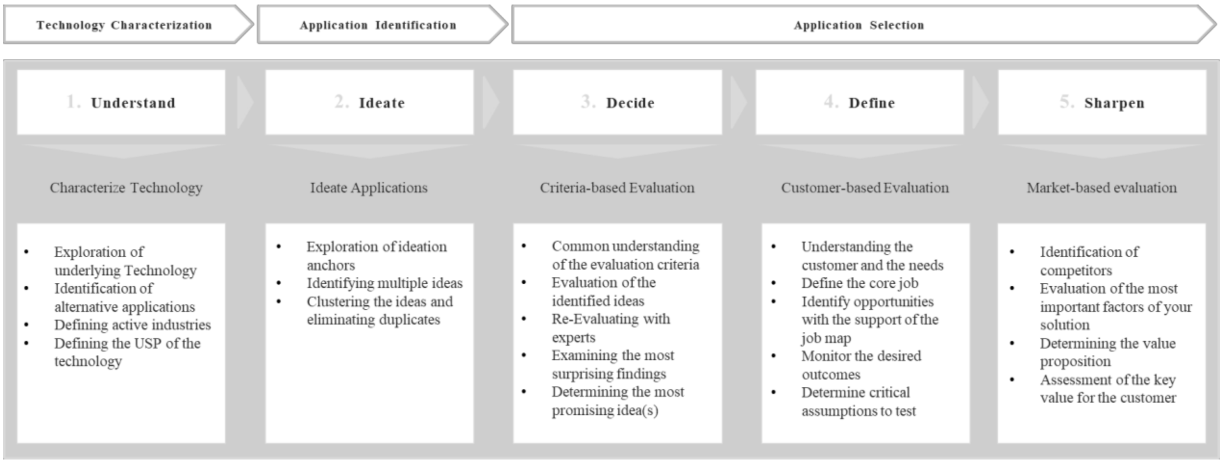

Figure 13: Objectives of the Five Phases of the TAS Framework Version One (Own Illustration)

The functional requirements for the artifact are integrated into various phases, some specifically tailored to meet particular criteria, while others address overall requirements across the entire artifact. A comprehensive understanding of the given technology is fostered in the initial phase “Understand”, focusing on describing and characterizing the technology. Subsequently, support is provided during the second phase “Ideate”, guiding the identification of diverse alternatives and applications. Phase 3 “Decide” serves as the initial step in evaluating the identified applications, encompassing additional requirements, given the intensive nature of the evaluation process—consequently, phase 4 “Define” concentrates on comprehending customer's needs and guiding the utilization of social capital. Phase 5 “Sharpen” supports enhancing market knowledge. In summary, the structured TAS Framework facilitates a purposeful and efficient utilization of resources throughout all phases of the TAS framework, representing the final functional requirement.

Table 33: Incorporation of the Requirements in the TAS Framework

Functional requirements	
Requirements	**Located**
The TAS process must facilitate the improvement of researchers' market knowledge.	Phase 5
The TAS process must support researchers in gaining a versatile understanding of the technology.	Phase 1
The TAS process must enable researchers to comprehend the worth of social capital and leverage it effectively.	Phase 1-5
The TAS process must provide assistance to researchers in identifying various alternatives and multiple applications.	Phase 2
The TAS process must offer guidance to researchers in evaluating the identified applications.	Phase 3-5
The TAS process must provide structured guidance to ensure the purposeful and efficient utilization of resources in conducting TAS.	Phase 1-5
The TAS process must offer guidance to help researchers comprehend potential customers and their needs.	Phase 4

According to the Goal Setting Theory, specific objectives are defined for each phase, providing insights into what to expect in that particular phase and its objectives. These phases are supported by various methods that break down the goals into manageable subtasks, providing adequate support. The goals are chosen to align with the underlying methods, allowing the user flexibility in determining the amount of time invested in each method and phase. This flexibility empowers the user to choose the depth of content engagement. Additionally, the visualization of segments and phases in the framework illustrates the progress of the process (Table 34).

Table 34: Incorporation of Goal Setting Theory in the TAS Framework

Goal Setting Theory (Version One)		
Steps	**Application in TAS Framework**	**Located**
1. Define clear and specific criteria for evaluating new technologies.	Assessment of technology integrated in phase 1.	Phase 1
2. Set challenging and attainable goals for each phase of the process.	Objectives integrated in each phase.	Phase 1-5
3. Ensure commitment and participation from all stakeholders involved.	Commitment of users is ensured by the application setting.	Overall Setting
4. Provide regular and constructive feedback on the progress and performance of the process.	Feedback is ensured by obtaining external input.	Phase 4, 5
5. Manage task complexity by breaking down the process into manageable subtasks.	Segments are separated into phases, with subtasks in each.	Phase 1 -5

In alignment with environmental requirements, efforts are made to ensure the framework is easy to comprehend and use. Instructions and explanations are incorporated accordingly. Additionally, visual elements are employed to enhance the appeal of the framework, thereby increasing motivation. The complexity of the framework is appropriately managed, allowing for an in-depth exploration of the TAS process at different levels of engagement. Furthermore, the framework is geared towards guiding the user in a resource-oriented manner.

The structural requirements are integrated by building the sequence of phases upon one another, along with the methods employed within them. Each incorporated methodology is standalone and crucial to the process, reducing redundancy.

User requirements are partially embedded within the other requirements. The TAS Framework comprises a comprehensive process with respective methods and descriptions structured in a canvas-like format. The design and structure of the process draw significant inspiration from the work of Lau (2022) and Terzidis and Vogel (2018). It adheres to clear design principles and provides a step-by-step procedural guide. The methods support the achievement of phase-specific and overall TAS process goals. It is possible to prioritize individual components, although complete engagement is recommended. Moreover, the framework is customizable, ensuring individual adaptability by integrating goals, progress tracking, instructions, and supporting questions.

6.3.3 Development

The proposed design requirements have been instantiated in the artifact, which is designed as a pen and paper-based framework inspired by the business model canvas (Osterwalder & Pigneur, 2010), the systematic business model by Lau (2022), and the competitor framework by Hatzijordanou (2019). A graphical framework is intended to provide a coherent overview, facilitate communication between team members and increase creativity and innovation by allowing for discussion and brainstorming sessions

(Trimi & Berbegal-Mirabent, 2012) while also allowing for time management (Lukas, 2018). The framework comprises three segments: Technology Characterization, Application Identification, and Application Selection, based on specific building blocks (Manthey et al., 2022a). The design decisions led to the creating a prototype suitable for a Din A0 printout, utilizing Microsoft Office PowerPoint. In Figure 9, scaled-down previews of the respective phases of the TAS Framework are integrated.

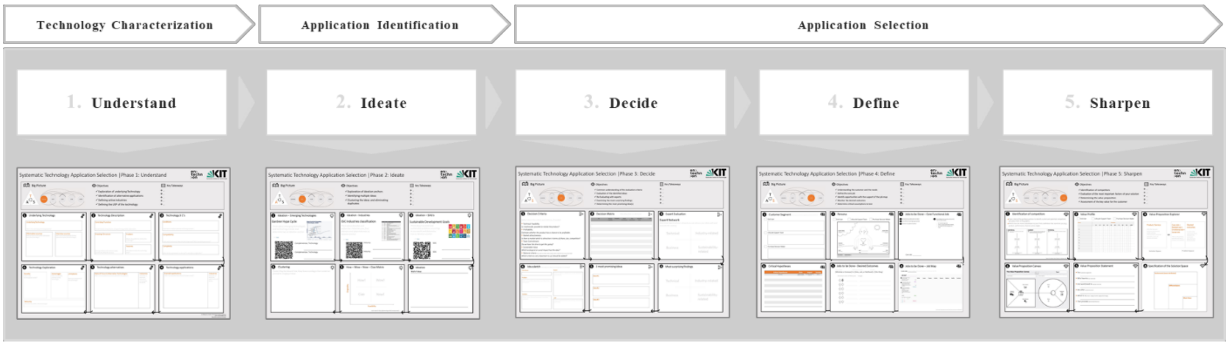

Figure 14: Outline of the TAS Framework with the Respective Phases (Own Illustration)

The segments are assigned into five phases, each aiming to achieve different objectives to meet the functional requirement set (Figure 14). The framework consists of different methods applied in the respective Canva, each covering one phase of the TAS framework. During each stage, users progress through six steps intended to optimally assist them in reaching the goals of the corresponding phase. The steps integrated are based on identified methods through literature and were adapted and extended within the design discussions with the second researcher and the founder, leading to a final set of six steps in each phase (Table 35).

Table 35: Overview of Integrated Steps in the TAS Framework

Segments	Phases	Underlying approaches	Steps
Technology Characterization	Technology Characterization	Adapted Version of: Technology Canvas (Terzidis & Vogel, 2018) Technology Function Map (Felkl, 2013) Technology Description (Linton & Walsh, 2008)	Step 1: Underlying Technology Step 2: Technology Description Step 3: Technology 3 C's Step 4: Technology Applications Step 5: Technology Alternatives Step 6: Technology Exploration
Application Identification	Application Identification	Adapted version of: Creativity workshops (Maier et al., 2016) Industry domains (Terzidis and Vogel, 2018) Technology trends (Gardner Hype) (Terzidis and Vogel, 2018)	Step 1: Emerging Technologies Step 2: Industries Step 3: SDG's Step 4: Ideation Step 5: How-Wow-Now-Ciao Step 6: Clustering
Application Selection	Criteria-based evaluation	Adapted version of: Assess by given criteria (Bianchi et al, 2010) Decision matrix (Terzidis and Vogel, 2018)	Step 1: Decision Criteria Step 2: Decision Matrix Step 3: Expert Evaluation Step 4: Most Surprising Findings Step 5: 3 Most Promising Ideas Step 6: Idea Sketch
	Customer-based evaluation	Adapted version of: Customer Buy Decision Map (Felkl, 2013) Value adding functions (Felkl, 2013)	Step 1: Customer Segment Step 2: Persona Step 3: Core Functional Job Step 4: Job Map Step 5: Desired Outcomes Step 6: Critical Hypotheses
	Market-based evaluation	Adapted version of: Pre-assessment of the market value (Moncada-Paternò-Castello, 2003) Value adding functions (Felkl, 2013) Value-Profile (Terzidis and Vogel, 2018) Analyse Value-Chain-Customer (Evans et al., 2003)	Step 1: Competitor Identification Step 2: Value Profile Step 3: Value Proposition Explorer Step 4: Solution Space Step 5: Value Proposition Statement Step 6: Value Proposition Canvas

Phase 1: Understand

The initial segment is encapsulated in the "Understand" phase, marking the commencement of the TAS process. The primary objective of this phase is to acquire comprehensive information about the given technology to establish a profound understanding. This becomes particularly vital when collaborating in a team, necessitating a shared understanding for successful application identification. The goals of this phase encompass exploring the given technology, identifying alternative applications with comparable technologies, defining the active industries in which the technology or similar technologies operate, and ultimately delineating the Unique Selling Proposition (USP) of the technology to derive its distinctiveness and the features with the highest potential.

In this phase, the user is guided to initially document the technology and sources of information about the technology—both already acquired and potentially interesting—to ensure a valid data collection. Additionally, the technology needs to be described based on predefined aspects. A deeper understanding of the technology is achieved by delving into the analysis of conditions, compatibility, and complexity.

Furthermore, the analysis extends to technology applications, aiming to identify applications where comparable technologies are used and assessing the industries in which they operate. The user is then directed to analyze, based on the identification of comparable technologies, alternative products or services in the area by addressing the problems tackled. Additionally, the focus includes active industries and characterizing the technology based on its novelty, advantages, limitations, and maturity in light of the findings.

Phase 2: Ideate

The second segment is embodied by the "Ideate" phase, which constitutes the application identification aspect within TAS. The primary objective of this phase is to generate potential applications, emphasizing the identification of multiple and alternative ideas. The goals for this phase encompass the exploration of ideation anchors, the identification of multiple ideas, and the clustering of ideas while eliminating duplicates.

In this phase, the user is directed to explore each ideation anchor, which comprises three areas: Emerging technologies, industries, and SDG's. For emerging technologies, complementary technologies serve as ideation anchors; for industries, market domains are chosen, and for SDGs, sustainability pillars are selected as ideation anchors. The ideation process commences with brainstorming in both written and spoken form within the team, generating several ideas. Each anchor is independently subjected to ideation. Subsequently, the results are organized using the How-Wow-Now-Ciao matrix to pinpoint ideas that merit further exploration. The ideas from the "How-Wow-Now" sections are transferred into the clustering process, where a thematic grouping of generated ideas fosters new, more valid ideas. Consequently, this phase culminates in a collection of diverse and alternative ideas.

Phase 3: Decide

The subsequent phase, "Decide," marks initiating the "Application Selection" segment. The principal aim of this phase is to undertake an initial, criteria-based evaluation of the identified applications, encompassing the establishment of a common understanding of the evaluation criteria, evaluation of identified ideas, re-evaluation with experts, examination of the most surprising findings, and determination of the most promising idea(s).

The decision criteria are initially enumerated and elucidated to guarantee a shared comprehension. Additionally, an optional criterion is introduced, allowing the team to adapt as per their requirements. The decision matrix, functioning as a ranking matrix, serves to pinpoint the most promising ideas based on the rating of each criterion for each idea. Simultaneously, an expert network spanning technical, sustainability, and business domains is engaged to deliberate on the ideas. The insights from these discussions are recorded. Drawing on the insights from the matrix and expert consultations, the three most promising ideas are documented, culminating in a final idea sketch of the favored concept. This sketch succinctly outlines the problem, solution, and unique selling proposition (USP) and includes a visualization, ensuring a cohesive understanding within the team.

Phase 4: Define

The fourth phase, situated within the "Application Selection" segment, is designated as "Define" and revolves around customer identification and understanding their underlying needs. The established goals for this phase include understanding the customer and their needs, defining the core job, identifying opportunities with the support of the job map, monitoring the desired outcomes, and determining critical assumptions to test.

To initiate this phase, customer segments for the identified application from the idea sketch in the preceding phase (Decide) are outlined, providing an initial understanding of the customer base. Subsequently, a persona canvas is filled out to delve deeper into the underlying persona and humanize the potential customer. The Jobs-to-Be-Done Framework is then employed to identify the core job of the underlying task, accompanied by outlining the Job Map to gain deeper insights into the customer's thought process. The next step involves defining the desired outcomes by the customer, elucidating their aspirations and enabling reflection on the identified application in this context. Finally, hypotheses and assumptions related to the customer, the problem itself, and its perceived value are documented, ranked, and subjected to testing. If a hypothesis is identified as incorrect, corrective steps are taken, and the process is revisited. This iterative testing ensures the reliability and accuracy of the identified assumptions before progressing to the subsequent stage.

Phase 5: Sharpen

The final phase of the TAS process, marking the culmination of the "Application Selection" segment, is termed "Sharpen." Its primary objective is to achieve a preliminary market validation to determine whether the identified application is worth pursuing. This phase encompasses the following goals: Identification of competitors, Evaluation of the most critical factors of your solution, Determining the value proposition, and Assessment of the critical value for the customer.

Starting with identifying rivals, an extensive overview is created by distinguishing between past, present, and future and nearby and faraway competitors. This differentiation aids in understanding the competitive environment thoroughly. Subsequently, the critical aspects of the identified application are highlighted and compared to those of the main competitors to assess its competitiveness. If proven potentially superior to competitors, a detailed exploration of the Value Proposition ensues, formulating a concise value proposition statement that encapsulates the solution's value. The final step involves filling out the Value Proposition canvas to consolidate the findings and set the initial steps toward business modelling. Typically, this business modelling is supported by tools like the Business Model

Canvas (Osterwalder & Pigneur, 2010), facilitating a structured and strategic approach to refining the business concept and preparing for further development and implementation.

6.3.4 Evaluation[3]

The evaluation phase in a DSR project holds significant importance, as emphasized by scholars such as Hevner et al. (2004a) and Kuechler and Vaishnavi (2008). This phase serves multiple crucial functions, including providing evidence that the artifact effectively addresses the problem or enhances the situation. Additionally, the evaluation process offers valuable feedback for refining the artifact in subsequent iterations and ensures the research's methodological rigor, as Venable et al. (2012) highlighted. The artifact is evaluated to answer the research questions: “Is the developed artifact supporting the application identification and selection of technologies?” and “How can the developed artifact be further improved, if necessary?” Therefore, an evaluation strategy was developed based on the existing FEDS framework by Venable et al. (2016), applying the Human Risk and effectiveness approach as the primary strategy. This approach was chosen due to its solid formative and naturalistic character while being feasible to evaluate with real users in their real application context. As it focuses on assessing the long-term effectiveness of an artifact in real-world use, it recognizes that the impact of real users significantly shapes the performance of the artifact. Emphasizing the evaluation of artifacts in authentic, real-world contexts, this approach aligns with the concept of naturalistic evaluation as outlined by Venable et al. (2016). Such evaluations are thought to be easier to conduct because they align with the natural use environment. This iterative approach aligns with the principles of DSR, allowing for continuous refinement and advancement based on empirical evidence and practical application.

6.3.4.1 Evaluation Strategy

An evaluation concept is essential for establishing a systematic evaluation process and setting. The four-step approach by Reinders (2012) and their interdependencies provide suitable guidance (Table 36). While the primary objectives of the base phase (1) include clarifying available resources, understanding the theoretical framework, and reviewing the current state of research, the planning phase (2) outlines an overview of evaluation questions, evaluation sample and data collection. In the implementation phase (3) the underlying evaluation methods are described, and the final analysis phase (4) represents the analysis of the data as well as the report of the results. For the development of the TAS framework (1), the resources are set as entrepreneurial workshops with students with diverse technical backgrounds, consisting of different time frames of each workshop, thereby spanning the total evaluation episode over a year, testing the theoretical framework presented in 6.3.3. The current research status was already highlighted in 6.3.1. The planning phase is supported by the FEDS framework approach by Venable et

[3] The chapter is based on Manthey & Terzidis 2024.

al. (2016), presented below. Phase three and four, compromising the implementation of methods for collecting and evaluating the data, is further described below.

Table 36: Description of the Four-Step Research Process, Based on Reinders (2016)

Steps	Interdependencies
Basic Phase	Clarification of resources Theoretical framework Review of the research status
Planning Phase	Definition of the evaluation questions Determination of the survey methods Choice of samples Description of the evaluation cycles
Implementation Phase	Implementation of the data collection Preparation of the data collection
Analysis Phase	Analysis of the data Report of the results

Advancing the planning phase of the four-step approach by Reinders (2012), the FEDS framework by Venable et al. (2016) is employed (Table 37), involving the following four steps:

1. **Explication of Evaluation Goals:** The primary objectives of the evaluation are clarified, with considerations for rigor, uncertainty and risk reduction, ethics, and efficiency, as proposed by Venable et al. (2016). Rigor, emphasizing the degree of fulfilment and quality, is particularly critical. This entails assessing how well the defined requirements for the TAS framework are met, necessitating the derivation of artifact requirements. Beyond functional aspects, structural, environmental, and user requirements are also taken into account.

2. **Choice of Evaluation Strategy/Strategies:** Selecting one or more evaluation strategies is based on the identified goals. The choice involves considering why, when, and how to evaluate alongside the heuristics proposed by Venable et al. (2016). Factors such as potential design risks, the costliness of real-world settings, the artifact's purpose (technical or human-centric, immediate or future use), and the complexity of design are weighed. This research selects the human risk and effectiveness strategy, focusing on naturalistic evaluation using real people in natural settings.

3. **Determination of Properties to Evaluate:** The evaluation objects are customized to align with the evaluation's specific purpose and context, as Venable et al. (2016) emphasized. In this instance, the properties targeted for evaluation encompass functional, structural, environmental, and user-oriented requirements imposed on the artifact. These requirements were thoroughly expounded and outlined in detail in 6.3.1.6.

4. **Design of Individual Evaluation Episodes:** First, the framework conditions are identified, analyzed, and prioritized, which leads to the definition of the individual evaluation episodes and results in a multi-stage evaluation design. The examination of the results from this episode will

inform subsequent iterations. The detailed evaluation concept is tailored to the TAS framework, adhering to the guidelines as mentioned earlier.

Table 37: Overview of the Evaluation Strategy of the Evaluation Episode One

Evaluation Strategy (Version One)	
Explanation of the objectives of the evaluation	**Design requirements** Functional requirements Environmental requirements Structural requirements User requirements
Selection of the evaluation strategy	**Human Risk & Effectiveness** Definition of the evaluation questions Determination of the survey methods Choice of samples Description of the evaluation cycles
Selection of the evaluation strategies	**Field Experiment** Setting: Entrepreneurial Education Workshop Unit: Students, MBA Students, PhD Treatment: Multiday workshop
Data analysis	**Qualitative and Quantitative** Evaluation of the quantitative survey Evaluation of the Interviews & open text questions Comparison with the requirement criteria Deriving suggestions for improvement

The actual evaluation episodes are designed based on the chosen strategies and properties to evaluate. Depending on the project stage and goals, the evaluation strategy may shift over time, focusing first on the functional aspects and the initial instantiation domain and later on human factors, such as usability. The underlying requirements are evaluated, and suggestions are derived for improvement. Each one is assigned a code to organize the requirements, facilitating a more structured and orderly approach for subsequent work (Table 38).

Table 38: Coding of the Design Requirements for Evaluation

Requirement	Code	Description
Functional requirements	FR_1	The TAS process must facilitate the improvement of researchers' market knowledge.
	FR_2	The TAS process must support researchers in gaining a versatile understanding of the technology.
	FR_3	The TAS process must enable researchers to comprehend the worth of social capital and leverage it effectively.
	FR_4	The TAS process must provide assistance to researchers in identifying various alternatives and multiple applications.
	FR_5	The TAS process must offer guidance to researchers in evaluating the identified applications.
	FR_6	The TAS process must provide structured guidance to ensure the purposeful and efficient utilization of resources in conducting TAS.
	FR_7	The TAS process must offer guidance to help researchers comprehend potential customers and their needs.
Environmental requirements	ER_1	Usability (Easy to use)
	ER_2	Comprehensibility (Easy to learn)
	ER_3	Completeness
	ER_4	With adequate complexity
	ER_5	Efficiency
	ER_6	Suitability
	ER_7	Customizability
Structural requirements	SR_1	Coherence
	SR_2	Conciseness
User requirements	UR_1	Comprehensive process and method description
	UR_2	Guiding poster (Canvas-like structure)
	UR_3	Include supporting methods for each component
	UR_4	Prioritization of components possible
	UR_5	Usable without external guidance

The "Human Risk & Effectiveness" strategy selected for evaluation primarily employs naturalistic methods (Venable et al., 2016). A critical method is the field experiment, characterized by its implementation in a real-world, natural environment. By enabling the researcher to observe the artifact in real-world contexts, potential risks related to human interaction can be identified, as the user experiences can be captured. Further, they provide insights into how well the artifact achieves its intended purpose. Further, qualitative and quantitative methods can be combined in field studies to strengthen the research's validity and help address multifaceted challenges. The natural environment of the field studies distinguishes it from laboratory experiments conducted under artificial conditions. In the present work context, field experiments serve as the primary approach for the first evaluation episode. The degree of naturalness in a design or experiment refers to how closely it aligns with real-world conditions. In the case of field experiments, the emphasis is on capturing the authenticity of the environment in which the artifact or strategy is being evaluated. This approach allows researchers to observe and measure the artifact's performance in conditions that closely mirror those it would encounter in practical, everyday use. The reliance on field experiments underscores a commitment to assessing the artifact's effectiveness within the context for which it is intended, enhancing the ecological validity of the evaluation.

Based on the existing knowledge that such frameworks have had limited practical application and those researchers typically lack familiarity with entrepreneurial frameworks, the primary focus of the initial evaluation episode is to assess the functionality and effectiveness of the artifact itself. In this context, the target audience for the first episode is temporarily excluded. However, since using such frameworks often occurs in entrepreneurial education workshops, and these settings are conducive to testing such frameworks, such a program has been chosen as the natural environment for the experiment.

Entrepreneurial education workshops typically span multiple days and follow an action-oriented approach. Participants receive brief inputs and then work independently in teams on assigned tasks. The workshop leader ensures that participants receive the necessary information and is available for questions. Feedback is provided as needed after work phases. Workshop leaders can also offer advices during task execution. The setting of these workshops is based on participants interactively and independently working on tasks using the provided materials. It is expected that participants autonomously gather information for task completion.

Thus, the data analysis for the field experiments is based on multiple methods to strengthen the research but also to allow the exploration of nuances, motivations, and underlying reasons. Hence, a questionnaire is designed to evaluate the effectiveness of the DSR artifact, inspired by the work of Lau (2022) and Hatzijordanou (2019). The questionnaire is adapted explicitly to the design requirements of the TAS framework. The questionnaire also includes open questions for strengths, weaknesses, and possible suggestions for improvement. Further, additional interviews are conducted with users, following a semi-structured guideline to evaluate the TAS framework and explore the user's experiences and thoughts. Finally, the evaluation results are analyzed and compared with the design requirements of the TAS framework. Additionally, suggestions for further development and refinement are derived.

6.3.4.2 Sample

Six entrepreneurial education workshops represented the field experiments. The settings of the workshops were similar, although the target group differed between students, MBA students already working in industry in different positions, and PhDs of different fields (Table 39). Participants immerse themselves in the entrepreneurial experience, navigating the start-up process, from idea development to business pitching, accompanied by the structured TAS framework. Open-access patent descriptions of the university represent the given technologies. Spanning multiple sessions, these workshops offer an extended timeframe for team collaborative work.

Table 39: Overview of the Sample for EE1

Participants of the evaluation studies (Version one)					
Evaluation Episode	**Setting**	**Date**	**Number of Teams**	**Questionnaire (n)**	**Interview (n)**
1	Students	June 22	6	13	9
1	Students	July 22	7	9	-
1	Students	Sep-22	6	20	-
1	MBA students	Sep-22	5	10	-
1	MBA students	Sep-22	5	12	-
1	PhD	October 22	5	10	-

Following an action-based approach (Rasmussen & Sørheim, 2006), the workshops blend theoretical input on the TAS framework with practical group work phases. Those group work phases could be conducted online using a digital whiteboard to enable location-independent collaboration. A designated moderator guides the workshop to ensure clarity and usability. Post-workshop interviews with several participants explore the effectiveness of employing the TAS framework for generating novel technology-based ideas. Additionally, questionnaires distributed to participants after completing the TAS framework contribute valuable anonymized insights.

The assessment assumes a naturalistic approach, encompassing students, researchers (PhDs), and industry stakeholders (MBA Students). Given their unintentional involvement and the absence of a deliberate intent to leverage their technology, their representation cannot be presumed to align with the ultimate target group of the TAS framework. Participants engaged in the evaluation primarily out of intrinsic interest in the subject matter rather than with the explicit aim of utilizing their technological resources. Hence, this field experiment offers the possibility to evaluate the TAS process in a practical but stimulated setting, using patent descriptions of the university. Potential difficulties and challenges within a practical application of the TAS framework could still be tested without fearing potential demotivation and a bad reputation for using the TAS framework. This approach effectively addresses the fulfilment of the underlying requirements of the framework, as well as its improvement, allowing for the thorough testing of the practical application of the TAS process without causing frustration among participants. By integrating the framework in a workshop, the guidance by the workshop moderator supports the utilization, thereby decreasing potential confusion. Incorporating patent descriptions from the university adds a practical yet stimulated dimension to the evaluation, crucial for bridging the gap between theoretical knowledge and practical application. This is particularly relevant as researchers, initially unaware of the TAS process's utility in generating promising applications, may hesitate to test a purely theoretical framework.

6.3.4.3 Data Collection

The data collection methods were systematically implemented based on the specified requirements. Table 40 provides a comprehensive overview of how each specific requirement is evaluated using at least one method. The table outlines which method is employed for each requirement. Detailed descriptions of all empirical instruments are provided in the subsequent chapters.

Table 40: Monitoring Scopes of the Requirements

Evaluation Instruments				
Code	**Requirement**	**Questionnaire**	**Interviews**	**Logical**
ER	**Environmental Requirements**			
ER_1	Usability	x	x	x
ER_2	Comprehensibility	x	x	x
ER_3	Completeness	x	x	x
ER_4	Adequate complexity	x	x	x
ER_5	Efficiency	x	x	x
ER_6	Suitability	x	x	x
ER_7	Customizability	x	x	x
FR	**Functional Requirements**			
FR_1	Enhance market knowledge	x	x	x
FR_2	Enhance knowledge about technology	x	x	x
FR_3	Improve utilization of social capital	x	x	x
FR_4	Provide ideation guidance	x	x	x
FR_5	Evaluate applications	x	x	x
FR_6	Enable structured process	x	x	x
FR_7	Consider customers	x	x	x
SR	**Structural Requirements**			
SR_1	Coherence			x
SR_2	Conciseness			x
UR	**User Requirements**			
UR_1	Comprehensive process and method description		x	
UR_2	Guiding poster (Canvas-like structure)		x	
UR_3	Include supporting methods for each component		x	
UR_4	Prioritization of components possible		x	
UR_5	Usable without external expert guidance		x	

6.3.4.3.1 Survey Questionnaire

After the respective workshop days, participants are expected to engage in a survey, with the deployment of the questionnaire taking place on the final day of the TAS Framework integration in the respective workshops. Following a brief oral presentation, participants were provided access to the questionnaire via a QR code or a designated link. Subsequently, participants were allocated time to respond to the questionnaire directly. The questionnaire commenced with a concise introductory text outlining the background and thematic focus. Participants were explicitly informed in written form and verbally that their data would be treated confidentially, utilized solely for scientific purposes, and would not impact their seminar grade. The allocated time for completing the questionnaire was 10-15 minutes. The questionnaire comprised four scales, with scales 1-3 utilizing a five-point Likert scale, allowing respondents to indicate their agreement or disagreement on a spectrum. Conversely, scale four featured open-text items. The collected data underwent analysis using SPSS and Excel. The quantitative analysis of data from scales 1-3 was descriptive and inductive, whereas the data from scale 4 underwent qualitative evaluation.

Table 41: Overview of the Questionnaire and the Related Requirements of the TAS Framework

Survey Questionnaire		Requirement(s)
1.	**Usability**	
1.1.	The framework is easy to use.	ER_1
1.2.	The framework is easy to understand.	ER_2
2.	**Evaluation of the framework**	
2.1.	The framework helped us to improve our market knowledge.	FR_1, ER_7
2.2.	The framework helped us to gain a versatile understanding of the technology.	FR_2, ER_7
2.3.	The framework helped us to understand the worth and leverage social capital.	FR_3, ER_7
2.4.	The framework helped us to identify various alternatives and multiple applications.	FR_4, ER_7
2.5.	The framework provided guidance to evaluate the identified applications.	FR_5
2.6.	The framework enabled to do the TAS process with limited resources.	FR_6, ER_4
2.7.	The framework helped us to understand potential customers and their needs	FR_7
3.	**General judgement**	
3.1.	The framework supported all our relevant purposes for the TAS process.	ER_6
3.2.	The framework contained all necessary information to complete the TAS proccess.	ER_3
3.3.	The framework provided clear guidance on the TAS process.	ER_5
4.	**Suggestions and comments**	
4.1.	In your opinion, what were the most important weaknesses of the TAS Framework?	
4.2.	In your opinion, what were the most important strengths of the TAS Framework?	
4.3.	What improvements would you suggest for the TAS Framework?	
4.4.	Do you have other general comments about the framework and its application?	

The questionnaire's composition includes inquiries about the requirements of the TAS framework and a section covering strengths, weaknesses and improvement suggestions. The survey draws inspiration from the preliminary work of Hatzijordanou (2019) and Lau (2022). Both researchers developed questionnaires for assessing specific DSR artifacts in a workshop setting. Because of the different artifact requirements, items from their questionnaires were adapted to the design requirements of the TAS framework presented in 6.3.1.6. The questionnaire focuses on functional and environmental requirements, of which an item targeted each requirement. User requirements were evaluated separately. The requirement assignment towards the items is represented in Table 41. Reliability is assessed after the data collection, employing established metrics such as Cronbach's alpha, item difficulty (pi), and item selectivity (rit-i).

In evaluating the survey questionnaire in 6.3.4.3.1, an analysis of the standard quality criteria objectivity, reliability and validity is first conducted. Subsequently, the requirements and target of the TAS framework are analyzed.

6.3.4.3.2 Interview Questionnaire

In addition to the survey questionnaire, data will be collected through qualitative interviews with participants. The process for conducting qualitative interviews, as per Döring and Bortz (2016), involves a ten-step approach:

1. **Content Preparation:** Semi-structured interviews are conducted to explore the research question. These interviews are versatile and flexible, allowing variation in structure based on research goals. The interviewee has the freedom for verbal expressions, and the interviewer can ask follow-up questions (Kallio, Pietilä, Johnson, & Kangasniemi, 2016).
2. **Organizational Preparation:** This includes the sampling of interviewees. Additionally, interview materials such as an audio recorder, interview guidelines, a digital version of the TAS framework, and a consent form are organized.
3. **Beginning of Conversation:** The interviewee is briefed on the topic and the relevance of the interview. The anonymity of statements is assured, and a consent form is signed. A digital STAS framework is provided for reference during the interview.
4. **Implementation and Recording:** The interview is conducted following the interview guidelines created. The interviewee can refer to the digital version of the TAS framework during the interview, and the session is recorded.
5. **End of Conversation:** The interview concludes after turning off the audio recorder. Any additional information provided by the interviewee is noted.
6. **Farewell:** The interviewer expresses gratitude to the interviewee for their participation.
7. **Memos**: Additional notes are taken during the interview if necessary.
8. **Transcription:** Full transcription of the interviews is performed, with linguistic smoothing excluding delayed words, stuttering, and word breaks. Transcriptions are pseudonymized.
9. **Analysis of Transcripts:** The transcribed interviews undergo qualitative data analysis, following the method described in chapter 4.2.2.
10. **Archiving the Material:** Transcriptions and consent forms are stored securely, and audio recordings are deleted after transcription.

The interview guideline is based on the problem-centered interview methodology by Witzel (2020), combining an inductive and deductive approach. It targets identifying ways of acting, individual perceptions, and processing methods of the interviewees. The guideline incorporates open and general questions, allowing participants to respond spontaneously and honestly (Kruse & Schmieder, 2014).

Various stimulus techniques are considered in creating the guideline, including an icebreaker question to encourage free and comfortable conversation. The guideline comprises short and comprehensive questions, avoiding closed questions and incorporating text-generating and sustaining inquiries (Helfferich, 2009; Kruse & Schmieder, 2014). Immanent and exmanent questions are included, with exmanent questions often introduced towards the end of the interview. The Fielmann question, a hypothetical question, explores alternative attitudes and behaviors. The guideline is evaluated with a second researcher before use. Table 42 displays the interview guidelines, outlining topics, targeted requirements, estimated duration, types of questions, and stimulus techniques.

Table 42: Interview Guideline (including Questions, Targeted Requirements, Type of Question and Stimulus Technique)

Topic	Question	Requirement	Type of question/ stimulus technique
Warm up, Welcome	How have you been doing in the past weeks? Are you getting on well with your idea?		Warming-up-question/ icebreaker
Simplicity/ Complexity	How did you find the usability of the TAS framework (if question is unclear, give examples: simple, understandable, confusing, etc.)? Is the degree of complexity adequate for this seminar?	ER_1, ER_2, ER_4, UR_1, UR_2	Open question/ open stimulus + maintain question/ immanent & UR_1, exmanent inquire
Understanding Technology/ Market	To what extend did the TAS framework help you to understand your technology and market? Through your own knowledge or newly acquired knowledge?	FR_1, FR_2, FR_4, ER_6, ER_7	Open question/ open stimulus + maintain question/ immanent & ER_6, exmanent inquire
Potential Markets/ Customers	In what ways has the TAS framework helped you to map your technology to potential markets? And to find and understand potential customers? Through your own knowledge or newly acquired knowledge?	FR_3, FR_4, FR_6	Open question/ open stimulus + maintain question/ immanent & exmanent inquire
Alternatives	How did the TAS framework help you consider multiple and alternative applications? Through your own knowledge or newly acquired knowledge?	FR_4, FR_7	Open question/ open stimulus + maintain question/ immanent & exmanent inquire
Ideation/ Evaluation	Was the TAS framework helpful in the ideation despite the limited resources? And in the idea evaluation? In what ways?	FR_7, FR_8, ER_5	Open question/ open stimulus + maintain question/ immanent & exmanent inquire
Ideal process	How would you describe the ideal Technology Application Selection process? Was anything missing? What would you change?	UR_1, UR_2, UR_3, UR_4, UR_5, ER_3	Open question/ open stimulus + maintain question/ immanent & exmanent inquire
Comparison with/ without	Would you say, that by using the TAS framework, the quality of your work improved (compared to not having used it)?		Hypothetical question + "Fielmann" - question
General comments	Finally, do you have any additional comments on the TAS framework?	All	Open question of exit

Participation in interviews is voluntary, and participants provide written consent. Interviews are digitally recorded for subsequent transcription, following the standardized rules (Helfferich, 2009). The transcriptions are conducted in the language of the interview, which is German in this case. Critical statements used in the analysis are then translated into English for this research. All collected data is anonymized.

Each transcript includes a transcription header containing information about the interviewee code, recording date and place, interview duration, the name of the interviewer and transcriber, and the interview situation. In this case, denaturalized transcription focuses on verbal speech and omits idiosyncratic speech elements such as stutters, pauses, involuntary vocalizations, and non-verbal language for a more effortless reading flow. This type of transcription is chosen for its suitability in cases where interviews are not emotional, and participants may not speak in entirely grammatically correct sentences, including instances of "ehms," which are not crucial for qualitative data evaluation. The denaturalized transcripts aim to provide a more accessible and more comprehensive understanding of interview contents without omitting important information.

6.3.4.4 Analysis

As mentioned, a mixed-methodology research approach is employed to evaluate the considered artifact. The following sub-chapters provide a detailed description of the analysis for both quantitative and qualitative data.

6.3.4.4.1 Analysis of the Survey

As highlighted by Döring and Bortz (2016), quantitative data analysis involves evaluating numerical data. This analysis typically encompasses both descriptive and inferential statistics. Descriptive statistics, including measures like median values, standard deviations, and correlations, describe the collected data, while inferential statistics are employed to conclude population effects (Hatzijordanou, 2019). The examination of quantitative data is carried out using the SPSS software tool and Microsoft Excel.

Determination of the Objectivity

Objectivity is examining a result only depending on the examined object itself. It is independent of any external influencing factors (Himme, 2007). It can be further classified into the objectivity of execution, the objectivity of evaluation and the objectivity of interpretation (Rammstedt, 2004).

The objectivity of execution ensures fair and equal conditions and, thus, the constancy of the questionnaire for the survey participants (Himme, 2007). By using a standardized questionnaire, the objectivity of execution is ensured. Regarding the second aspect, Rammstedt (2004) states that influencing factors of the objectivity of evaluation are mistakes, e.g., missing or falsely transferring data. The survey questionnaire was distributed and to fill in digitally. Crosses had to be put in order to get to the next page. The data transformation did not happen manually but digitally through the survey software. Therefore, most possible mistakes are avoided, and the objectivity of evaluation is primarily secured. The third aspect, objectivity of interpretation, corresponds to the comparability of different result interpretations of numerical survey results (Rammstedt, 2004). It is ensured, for instance, when the interpretation result is a typical result of different interpreters.

Furthermore, standard values or benchmarks such as mean values and standard derivations are essential for quantitative interpretations. Using standard values and benchmarks for the single-choice questions but only one person as an interpreter, the objectivity of interpretation cannot be unambiguously ensured. Regarding the open-text questions, a second interpreter's opinion was considered.

Determination of the Reliability

The reliability of a survey questionnaire is a decisive criterion for the quality of multi-item scales because it quantifies the accuracy with which a scale measures a characteristic. It gives information about the replicability of the measured results through correlation coefficients (Rammstedt, 2004). The following paragraphs explain the correlation coefficients to describe the reliability and other important variables. Concrete corresponding values for the individual items for each scale are shown and interpreted.

From various methods of examining reliability, the consistency analysis is chosen for this thesis because this method determines whether all items of an instrument correlate with each other (Himme, 2007). One variable to calculate this internal consistency is the alpha coefficient according to Cronbach, which considers the total number of items and their mean intercorrelations. If the value is high enough, the item is homogenous and consistent within the scale (Schecker, 2014). The ideal value of the Cronbach's-Alpha is $\alpha = 1$, and the Cronbach's-Alpha of the three considered scales is with $\alpha = 0.91$, close to the ideal value (Pospeschill, 2022). Although there is no objective limit from which upwards the Cronbach's-Alpha is sufficient for an item to be internally consistent (Schecker, 2014), Döring and Bortz (2016) state $\alpha = 0.8$ as to be targeted. Schmitt (1996) even refers to $\alpha = 0.7$ as a commonly used limit. A study by Taber (2018) researches what qualitative descriptors are commonly used to interpret alpha values, out of which the following are being used as references in this thesis. An $\alpha > 0.61$ is moderate, $\alpha > 0.73$ is high, and $\alpha > 0.91$ is classified as vital. However, it must be emphasized that the acceptability for alpha values is only "a rule of thumbs" (Taber, 2018). In addition to the analysis of the Cronbach's Alpha, it will be evaluated how the Cronbach's Alpha of a scale changes when an item is excluded. This Cronbach's Alpha is then labelled α_{i_ex}.

As another variable, the item difficulty index, also known as P_i-value, is essential. It makes a quantitative statement about the probability of fully agreeing on an item and takes a value between 0 and 1 (Moosbrugger & Kelava, 2020). If the value is close to $P_i = 0$, the participants all disagree with the item's statement. In contrast, if the value is close to $P_i = 1$, they tend to agree on the statements easily. Therefore, Moosbrugger and Kelava (2020) recommend a value between 0.2 and 0.8. The items' difficulties are between $P_i = 0.733$ and $P_i = 0.815$. Thus, item 2.5 lies slightly above the limit.

Furthermore, the corrected item selectivity, rit_{-i}, states the correlation of a single item with the other remaining items of the considered scale (Sürücü & Maslakci, 2020). By that, the relation of the single item to the scale is being tested. Sürücü and Maslakci (2020) suggest values between 0.3 and 0.8 mean that "the items are sufficiently homogenous and contain the original variance" (Sürücü & Maslakci, 2020). Considering scales 1-3, the minimal value of the corrected item-total correlation is $r_i = -0.135$, and the maximal value is $r_i = 0.965$. The suggested limitation of $r_i = 0.8$ is neither overcut nor the limitation $r_i = 0.2$ undercut by any of the items.

6.3.4.4.1.1 Quantitative Analysis of the Survey: Scale 1-3

The quantitative analysis of the survey covers Scale 1 to 3, which assesses usability, general feedback on the framework, and overall judgment.

Scale 1: Usability

Scale 1 asks about the usability and comprehensibility of the TAS framework with items 1.1. and 1.2., representing the requirements ER_1 and ER_2.

Table 43: Item Analysis of Scale 1 Usability (Version One)

1. Usability (Version One)				
	M	**SD**	**pi**	**rit-i**
1.1 The framework is easy to use.	4,16	0,907	0,790	0,724
1.2 The framework is easy to understand.	4,00	0,876	0,750	0,724

Remarks: N = 74. coding: 1 (fully disagree), 2, 3, 4, 5 (fully agree). M = mean value; SD = Std. Deviation; pi = item difficulty; rit-i = corrected item selectivity. Cronbach's Alpha = 0.842.

As shown in Table 43 the corrected item-total correlations are below the limit of $r_i = 0.8$. Cronbach's Alpha has a value of $\alpha = 0.842$ and is therefore high but slightly above the limit of 0,8. As the scale consists only of two items, discarding items is impossible, and the items are not changed. With an average of 4,08 items, scale 1 represents a positive emphasis of the participants towards usability and comprehensibility.

Scale 2: Evaluation of the framework

Table 44 shows the following characteristic values with a sample size of N = 74. The Cronbach's Alpha has a value of $\alpha = 0.825$, which would be decreased to 0,781 when discarding item 2.4. In these cases, the items can be interpreted as not representing the whole scale but only a specific area of the conceptual structure (Sürücü and Maslakci, 2020).

Table 44: Item Analysis of Scale 2 Evaluation of the Framework (Version One)

2. Evaluation of the framework (Version One)	**M**	**SD**	**pi**	**rit-i**
2.1 The framework helped us to improve our market knowledge.	4,00	1,034	0,750	0,643
2.2 The framework helped us to gain a versatile understanding of the technology.	3,96	0,971	0,740	0,497
2.3 The framework helped us to understand the worth and leverage social capital.	3,78	1,050	0,695	0,623
2.4 The framework helped us to identify various alternatives and multiple applications.	4,20	0,811	0,800	0,710
2.5 The framework provided guidance to evaluate the identified applications.	4,26	0,812	0,815	0,409
2.6 The framework enabled to do the TAS process with limited resources.	4,04	0,818	0,760	0,600
2.7 The framework helped us to understand potential customers and their needs	4,24	0,857	0,810	0,528

Remarks: N = 74. coding: 1 (Fully disagree), 2, 3, 4, 5 (fully agree). M = mean value; SD = Std. Deviation; pi = item difficulty; rit-i = corrected item selectivity. Cronbach's Alpha = 0.825.

The mean value is M_7 = 4,042, with a standard deviation of SD_7 = 0.908. The participants thus give a positive evaluation of the framework. The survey results show that the framework helped the students enhance their knowledge of markets and technologies. In general, the participants agree that it supported using and extending their human capital, although it should still be enhanced with a mean of 3,78. The students agree that the framework provided guidance for exploring and considering multiple and alternative applications throughout the process. They claim that considering potential customers and their needs was enhanced through the framework. Also, ideation within limited resources was enabled, and the generated ideas were evaluated.

Interestingly, as item 2.5. not only represents the one with the highest mean and the P_i-value above 0.8. As the value is close to $P_i = 1$, the participants tend to agree on the statement very quickly, which can be interpreted as agreeing with the item.

Scale 3: General judgement

Finally, the scale 3 “general judgement” results with items 3.1 – 3.3 are presented.

Table 45: Item Analysis of Scale 3 General Judgement (Version One)

3. General judgement (Version One)	**M**	**SD**	**pi**	**rit-i**
3.1 The framework supported all our relevant purposes for the TAS process.	3,97	0,827	0,743	0,789
3.2 The framework contained all necessary information to complete the TAS proccess.	3,93	0,849	0,733	0,714
3.3 The framework provided clear guidance on the TAS process.	3,97	0,860	0,743	0,695

Remarks: N = 74. coding: 1 (Fully disagree), 2, 3, 4, 5 (fully agree). M = mean value; SD = Std. Deviation; pi = item difficulty; rit-i = corrected item selectivity. Cronbach's Alpha = 0.858.

As seen in Table 45, Cronbach's Alpha has a value of 0.858 and is classified as vital. Discarding any item would not significantly increase Cronbach's Alpha. Regarding the TAS framework, the students agree that the framework supported all relevant purposes, contained all necessary information and provided clear guidance on the process.

With the statistical results, the items of scale 1-3 can be transformed back into the functional and environmental requirements to check whether the requirements for the artifact have been met. Table 46 shows the transformation of the items and whether they are fulfilled. The environmental requirement ER_7 (Customizability) relates to four different items. The presented mean value, and therefore the fulfilment is made of the average of these four items. A requirement will be considered fulfilled if the corresponding item's mean value exceeds M = 4,0. However, a distinction is still made between acceptable and needing improvement. With mean values between M = 3.5 and M = 3,99, the fulfilment of the requirements should be improved further. There is room for improvement for values higher than M = 4.0, but they are already accepted as wholly fulfilled. Still, to compare it to the results of the interviews, the separation is made between accepted and not accepted.

Table 46: Fulfilment of Requirements (Version One)

Fulfillment of environmental and functional requirements (Version One)			
	Mean	**Fulfillment**	**related Item**
ER_1 Usability	4,16	+	1.1.
ER_2 Comprehensibility	4,00	+	1.2.
ER_3 Completeness	3,93	-	3.2.
ER_4 Adequate complexity	4,24	+	2.6.
ER_5 Efficiency	3,97	-	3.3.
ER_6 Suitability	3,97	-	3.1.
ER_7 Customizability	3,99	-	2.1., 2.2., 2.3., 2.4.
FR_1 Enhance market knowledge	4,00	+	2.1.
FR_2 Enhance knowledge about technology	3,96	-	2.2.
FR_3 Improve utilization of social capital	3,78	-	2.3.
FR_4 Provide ideation guidance	4,20	+	2.4.
FR_5 Evaluate applications	4,26	+	2.5.
FR_6 Enable structured process	4,04	+	2.6.
FR_7 Consider customers	4,24	+	2.7.

Given the areas of requirement fulfilment defined above, almost half of the functional and environmental requirements are considered as not fulfilled. With further distinction, the functional requirement FR_2 (Enhance technology knowledge) and FR_3 (Improve utilization of social capital) have a mean value slightly below the limit of M = 4.0 and should, therefore, be improved further. Further, the environmental requirements ER_3, ER_5, ER_6 and ER_7 need further improvement. Besides, they almost reached 4.0, with the most significant differentiation of 0,07 within ER_3. All of the other requirements are fulfilled. However, they still have room for improvement. To obtain a holistic view about the evaluation results, the results of the interview analysis will be integrated in order to assess the final fulfilment of the requirements.

Determination of the Validity

Rammstedt (2004) describes the validity of a system as the degree of accuracy to which the procedure captures the characteristic being measured. In general, a distinction is made between three types of validity: content validity, criterion validity, and construct validity (Rammstedt, 2004).

The basis for content validity is a content analysis of the system in order to validate whether the items effectively represent the characteristics to be measured (Rammstedt, 2004). The criterion validity describes the degree of conformity of a questionnaire result compared to the result of an external criteria. Sometimes, the given validity is difficult to verify since no concrete external valid criteria exist (Paulitsch, 2017). In this case, the content and criterion validity can be regarded as primarily given since questionnaires with already tested items were used to construct the questionnaire. These mentioned questionnaires include the questionnaire for DSR artifacts by Lau (2022) and Hatzijordanou (2019).

Determination of Secondary Quality Criteria

The secondary quality criteria include the economy of a test, usefulness, acceptance and reasonableness (Moosbrugger & Kelava, 2020; Palmer, 2016). Each criterion is briefly discussed in this paragraph, starting with the economy. The economy of a test examines the strain of resources during execution (Moosbrugger & Kelava, 2020). The economic quality criterion is met thanks to the fast, simple and resource-saving implementation, evaluation and interpretation of the evaluation. The usefulness criterion checks the test's practical relevance (Palmer, 2016). As described at the beginning of this thesis, the evaluation is crucial in developing DSR artifact (Hevner et al., 2004a). This test is therefore, helpful to answer the research question of this work and thus contribute to developing the TAS framework as a DSR artifact. Due to the neutral questions and the short processing time, which was made available in a time slot during the workshop, the questionnaire is declared to be reasonable.

6.3.4.4.1.2 Qualitative Analysis of the Survey: Scale 4

Unlike the other scales, scale 4 consists of open-text questions. Table 47 shows the items used, which explicitly ask about weaknesses, strengths, and suggestions for improvement, and other general comments on the workshops, including the framework.

Table 47: Scale 4 (Version One)

4. Suggestions and comments
4.1. In your opinion, what were the most important weaknesses of the TAS Framework?
4.2. In your opinion, what were the most important strengths of the TAS Framework?
4.3. What improvements would you suggest for the TAS Framework?
4.4. Do you have other general comments about the framework and its application?

The qualitative data analysis employs a content structuring content analysis, following the approach outlined by Kuckartz (2012) to summarize the material, as suggested by Mayring (2016). The process involves the development of inductively emerging categories using the Gioia Method (Clark, Gioia, Ketchen, & Thomas, 2010; Corley & Gioia, 2004; Gioia et al., 2013; Gioia & Chittipeddi, 1991). It is essential to note that the primary aim of this evaluation is not to derive a structure from the data; hence, identifying relationships between categories is of secondary importance. The primary focus is on detecting improvement potential. Consequently, a hybrid form of category building is applied, emphasizing sub structuring by categorizing data based on their affiliation to a particular statement in a questionnaire (Strengths, Weaknesses, Improvement). The categorization follows this structure. The qualitative data analysis of Scale 4 is there for examined within the predetermined dimensions of "Strengths," "Weaknesses," and "Improvements." Subsequently, a comparative analysis will be conducted to provide a broader perspective and derive implementation actions for concluding the first design cycle.

The analysis units, coding units, and context units are defined to structure the content material. Individual transcripts serve as the analysis units, one-word sentences are chosen as the coding units, and statements of one person constitute the context units. Developing the code system is the central focus, employing open coding rooted in grounded theory methodology (Corbin & Strauss, 1990). The code system is formed inductively, with codes derived directly from the material, following certain questions aimed at identifying relevant text passages and developing codes:

Table 48: Code System of Scale 4 (Version One)

Code system of the Scale 4 (Version One)			
Main Code	**# Codes Sublevel 1**	**# Codes Sublevel 2**	**# Mentions**
Strength	2	11	74
Weaknesses	3	10	48
Improvement areas	3	10	46

The final code system consists of three principal codes subdivided into 8 codes at the first sublevel and 31 at the second sublevel. 168 text passages are assigned to these codes (Table 48).

Strengths

Table 49: Coding of Strength (Scale 4 - Version One)

Main Code: Strengths	
Level 1: Framework	**Mentions**
Level 2: Concept	1
Level 2: Entrepreneurial Input	15
Level 2: Hands-on Approach	8
Level 2: Practical application	7
Level 2: Support in Ideation	10
Level 2: Supportive Framework	8
Level 1: Workshop	**Mentions**
Level 2: Concept	3
Level 2: New perspectives	15
Level 2: Structure	3
Level 2: Technology Market Linkage	2
Level 2: Time	2

In the Strength section comments, distinct categories emerged, focusing on the TAS Framework and the workshop. Regarding the TAS Framework, participants perceived it as highly supportive. The holistic approach, well-designed structure, segmentation, and guidance through all steps were lauded. The framework provided a clear path for all stages, incorporating a hands-on approach with practical steps and comprehensive guidance. Participants valued the entrepreneurial input facilitated by the TAS framework, appreciating its clarity, defined tasks, methods introduced, and instructions supporting linking technology to potential markets. The topics covered were considered inspiring, offering valuable insights into entrepreneurship, especially for participants with technical backgrounds. The practical and easy-to-apply nature of the knowledge transfer was highlighted, emphasizing detailed perspectives on customers, markets, and technology. Notably, the support provided during the ideation phase was commended for fostering the generation and selection of ideas. The application of the Technology Push approach within the TAS framework was positively acknowledged, representing a novel method for initiating ideation and contributing to the overall positive feedback from participants.

Participants praised the workshop embedded with the TAS Framework's clear structure and concept. The action-based approach, distinguishing between input and work tasks and discussion rounds on tasks and results, was appreciated. Participants valued the time allocated to work on tasks and apply the TAS framework. The workshops also provided new perspectives beyond the TAS framework, facilitated through guest talks by entrepreneurs and individuals in the entrepreneurial field. These talks aimed to increase awareness of different viewpoints, emphasizing the importance of social capital and networking.

Weaknesses

In the weakness section, five categories were identified, encompassing comments related to the TAS Framework, given technologies, the Technology Push approach, and time constraints (Table 50).

Table 50: Coding of Weaknesses (Scale 4 - Version One)

Main Code: Weaknesses	
Level 1: Framework	**Mentions**
Level 2: Complexity of Framework	2
Level 2: Lack of Clarity	4
Level 2: Lack of flexibility	1
Level 2: Lack of guidance	1
Level 2: Repetitive tasks	4
Level 2: Simulation	4
Level 2: Technology focus	2
Level 1: Technology	**Mentions**
Level 2: Complex technology	14
Level 2: Limited choice	4
Level 1: Workshop	**Mentions**
Level 2: Course intervall	12

Participants criticized the TAS Framework's complexity, finding certain aspects challenging to comprehend, leading to the omission of specific steps—ambiguities in understanding individual steps and methods. Participants also noted difficulties in recognizing differences between various steps or methods. The framework was deemed too static for practical use, and concerns were that it was not always sufficient as a guiding tool. Repetitive tasks within the framework were highlighted, diminishing motivation and completion rates. There was a call for a stronger focus on technology, as the given technology proved challenging to understand. Criticisms included the framework being perceived as a simulation rather than an application-oriented tool, focusing too much on research rather than practical use.

Concerning given technology, represented by patents from the university's technology exchange in focus groups, criticisms were directed at the complexity and the lack of freedom to choose a technology. The patents were considered inconvenient, very complex, and limited in application, making it challenging for participants to comprehend and hindering the TAS process. Criticisms also included the restriction of choosing from a predetermined set of technologies. The Technology Push concept was perceived as strenuous and unrealistic, attractive to some but lacking sufficient time allocation within the workshop context.

Time-related concerns were prevalent. Ambiguities were expressed regarding the time structure, allocation for specific tasks, methods, and steps, and dissatisfaction with the course interval. Participants felt that more time between phases and their execution was needed, ultimately deeming the allotted time insufficient.

Improvement Areas

In addition to addressing strengths and weaknesses, explicit attention was given to improvement areas, categorized into Framework and Technology (Table 51).

Table 51: Coding of Improvement Areas (Scale 4 - Version One)

Main Code: Improvement area	
Level 1: Framework	**Mentions**
Level 2: Add information and instruction	2
Level 2: Add examples	4
Level 2: Explicit goals	1
Level 2: Provide guidance	3
Level 2: Foster interaction	1
Level 2: Integrate time management	7
Level 2: Improve UX	2
Level 1: Technology	**Mentions**
Level 2: Rework phase 1	4
Level 2: Assess underlying technologies	13
Level 1: Workshop	**Mentions**
Level 2: Reflect on course intervall and time management	9

Within the TAS Framework, the need for greater integration of examples to enhance process understanding and mitigate diverse interpretations of methods was highlighted. Additionally, there is a call for more information and instructions. Some phases and methods lacked clear objectives, emphasizing the necessity for explicitly stated goals. Participants suggested a heightened focus on utilizing social capital, with a need for support, such as interview guidance. The proposal for a TAS Manual providing comprehensive information on navigating the TAS Framework was also made. Time management concerns led to the suggestion of implementing time scheduling to address previously identified Framework weaknesses. Furthermore, there was a call to prioritize the user experience (UX) of the TAS Framework.

In the realm of Technology, participants noted the requirement for more information and instructions. The given technology was perceived as "too complex" and challenging to comprehend, prompting a need for support. Participants desired greater autonomy in choosing the technology to engage with.

Compilation and Comparison

The results could be analyzed and compared by compilating the identified categories into the respective dimensions of strengths, weaknesses, and improvements. Further, improvement suggestions could be assigned to the respective weaknesses and strengths to ensure the integration of the suggestions. Based on the comparison, action items were formulated that are considered for the second design cycle.

Upon reviewing the evaluation outcomes, actionable recommendations emerge to enhance the TAS framework. This includes the imperative to reduce complexity by incorporating illustrative examples. Advocating for framework simplification by integrating examples aims to improve accessibility and user-friendliness. Additionally, ensuring clarity of objectives is deemed crucial. The recommendation entails articulating precise objectives for each framework phase, providing users with a clear roadmap.

Consequently, the proposal to integrate instructions and information within the framework is put forward to streamline the user experience and foster cohesion. Further recommendations include a thorough review of tasks to enhance differentiation. A targeted revision of Phase 1, specifically Technology Characterization, is suggested to improve its efficacy and relevance. Additionally, incorporating time management features is recommended to facilitate effective time management, thereby increasing productivity during the framework process. Critical evaluation and modification of the overarching design are suggested to improve aesthetics and functionality. Integrating interactive elements, such as call-to-actions or prompts, within the framework is advocated to stimulate user engagement. Ensuring a comprehensive understanding of TAS is proposed, possibly through supplementary support materials or resources.

Furthermore, a thorough evaluation of the given technologies is recommended to ascertain their relevance and alignment with the framework's objectives. A reflective analysis of the course interval and time management components is also advised to optimize the learning process and overall operational efficiency. These proposed actions collectively aim to refine the TAS framework, making it more user-centric, efficient, and aligned with the expectations and requirements of its user base.

6.3.4.4.2 Analysis of the Interviews

The qualitative interviews were conducted after the workshop A with nine of the workshop participants. The process described in 6.3.4.3.2 will serve as the basis for the analysis. Given the purely formative evaluation goal of this episode, the interviews are analyzed regarding their improvement potential for the artifact, including negative assessments, improvement suggestions and neutral remarks, that highlight specific already implemented or neutrally observed aspects. All discussions were conducted in German and translated word-for-word to English, following standard orthography and British or American spelling conventions.

Sample Description

Nine participants of the first workshop agreed to conduct interviews. The analysis is thus based on these nine semi-structural interviews. The interviews were conducted between the 1st of June, 2022 and the 22nd of July 2022. The interviewees were allowed to voluntarily decide whether they wanted to participate and whether the interview should be conducted in person or online via Zoom. Table 52 lists each interviewee and the duration of the interview.

Table 52: List of Interviews Conducted (Version One)

List of interviews conducted (Version One)	
Interviewee (Code)	**Duration**
Interviewee 1 (I01)	00:11:59
Interviewee 2 (I02)	00:21:18
Interviewee 3 (I03)	00:13:27
Interviewee 4 (I04)	00:22:10
Interviewee 5 (I05)	00:33:58
Interviewee 6 (I06)	00:18:02
Interviewee 7 (I07)	00:20:25
Interviewee 8 (I08)	00:21:53
Interviewee 9 (I09)	00:17:04

Remarks: Summed duration: 03:00:16; Average duration: 00:20:25

Analysis

The qualitative analysis of the interviews will be conducted according to the rigorous methodology of Gioia et al. (2013). The interpretation objectivity of the analysis of the interview transcripts, including the category formation, is given by applying the four-eye principle and thus two interpreters. The three levels of categories then build the basis of the data structure. Table 53 shows parts of the data structure, which is separated into codes Sublevel 1 and Sublevel 2, representing the first and second-order categories. The main code represents the corresponding dimensions.

Table 53: Code System of the Qualitative Interviews (Version One)

Code system of the Interviews (Version One)			
Main Code	**# Codes Sublevel 1**	**# Codes Sublevel 2**	**# Mentions**
Strength	3	14	87
Weaknesses	3	8	49
Improvement areas	2	4	10

Strengths

In the analysis of participant responses, it is evident that the TAS framework is perceived positively. This is emphasized by the 87 interview mentions, highlighting the framework's strength (Table 54). These were categorized into the codes “framework application”, “framework as support,” and “helpful methods and tools”.

Table 54: Code System of Strength (Interviews – Version One)

Main Code: Strengths (Version One)	
Level 1: Framework application	**Mentions**
Level 2: Appropriate degree of complexity	7
Level 2: Ease of use of framework	6
Level 2: Interactive design	2
Level 2: Collaborative usage	3
Level 1: Framework as support	**Mentions**
Level 2: Advantage to status quo	6
Level 2: Consideration of alternatives	5
Level 2: Documentary purpose	5
Level 2: Retrospective featuring of purpose	7
Level 2: Structured process	11
Level 1: Helpful methods and tools	**Mentions**
Level 2: Customer understanding	8
Level 2: Evaluation Criteria	2
Level 2: Market understanding	1
Level 2: Support in ideation	19
Level 2: Technology understanding	5

Framework Application

The framework's clarity and structure are valued by participants, suggesting an optimal level of complexity. The step-by-step instructions provide insightful guidance for each stage of the process. Consistent feedback confirms the suitability of the framework's complexity, maintaining a balance between comprehension and critical thinking stimulation. Participants consistently report satisfaction with the guidance offered, highlighting that the TAS framework efficiently aids them in navigating the entrepreneurial process. This positive sentiment is repeated in several responses, which supports the conclusion that the TAS framework upholds a suitable level of complexity, thereby contributing to its overall effectiveness. Feedback from participants consistently affirms the user-friendliness and effectiveness of the TAS framework. The framework receives praise for its simplicity, clarity and structured approach. Its comprehensibility and ease of use are emphasized, highlighting a clear understanding of the framework. The arrows guiding the sequence of steps in the structured design contribute to an organized and straightforward application. The instructions within the framework are conclusive, providing clear guidance for each field, as noted by the participants. This clarity facilitates straightforward decision-making and enhances the overall efficiency of the process. Including concise descriptions below each field is highly valued, as it bolsters understanding and usability. Participants approve of the interactive design of the TAS framework, noting that they derive valuable insights from actively engaging with the content. Compared to other workshops, this approach is described as particularly enjoyable, emphasizing the positive learning experience it provides. Including brief practical sessions during face-to-face sessions is praised as advantageous, enabling attendees to implement what they have learned promptly.

Framework as Support

Participants emphasized the vital role of the TAS framework in improving project focus, enhancing efficiency, and elevating work quality. The structured approach offered a clear direction, promoting goal orientation. Moreover, the framework facilitated coordinated efforts, leading to higher efficiency and superior project outcomes. Furthermore, it provided a distinct outlook, enriching participants' comprehension of project dynamics. Overall, the TAS framework proved valuable, positively impacting various aspects of the project narrative. The framework played an integral role in expanding perspectives and fostering a comprehensive approach to project setup. Participants reported its effectiveness in prompting consideration of alternative use cases and ideas. Its structured nature facilitated thinking in different directions, ensuring participants consistently revisited and explored various alternatives. This methodology propelled the project further and facilitated a deeper analysis of prospective use cases. Overall, the model proved helpful in assisting participants in considering and integrating alternative concepts in their project strategies.

Participants highlighted the practicality of documentation, expressing satisfaction with the phrase, "All right, we have something in our possession." They appreciated being guided to record all information to navigate the TAS process successfully. Participants acknowledged that they may not have fully realized the benefits of completing each step of the TAS framework initially, but over time, they came to recognize its positive impact. While documenting the progress can be occasionally cumbersome, it is recognized that this ritual serves an essential purpose. Furthermore, the exercise draws attention to fundamental aspects that could be overlooked otherwise. Participants stress the methodical aspect of the exercise established by the framework and praise the detailed input, which fulfils their requirements to satisfaction. The systematic, step-by-step guidance is highly valued for its emphasis on structured approaches to this process. The shared experience of utilizing a cohesive and common guide in a group setting is also positively acknowledged, contributing to a unified and aligned understanding of the framework.

Helpful Methods and Tools

The participants hold a favorable view regarding the framework's ability to aid customer comprehension. The Persona tool is highly regarded, emphasizing the Unique Selling Proposition (USP). Moreover, the allocation of tasks to prospective clients is generally deemed satisfactory. Feedback on the application of the Jobs-to-be-Done theory is positive, as participants consider it to be beneficial. Identifying and emphasizing core functions are recognized as advantageous for improving customer comprehension. The participants highlight the decision matrix's effectiveness in the assessment procedure. They find reducing several concepts to just a few valuable options particularly helpful. Acknowledging the significance of including rivals in the analysis, the attendees appreciated the assessment of the market competition utilizing instruments such as the Value Profile.

The framework was equipped with a range of ideation support tools. The German Startup Monitor proved instrumental in providing valuable insights for orientation. Although the input from SDG's was less valuable, it was deemed acceptable and introduced unique perspectives that may not have been considered otherwise. The Gartner Hype Cycle was valid and, for categorization, a combination of three surveys, which included the Gartner Hype Cycle, German Startup Monitor, and SDGs, was advantageous. In general, the participants emphasized the importance of evaluating various areas during ideation, with agreement that no aspect should be disregarded. Although the framework does not provide immediate aid in comprehending technology, it stimulates research. The exercise encourages a thorough understanding by prompting participants to engage in in-depth reviews of technology requirements. The framework's function is highlighted as a blueprint to establish a shared understanding of the intricacies of the technology. It is suggested that direct communication with the inventor is also a viable approach to attain such comprehension.

Weaknesses

Also, weaknesses were identified throughout the interviews. With 49 mentions, the amount is lower than the strengths. Still, the categories “Framework application”, “Framework limitations”, and “Less helpful methods and tools” were identified (Table 55).

Table 55: Code System of Weaknesses (Interviews – Version One)

Main Code: Weaknesses (Version One)	
Level 1: Framework application	**Mentions**
Level 2: Restrictions of the framework	8
Level 2: Limited amount of time	4
Level 2: Limited choice of patents	5
Level 2: Need for change of order	3
Level 1: Frameworks limitations	**Mentions**
Level 2: Lack of information and instructions	5
Level 1: Less helpful methods and tools	**Mentions**
Level 2: Limited support in customer understanding	10
Level 2: Limited support in ideation	7
Level 2: Limited support in technology understanding	7

Framework Application

Integrating the SDGs was considered too advanced for the given context. Participants also acknowledged straying from the predetermined order and choosing a more logical alternative sequence. Later in the process, there was a notable repetition of the decision matrix, and it was observed that the concept had become more tangible at that stage. Using multiple tools within a limited timeframe during the sessions was considered suboptimal. Participants desired to engage more deeply with the framework after each input session. Acknowledgement of the initial difficulties with the patent decision and the requirement of significant knowledge or industrial experience for dealing with the available patents was expressed.

Moreover, participants wished for a more extended period to decide on the patent. Participants reported feeling obliged to address core issues, even if they deemed them irrelevant to their understanding of technology. Some believed that continued technology exploration became redundant after reaching a certain level of comprehension. Instances were observed where participants found themselves compelled to document information, they were already familiar with, which created a perception of redundancy. One participant proposed a more minimalistic and adaptable approach, preferring a whiteboard over a framework. They suggested increased flexibility in framework usage, focused efforts, and more efficient time management could lead to potential improvements. For teams considering a pivot, the process was considered labor-intensive, leading to a recommendation for a shortcut that prioritizes essential aspects.

Restrictions of Framework

Participants indicated a requirement for more intricate clarifications or examples in the canvases, proposing that this supporting information could augment comprehension and lucidity. They raised concerns about losing information on slides and recommended making elaborate explanations or examples more accessible, potentially through hyperlinks, to boost overall visibility and understanding.

Less Helpful Methods and Tools

When applying the persona to a B2B product, participants encountered difficulties. Certain participants did not engage substantially with the empathy map, and there were apprehensions about its level of detail, implying it may have been deemed excessive. The feedback highlights limitations in the applicability and perceived usefulness of specific tools, particularly within the context of B2B products. This suggests the need for adjustments or alternatives in customer understanding aspects. Participants encountered difficulties generating ideas related to the SDGs. They expressed challenges in conceptualizing and developing concepts aligned with the SDGs. Despite receiving information from three studies, including the Gartner Hype Cycle, the participants mainly used the Wall of Ideas for ideation. The ideation process involved generating ideas without any specific clustering sessions, and the emphasis during the idea generation leaned towards technology aspects rather than insights from the studies provided. The feedback indicates that integrating SDGs into the ideation process posed challenges that require further assistance or modifications to improve effectiveness. Participants encountered difficulties with the technology-oriented aspects of the framework.

During the evaluation, it was observed that specific details were repeated in sections like Technology Descriptions and Technology 3C's, leading to redundancy. As a result, specific elements, including Technology Exploration, Underlying Technology and Technology Description, are potentially unnecessary and could be excluded. The framework was somewhat valuable for comprehending the technology, although some sections, notably the Technology 3C's, were deemed less advantageous. Furthermore, the ability to conduct a patent inventor interview was impeded by external factors, indicating restrictions in accessing specific information sources.

Improvement Areas

Improvement areas were mentioned just ten times, highlighting different areas, of which the mentions are respectively low (Table 56). Highlighted was the change of order, with six mentions.

Table 56: Code System of Improvement Area (Interviews – Version One)

Main Code: Improvement area (Version One)	
Level 1: Frameworks application	**Mentions**
Level 2: Change of order	6
Level 2: Patent choice	2
Level 1: Helpful methods and tools	**Mentions**
Level 2: Ideation	1
Level 2: Technology Understanding	1

Framework Application

The attendees proposed enhancements to the sequencing of the framework, underlining the importance of prioritizing market analysis at an early stage, even when pursuing a Technology Push strategy. To be more precise, they advocated for the reordering of phases 3 and 4 to accommodate earlier customer requirements in the process. This modification was viewed as better aligning technological advancement with customer demands and market trends. Additionally, participants highlighted the need for a broader range of patents or the ability to search for patents independently.

Methods and Tools

It was recommended to consider current trends and people's hobbies and interests as possible source of inspiration. Additionally, regarding the first phase, the level of detail in the "Technology 3C's" step should be increased to achieve a more in-depth comprehension of the technological aspects.

Summary of the Analysis Results

Upon analyzing the interview statements, an overall positive assessment of the TAS framework and its application emerges. The interviews underscored several strengths of the TAS framework. Clarity and structure were consistently praised, emphasizing an optimal complexity that fosters both comprehension and critical thinking. The framework's comprehensive approach to project setup was acknowledged, encouraging participants to consider alternative use cases and ideas. Providing step-by-step guidance emerged as a valuable aspect, providing insightful instructions for each entrepreneurial stage. The user-friendly design of the TAS framework, marked by simplicity and clarity, contributed to its effectiveness. Including customer comprehension tools such as Persona and Jobs-to-be-Done theory, received a commendation for improving understanding. The framework's support in ideation, incorporating tools like the German Startup Monitor, and its practical documentation approach were also highlighted as key strengths.

The interviews highlighted specific weaknesses and areas for improvement in the TAS framework. There were limitations in technology exploration and understanding, suggesting challenges. The framework faced challenges in dealing with the underlying technology, indicating a need for refinement. Some methods, like the SDG ideation anchor, were perceived as partly limiting. The interviews also highlighted the constraint of a limited timeframe, which participants considered suboptimal. Furthermore, there was a recognized need for clarifications in canvases to enhance comprehension and lucidity. These insights provide valuable considerations for refining and optimizing the TAS framework.

Special attention is paid to strengths and weaknesses to determine their impact on the further development of the TAS framework. Documentation practicality emerges as a dual-edged aspect. On the one hand, participants expressed satisfaction with the practicality of documentation, emphasizing its role in successfully navigating the TAS process. However, some of the participants occasionally view the documentation as cumbersome, suggesting a need to balance the advantages and potential drawbacks. The Technology Understanding framework provides a two-fold perspective, stimulating research and prompting participants to delve into technology requirements. However, the participants consider certain technology-oriented aspects, particularly the Technology 3C's, less advantageous. This duality necessitates a more in-depth analysis of how the framework can efficiently assist in grasping technology. The constraint of a limited timeframe is acknowledged as a drawback, especially when participants wish for more profound involvement with the framework following each input session. The TAS framework's interactive design is praised for its immediacy in face-to-face sessions. However, time constraints highlight the need to reassess the balance between structured implementation and prolonged exploration. The provision of Ideation Support via tools such as the German Startup Monitor and the consideration of SDGs represents a critical asset. Generating ideas related to SDGs poses challenges, highlighting a potential gap in effectively integrating sustainability aspects into the ideation process.

The robustness of the Framework Application, valued for its lucidity and organization, encounters obstacles when participants accept deviating from the pre-established order and favoring a more rational alternative sequence. The challenges of understanding customers underscore the strengths and limitations. This leads to a thorough examination of the alignment between adhering strictly to the designated structure and the preferences and dynamics of the project's participants. The Persona and Jobs-to-be-Done theory are reputable tools for enhancing customer understanding. In contrast, the empathy map and persona may face difficulties when implemented for B2B products, necessitating bespoke techniques or replacements for individual customer comprehension aspects. A proposal for a

Minimalistic Approach is grounded in the commendation of the TAS framework's simplification, clarity, and structured methodology. However, a proposal for a more straightforward and flexible approach favoring a whiteboard over a structured framework emphasizes the desire for enhanced efficiency and adaptability. The request for Clarifications in Canvases highlights the clarity and user-friendliness of the TAS framework. Nevertheless, participants have expressed a requirement for more detailed explanations or examples in the canvases, indicating that additional information could improve understanding and lucidity.

A nuanced analysis is required due to the interconnectivity of strengths and weaknesses within the TAS framework. The identified challenges highlight areas requiring targeted enhancements, while the positive aspects emphasize the framework's effectiveness. This holistic understanding provides a solid foundation for further refinement, which ensures that the TAS framework evolves in line with user needs and the underlying requirements.

6.3.4.5 Fulfillment of Requirements

The respective strengths and weaknesses were assigned to the underlying requirements to assess the fulfillment of the requirements (Table 57, Table 58).

Table 57: Assignment of Codes to Requirements - Strengths (Interviews - Version One)

Strengths	Requirements	
Level 1: Framework application		**Mentions**
Level 2: Appropriate degree of complexity	ER_4	7
Level 2: Ease of use of framework	ER_1; UR_2	6
Level 2: Interactive design	ER_6; UR_4	2
Level 2: Collaborative usage		3
Level 1: Framework as support		**Mentions**
Level 2: Advantage to status quo	ER_5; ER_3	6
Level 2: Consideration of alternatives	FR_4	5
Level 2: Documentary purpose		5
Level 2: Retrospective featuring of purpose	ER_6; ER_3	7
Level 2: Structured process	UR_1; UR_2; UR_3; UR_5; ER_2; ER_3; FR_6	11
Level 1: Helpful methods and tools		**Mentions**
Level 2: Customer understanding	UR_3; FR_7	8
Level 2: Evaluation Criteria	UR_3; FR_5	2
Level 2: Market understanding	UR_3; FR_1	1
Level 2: Support in ideation	UR_3; FR_4	19
Level 2: Technology understanding	UR_3; FR_2	5

Table 58: Assignment of Codes to Requirements - Weaknesses (Interviews - Version One)

Main Code: Weaknesses	Requirements	
Level 1: Framework application		**Mentions**
Level 2: Restrictions of the framework	ER_7	8
Level 2: Limited amount of time	ER_6	4
Level 2: Limited choice of patents		5
Level 2: Need for change of order	Ur_4	3
Level 1: Frameworks limitations		**Mentions**
Level 2: Lack of information and instructions	UR_1	5
Level 1: Helpful methods and tools		**Mentions**
Level 2: Limited support in customer understanding	UR_3; FR_7	10
Level 2: Limited support in ideation	UR_3; FR_4	7
Level 2: Limited support in technology understanding	UR_3; FR_2	7

Subsequently, a sum was calculated based on the counts, indicating whether the requirement was met (Table 59), thereby outlining the fulfillment of the respective requirements. In some cases, specific requirements were not mentioned and thus received no rating. These were initially considered neutral.

Table 59: Comparison of Assigned Codes (Interviews - Version One)

Code	Requirement	Strength (#)	Weaknesses (#)	Sum	Fulfilment
ER	**Environmental Requirements**				
ER_1	Usability	6	-	6	+
ER_2	Comprehensibility	11	-	11	+
ER_3	Completeness	13	-	13	+
ER_4	Adequate complexity	7	-	7	+
ER_5	Efficiency	6	-	6	+
ER_6	Suitability	9	4	5	+
ER_7	Customizability	-	8	-8	-
FR	**Functional Requirements**				
FR_1	Enhance market knowledge	1	-	1	+
FR_2	Enhance knowledge about technology	5	7	-2	-
FR_3	Improve utilization of social capital	-	-	-	o
FR_4	Provide ideation guidance	24	7	17	+
FR_5	Evaluate applications	2	-	2	+
FR_6	Enable structured process	11	-	11	+
FR_7	Consider customers	8	10	-2	-
SR	**Structural Requirements**				
SR_1	Coherence	-	-	-	
SR_2	Conciseness	-	-	-	
UR	**User Requirements**				
UR_1	Comprehensive process and method description	11	5	6	+
UR_2	Guiding poster (Canvas-like structure)	17	-	17	+
UR_3	Include supporting methods for each component	35	24	11	+
UR_4	Prioritization of components possible	2	3	-1	-
UR_5	Usable without external expert guidance	11	-	11	+

The interviewees have fulfilled each requirement despite FR_3, which was not mentioned. Although numerous requirements were met, ER_7 (Customizability), FR_2 (Increase understanding of technology), FR_7 (Consideration of customers), and UR_4 (Ability to prioritize components) were not fulfilled.

ER_7 emerged as a weakness, with the second-level code "limitations of the framework", due to participant responses expressing the need for greater adaptability and customization within the TAS framework. Participants reported feeling obligated to address core issues that they deemed inconsequential. Moreover, they expressed dissatisfaction with transcribing familiar information, stressing the need for a more personalized and concentrated strategy. Participants ascertained that utilizing a more adaptable framework would improve their focus and enable them to utilize their time more effectively. Fr_2 had both strengths and weaknesses, with a greater emphasis on challenges in technology comprehension. The participants expressed dissatisfaction with the techniques employed to grasp the technology and observed that some were duplicative.

Furthermore, they desired to obtain a more comprehensive understanding of the methods by working on them in greater detail. Overall, participants emphasized the need for improved support mechanisms while calling for comprehensive documentation of given technology. FR_7 was mentioned in both sections, but there were slightly higher mentions of the weaknesses. The participants recognized the methods used in the customer understanding phase, such as the persona and the jobs to be done. However, they criticized using other methods and found the persona unsuitable for a B2B focus. UR_4 involved the prioritization of components and was represented by strengths and weaknesses. Although the interviewees claimed to have made alterations themselves as needed, they lacked the confidence to do so, feeling compelled to adhere to the framework's structure. Consequently, they pointed out the deficiencies of the TAS framework and suggested varied ways to enhance it. The primary criticism is rooted in the need for mandatory changes in order.

6.3.5 Conclusion

The fundamental requirements for the TAS framework were developed based on an extensive knowledge base rooted in a triangulation of methods. These were conceptualized in collaboration with another researcher and a founder of an academic spin-off concept and instantiated in a TAS framework. Subsequently, the framework underwent evaluation through field experiments. A total of six such field experiments were quantitatively and qualitatively analyzed using surveys and interviews. The results were examined to meet the respective requirements, and additional improvement potentials identified through the evaluations were summarized yet not reflected upon.

Table 60: Evaluation of the Requirements of Version One of the TAS Framework

Evaluation Instruments

Code	Requirement	Questionnaire		Interviews	Logical	Overall
ER	**Environmental Requirements**					
ER_1	Usability	4,16	+	+		+
ER_2	Comprehensibility	4,00	+	+		+
ER_3	Completeness	3,93	-	+		o
ER_4	Adequate complexity	4,24	+	+		+
ER_5	Efficiency	3,97	-	+		o
ER_6	Suitability	3,97	-	+		o
ER_7	Customizability	3,99	-	-		-
FR	**Functional Requirements**					
FR_1	Enhance market knowledge	4,00	+	+		+
FR_2	Enhance knowledge about technology	3,96	-	-		-
FR_3	Improve utilization of social capital	3,78	-	o		-
FR_4	Provide ideation guidance	4,20	+	+		+
FR_5	Evaluate applications	4,26	+	+		+
FR_6	Enable structured process	4,04	+	+		+
FR_7	Consider customers	4,24	+	-		o
SR	**Structural Requirements**					
SR_1	Coherence				+	+
SR_2	Conciseness				+	+
UR	**User Requirements**					
UR_1	Comprehensive process and method description			+		+
UR_2	Guiding poster (Canvas-like structure)			+		+
UR_3	Include supporting methods for each component			+		+
UR_4	Prioritization of components possible			-		-
UR_5	Usable without external expert guidance			+		+

The assessment outcomes of Version One of the TAS Framework provide a primarily optimistic outlook, with interviews affirming the achievement of most prerequisites, as illustrated in Table 60. Nonetheless, the survey produced a more mixed assessment, with the condition that rounding the figures would see the achievement of the targeted performance threshold of 4.0, except FR_3, achieving only a mean of 3,78 and was also unmentioned in any interviews.

Although the evaluation is primarily positive, some areas require improvement. The environmental requirements, especially ER_7 (customization), need particular consideration in the subsequent design phase. Additionally, it is recommended to reflect on ER_3, ER_5, and ER_6. Regarding the functional framework, greater emphasis on the artifact is necessary for FR_2 and FR_3, alongside the fundamental methods of FR_7 and FR_2. This recommendation is based on the results of interviews, demonstrating an appreciation for specific methods while indicating a lack of need for others. All user requirements have been satisfied except UR_4, which pertains to the desire to modify aspects of the framework or skip certain elements. This draws attention to an area requiring further deliberation and potential improvement in future iterations.

The evaluation in an artificial environment, facilitated by the utilization of field experiments in this EE1, allowed a particular focus on the configuration of the artifact and the validation of its content. Furthermore, applying both quantitative and qualitative methods provided a comprehensive understanding of the TAS Framework, which can be further developed based on the results and identifying improvement areas. It is to be noted that, even at this early stage, a positive impression has emerged, especially considering the lack of commonly used TAS artifacts as a concrete basis. It should be noted that, even though the field trials took place in simulated environments and that the workshops involved researchers, students, and industry stakeholders, different points of view have been collected. However, the effective adoption and use of the TAS framework by researchers require careful consideration and strategic planning. This emphasis on researchers presents a significant challenge to be addressed in Design Cycle 2.

6.4 Design Cycle 2

The second design cycle (Figure 15) starts with the reflection of the previous design cycle. The most important findings of EE1 are presented, and the improvement factors are derived and discussed to suggest the tentative design of the TAS framework version two. The evaluation of the framework is described, executed and analyzed, leading to the final interpretation of the results.

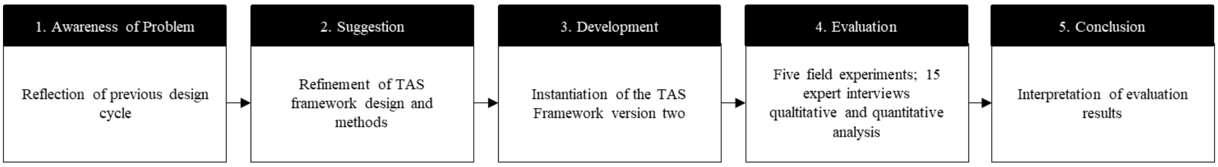

Figure 15: Overview of Design Cycle Two (Own Illustration)

6.4.1 Problem Awareness

The preceding evaluation episode has revealed an overall positive assessment of the TAS framework, with specific areas for improvement identified, particularly in terms of Customizability (ER_7) and functional requirements related to Technology Understanding (FR_2) and the utilization of social capital (FR_3). Notably, the qualitative evaluation portrayed a more favorable picture than the quantitative evaluation.

The qualitative assessment serves as a valuable starting point for critical reflection on the TAS framework and identifying potential areas for enhancement. Based on the interview data and comments from scale 4 of the survey, the initial phase addressing technology understanding received significant criticism, emphasizing the need for improvement in navigating the given technology. Specific technology-oriented elements like the Technology 3C's were deemed less advantageous. The complexity and lack of flexibility in dealing with given technology, particularly in the form of patents, were explicitly criticized. Participants found that patents were inconvenient, excessively complicated and limiting in their application, which impeded the TAS process. There was an expressed desire for greater autonomy in selecting the technology to engage with and to assess its application potential beforehand.

Furthermore, participants articulated difficulties with the concept of technology push, perceiving it as demanding and unrealistic. While some acknowledged its interest, they underscored the inadequacy of time allocation within the workshop context to engage with this concept effectively. Moreover, constraints were noted regarding specific methods, including the SDG ideation anchor. The temporal framework was also labelled as a drawback, with participants wishing for an extended time to address tasks and a predefined time duration. Ambiguities related to the temporal structure and discontent with the course intervals were apparent. Participants perceived that more time between phases and their execution was requisite for a practical engagement with the process.

Furthermore, there was an acknowledged necessity for clarifications in the phases to augment understanding and clarity. Participants articulated a need for more elaborate explanations or examples within the phases. Additional criticisms about the framework's complexity were inherent, contributing to challenges in comprehension. This resonated with perceived difficulties in grasping individual steps and methods, leading to confusion. Participants remarked on challenges in discerning differences between various steps or methods. The robustness of the framework application faced hindrances when participants preferred an alternative sequence.

Additionally, they emphasized the presence of repetitive tasks within the framework, adversely impacting motivation and completion rates. Concerns were raised regarding its adequacy as a guiding tool. Critiques were raised regarding the framework being perceived more as a simulation than a practical application, emphasizing research and a perceived lack of practical orientation. Weaknesses were also highlighted concerning the documentation within the TAS framework, the SDG ideation anchor, and the methods employed for understanding customers. Still, as this arose within a dualism of emphasizing the positive and the opposing perspective, these are not further considered a need for refinement.

The identified weaknesses are translated into action items and categorized. Additionally, they are assigned to the corresponding requirements on which they have an impact. The overview is presented in Table 61.

Table 61: Compilation of Action Items Derived from EE1

Code	Code#2	Action Item	Description	Requirement
Concept	**Concept**	Evaluation of frameworks adequacy as a guiding tool	Conduct a comprehensive evaluation of the framework's adequacy as a guiding tool, considering user concerns.	UR_1
Concept	**Concept**	Reconsideration of Technology Push concept	Reevaluate the integration of the technology push concept, considering user feedback and adjusting its implementation for practicality.	
Concept	**Concept**	Transition from simulation to practical application	Reorient the framework's emphasis from a simulation to a practical application, with a stronger focus on real-world utility.	UR_5
Overall framework	**Clarification**	Clarification in canvases	Provide more detailed explanations and examples within the canvases for better user comprehension.	ER_2
Overall framework	**Clarification**	Ensure clarity of objectives	Articulating precise objectives for each phase within the framework to provide users with a clear roadmap.	ER_2
Overall framework	**Clarification**	Review tasks for differentiation	Conduct a thorough review of tasks to eliminate redundancies and fortify clarity, ensuring distinctiveness between tasks.	FR_6
Overall framework	**Complexity**	Decrease complexity with illustrative examples	Advocating for simplification by incorporating illustrative examples to enhance accessibility and user-friendliness.	ER_4
Overall framework	**Comprehension**	Ensure comprehensive understanding	Implement measures to guarantee a comprehensive understanding of the TAS framework among users, potentially through supplementary support materials or resources.	UR_1, ER_2
Overall framework	**Comprehension**	Simplification of framework complexity	Simplify the framework to mitigate challenges in comprehension and reduce confusion among users.	UR_1, ER_2, ER_4
Overall framework	**Design**	Revise framework design	Critically evaluate and modify the overarching design for improved aesthetics and heightened functionality.	SR_1, SR_2
Overall framework	**Instruction**	Integrate instructions and information	Proposing the integration of instructions and information within the framework to streamline the user experience and foster cohesion.	UR_1
Overall framework	**Interactivity**	Integrate interactive elements	Advocate for the inclusion of interactive elements, such as call-to-actions or prompts, within the framework to stimulate user engagement.	UR_2, FR_3
Overall framework	**Methods**	Addressing repetitive tasks	Review and minimize repetitive tasks within the framework to enhance motivation and completion rates.	FR_6
Overall framework	**Methods**	Refinement of specific methods	Evaluate and refine specific methods to address user constraints and concerns.	FR_6
Overall framework	**Time**	Improvement temporal framework	Address ambiguities related to the temporal structure and course intervals to enhance user experience.	ER_5
Overall framework	**Time**	Incorporate time management features	Include components facilitating effective time management to amplify productivity during the framework process.	ER_5
Phase 1	**Phase 1**	Address issues with patents/ underlying technologies	Conduct a thorough assessment of the underlying technologies.	FR_2
Phase 1	**Phase 1**	Enhancement of Autonomy	Enable users greater autonomy in selecting the technology to engage with.	FR_6
Phase 1	**Phase 1**	Refinement of Technology Understanding Phase	Review and Refine.	FR_2

The listed action items are discussed in the suggestion to assess which ones should be integrated into the development of the next artifact and how this integration can be implemented.

6.4.2 Suggestion

The compilation of the highlighted weaknesses in EE1 leads to the formulation of the following action items that need to be reflected upon. These recommendations collectively aim to refine the TAS framework, ensuring it is more user-centric, efficient, and aligned with the expectations and requirements of its user base.

Table 62: Reflection and Design Decisions of Action Items

Code#2	Action Item	Reflection	Design Decision
Concept	Evaluation of frameworks adequacy as a guiding tool	Practicality of TAS framework	Evaluate with experts
Concept	Reconsideration of Technology Push concept	Goal of overall research	No action
Concept	Transition from simulation to practical application	Simulation based on EE1	Apply TAS in practical context
Clarification	Clarification in canvases	Supports comprehensibility	Add instructions/ explanations
Clarification	Ensure clarity of objectives	Supports comprehensibility	Refine objectives
Clarification	Review tasks for differentiation	Supports comprehensibility	Review methods
Complexity	Decrease complexity with illustrative examples	Supports adequate complexity	Review phases
Comprehension	Ensure comprehensive understanding	Supports comprehensibility	Integrate measures
Comprehension	Simplification of framework complexity	Supports adequate complexity	Review phases
Design	Revise framework design	Importance of user experience	Review design
Instruction	Integrate instructions and information	Supports comprehensibility	Add instructions/ explanations
Interactivity	Integrate interactive elements	Supports utilization of social capital	Add instructions/ explanations
Methods	Addressing repetitive tasks	Importance of user experience	Review methods
Methods	Refinement of specific methods	Supports comprehensibility	Review methods
Time	Improvement temporal framework	Simulation based on EE1	Review of workshop setting
Time	Incorporate time management features	Supports efficiency	Integrate time management
Phase 1	Address issues with patents/ underlying technologies	Supports efficiency and suitability	Review assessment methods for technologies
Phase 1	Enhancement of Autonomy	Depends on application setting - is given when applied by researcher themselves	No action
Phase 1	Refinement of Technology Understanding Phase	Supports comprehensibility and understanding of underlying technology	Review phases

Based on the identified action items, a comprehensive reflection on the background and implications of each action item was conducted. Collaborative discussions with a second researcher were initiated to delve into design decisions. Further actions were pursued for those items perceived as valuable, while a "no action" status was assigned to others.

It is important to note that some of the identified action items were not directly linked to the ongoing development phase. Tasks such as improving the temporal framework and evaluating the framework's adequacy as a guiding tool were reserved for the evaluation phase of the second DSR cycle. Further, the transition from simulation to practical application was not considered, as this was based on the choice of evaluation. Thus, the users were not the target group of the artifact. Two specific action items highlighted the need for additional research efforts: reviewing assessment methods for technologies and examining phase 1 – technology characterization. Consequently, essential groundwork for the required research surrounding these action items is initiated within the suggestion phase. This is followed by discussions about further action items that need to be integrated into the further developed version of the artifact - version two.

The categorization is rooted in design decisions, as they collectively address similar actions emanating from various action items. The discussed categories encompass "add instructions and explanations," "integrate measures," "integrate time management," "refine objectives," "review design," "review methods," and "review phases."

The category "add instructions and explanations" encompasses three action items. Firstly, detailed explanations and examples within canvases are sought to enhance user comprehension. More detailed instructions will be integrated in accordance with user requirements for the TAS framework. For instance, examples will be subtly inserted to provide orientation during the completion of Core Jobs in Phase 4, minimizing undue user influence. Detailed instructions consistently support the comprehensibility. The next action item pertains to the integration of instructions and information. The subsequent framework is expected to include more detailed instructions and additional information to be integrated into the respective methods. The final action item focuses on promoting interactive elements, emphasizing the "Call to action" and utilizing social capital. As this also represents a functional requirement in the overall evaluation that needs improvement, special attention is dedicated to its implementation. Boxes are planned to inspire potential contacts, encouraging users to utilize them in each phase. Checklists allow users to track interactions.

The action item in the "integrate measures" category concentrates on ensuring comprehensive understanding. Measures must be integrated to guarantee a thorough understanding of the TAS framework among users. While each TAS process varies, setting specific measurements is challenging. Nevertheless, a measurement is integrated when the respective phases are fulfilled and goals are achieved. This integration involves using checkboxes to highlight the relevant outcomes of each phase, enabling users to verify goal accomplishment and readiness for the next phase.

Additionally, the desire for time management features emerged during feedback, leading to the action item "incorporate time management features." Components facilitating effective time management were included, with each method in respective phases assigned a specific time frame for orientation and increased productivity.

Another action item is formulated regarding the objectives of each phase. Objectives in each phase are refined and reformulated to ensure clarity. The user experience, based on the current design, is also addressed. Aligning with the action item "revise framework design," the design will be reflected upon and altered to enhance the user experience.

In the "review methods" category, three action items are formulated. Firstly, methods are to be reflected upon to eliminate repetitive tasks and duplications, reducing demotivation and confusion among users. This aligns with the second action item, reviewing differentiation methods to enhance users' clarity. Specific methods should be reviewed, particularly those based on phase 1, customer understanding, and ideation.

Lastly, the phases, in general, should be reviewed. Participants recommended using illustrative examples and simplifying the overall framework complexity to decrease complexity. Although illustrative examples go beyond the TAS framework's design and represent an accompanying manual, the action items aim to enhance the user experience. Therefore, simplicity and illustration will be integrated into the review process by reviewing the design.

As highlighted in the action items, the request to assess the technologies beforehand and the review of phase one – technology characterization was also formulated. Further, within discussions with fellow researchers, it became apparent that the evaluation criteria of phase 3 should be revised and adapted if needed. Thus, research activities were conducted in these areas.

6.4.2.1 Reflection on Phase 1 – Technology Characterization[4]

Given the imperative recognition for a review of Phase 1, the aim is to progress the segment of Technology Characterization. Therefore, the essential factors for understanding technology were identified by conducting a systematic literature review and the analysis of the results. Subsequently, these findings were translated into a Technology Canvas, and enhanced through comprehensive assessment and testing with patents, followed by expert evaluations.

32 tools were identified and analyzed to distil essential factors for technology description. This involved categorizing individual factors into generalized main terms and organizing them based on their frequency of mention, as illustrated in Table 63. This process facilitates the identification of factors commonly utilized across various methods, tools, and frameworks.

[4] The chapter is based on Manthey, 2023.

Table 63: List of Relevant Factors for Technology Description

Main term	#	Factors
General description	**17**	Features; Product Description; Technology description; Title; Date; Interaction channels (of the technology); Technology itself; Basic information about the technology; copy of the patent; functional characteristics; situational characteristics; Technology features; Technology attributes; Functional / situational characteristics; Technical; Requirements; Requirements
Market	**14**	Market Match; Opportunity; Market Entry; Market Potential; Customer(s) & Market; Market definition; Market potential; Emerging market trends; Market; Trend; Opportunities; Threats; Market Segments; Market opportunity; Technology opportunity
Design	**12**	Aesthetics; Picture; Design and Development; Architecture / Design; Size; Material; Structure; Solution/Drawing; Product architecture; Product structure; prototypes; Product/Material
Performance / Testing	**12**	Performance; Reliability; Evidence of test accuracy; Performance; Unique Test; Lead User integration; testing results; Failure rates; Performance; Availability factor; Lifetime; Performances
Application	**11**	Application of scientific knowledge; Major Commercial Applications; Name of the application idea; Problem/Area of application; Application; Application Domain Maturity; applications & their results; Application; Fulfilled potential needs; Application; Product Ideas
Function	**10**	To achieve some specific purpose; Accomplishing a task especially using technical processes, methods, or knowledge; Function; Value Proposition; Function; Function of the technology; Functions
Risks / Weak Spots	**9**	Intrinsic potential failures; Cause root of the failure; Risks and Options; Disadvantages; Risk Management; Disadvantages; Relevant strategic issues; Risk; Weaknesses
Social outcomes, environment & safety	**9**	Social and environmental outcomes; Safety and pollution concerns; Safety profile established; Social benefits; Sustainability; Environmental context; Social and Environmental Impact; Environmental
Cost	**8**	Costs; Cost-effectiveness; Cost structure; Affordability Issues; Investment costs; Finance & Funding; Speed & Costs; Economic
HR / Company culture	**8**	People & Capability; Ways of working (culture); Employees; Company culture; People; Team Values Fit; Team; DevOps
Product roadmap	**8**	Opportunity identification; Testing and Preproduction; Production; Product Vision; Product Release; Technology Vision; Technology Plan; Production
Quality	**8**	Perceived Quality; Quality Assurance; Technology quality; Quality of proposal; Feasibility & Maturity; Technical Feasibility; Development Level; Knowledge Maturity
Advantage	**7**	Relative Advantageousness (degree of improvement of status quo); Advantages; Advantages; Strengths; Improvement (of status quo); Enhanced efficiency; Workload decrease
Resources	**7**	Usually involves a specific piece of equipment; Digital data required; Critical Materials; Unique Software; Resources; Inspection Equipment; Resources needed
Business context	**6**	Business Strategy; Business case; Success Metrics; Profitability; Value Development Activities (technology and business strategy); Intellectual Property Status
Regulatory	**5**	Conformance; Security, Identity & Compliance; Regulatory Evolution; Regulatory Status
Potential	**5**	Growth potential of product; Technology potential; Innovative potential; Radical Innovation Potential; Company's potential
Competitiveness	**3**	Competitiveness; Competition; Technological competitors
Ecosystem	**3**	Extendibility; Compatibility; Ecosystem
Outcome	**3**	Outcomes; Change and manipulation of the environment; Solution(s)
Supply/ Partners	**3**	Supply Track Record; Integration / Partners; Strategic Alliances / Partnerships
Innovation	**2**	Innovativeness; Replacing an already existing test/tool
Monitoring	**2**	Data & Analytics; Information and Monitoring
Service	**2**	Serviceability; Value-Added Service Related to the Product

Based on the identified factors, a comparative analysis was conducted. As the underlying method compilation of phase 1 of the TAS Framework is representing an adapted version of the Technology Canvas (TC) by Terzidis and Vogel (2018), the findings of the SLR were compared to it. The TC is used to describe new technologies by answering six key questions to retrieve the essential information about the technology (Terzidis & Vogel, 2018). Further, the TC represents one of the few evaluated technology description tools (Manthey, 2023). Thus, the results of further investigation are compared with this tool to evaluate the status quo and analyze potential improvements.

The TC comprises factors such as “problem”, “technology description”, “technology benefits”, “state of the art”, “drawing”, and “technical novelty”. A further developed technology description tool was formulated based on the commonalities and disparities observed between the findings of the SLR and the TC. Several points of convergence emerged during the comparison. For instance, the “technology description” in the TC aligns with the “general description” identified in the SLR, encompassing both the “technology/product description” and the “technology features”. Moreover, the “technology description” correlates with the “features” category, as it inquiries about solving the problem. Both the TC and the SLR highlight the representation of technology and its functionalities, and “design” and “drawing” are identified as common features. “Application” and “problem” demonstrate alignment, addressing the question of what problem the technology addresses. Similarly, “advantage” and “technical benefit” converge in addressing the issue of the (technical) advantage provided by the technology. Notably, “innovation” and “technical novelty” can be considered together, as both pertain to improvements relative to the state of the art, with “innovation” being infrequently mentioned in the literature. Given that the SLR identified 24 factors while the current TC includes six, variations were anticipated. Notably, the TC does not encompass the “market” factor. Additionally, the factors of “performance/testing”, “risks/vulnerabilities”, “social impact”, “environment & safety”, “product roadmap”, and “cost” are absent in the referenced TC. These variations are deemed appropriate as these factors are contingent on the application nature of the technology, and the TC was originally formulated by Terzidis and Vogel (2018) to describe a technology. This observation extends to other factors not incorporated in the TC, such as “HR/corporate culture”, “business context”, “competitiveness”, “supply/partners”, “ecosystem”, “monitoring”, and “service”. These factors are perceived more as supplementary or extensions of the technology once implemented. The factors “quality”, “resources”, “regulation”, “potential”, and “outcome” are typically contingent on the technology itself and can be part of the tool being developed. However, they are not part of the initial TC. Adhering to the design principles articulated by Terzidis and Vogel (2018), the new tool is designed to be straightforward and easily replicable. Consequently, a streamlined tool has been derived, comprising the factors outlined in Table 64, each expanded with supporting questions.

Table 64: Compilation of Derived Relevant Factors

Factors	Supporting Questions
Name	Name of the technology
Technology Description	What is the main idea and how does it solve the problem? What are its features and functions?
Benefits	What are the technical benefits of the technology? What advantage derives from using this technology instead of an alternative?
Technical Novelty	What makes the technology unique? How is it different from the state of the art? What makes the technology innovative? What are its potentials?
Market	What is the intended market/ industry? What are current solutions for the problem and in which markets are they active?
Resources	What resources are needed for the technology itself or its potential applications? Are costs, supply and partners known?
Application	What problem is solved by the technology? What are potential applications?
Depiction	How can the functionality or application of the technology be depicted?
Quality	How is the performance/availability? Does the technology fulfill specific standards/norms? How is the feasibility/ maturity of the technology?
Further	What is unique, different, or worth mentioning about the technology (e.g. sector, regulatory, risks, social or environmental outcome)

A novel TC, based on the identified factors, was developed and tested using two distinct technologies to identify potential limitations and areas for improvement. Subsequently, expert interviews were conducted within the field of technology transfer to evaluate the tool's practical utility. Overall, the experts articulated a clear need for a technology description tool, underscoring the significance of an appropriate design and layout to facilitate autonomous usage and ensure an optimal user experience. Additionally, suggestions were made to exchange certain factors to mitigate redundancy and incorporate more precise instructions. Factors infrequently mentioned in the literature were emphasized by the experts as being highly relevant and thus deemed necessary for inclusion. Furthermore, sequencing the factors in the tool requires revision to enhance its comprehensibility. Additionally, it was proposed that the tool should explicitly articulate its objectives. Drawing from the insights obtained through literature review, practical testing, and expert interviews, several prerequisites were identified for the development of an enhanced technology canvas:

Defining a Goal: Clearly articulate the objective of the technology canvas. In this instance, the technology description tool should facilitate identifying potential applications for a given technology by providing a profound understanding of its underlying principles.

Limiting Description Factors: Exclude certain factors found in the literature that are less pertinent for emerging technologies, such as “HR/Company culture”, “Business context”, “Competitiveness”, “Supply/Partners”, “Ecosystem”, “Monitoring”, and “Service”. These factors are deemed more relevant for already implemented technologies with established applications.

Step-by-Step Analysis: Implement a step-by-step analysis of the technology, integrating different factors in each step. Initially, focus on the "function", "visualization", "resources", "life cycle", "state of the art", and the "problem" the technology addresses. Subsequent steps can delve into technological features for a more in-depth understanding.

Consider Emerging Factors: Acknowledge and integrate factors highlighted by experts, even if they differ from those emphasized in the literature. Recognize the evolving importance of certain components, particularly "resources" and "life cycle", which have gained prominence recently.

Enable Assessment of Different Factors: Acknowledge the difficulty of assessing factors like "performance", "potential", "maturity", "novelty", or "costs", depending on the given technology. Allow for assessments with reasoned justifications, especially considering the tool's early-stage application identification focus.

Support Noting Further Information: Provide space for noting additional factors or ideas for potential applications that may not be explicitly mentioned in the literature or by experts. Recognize the diversity of technologies and the need for flexibility in capturing various aspects.

Usage of Relevant Resources: Encourage the utilization of diverse information sources to gain a comprehensive understanding of the technology. Incorporate multiple perspectives to avoid potential biases or limitations associated with relying solely on patents or individual sources.

Table 65: Identified Factors for the Design of an Advanced Technology Canvas

Technology Canvas		
Steps	**Factor**	**Guiding questions**
Step 1: Characterizing the Technology	Visualization	How can the functionality, application or design of the technology be visualized?
	Function	What are underlying functions of the technology?
	Resources	What resources are needed for the technology?
	Life-Cycle	What does the development, usage and recycling/ Disposal of the technology look like?
	Problem	What is the problem to solve by this technology?
	State of the art	Which kind of current products or services deal with this problem?
Step 2: Distillation in short manner	Technology description	Explain the technology in simple sentences based in step 1.
Step 3: Assessing Technology Features	Maturity	How close to the market is the technology?
	Potential	What is the growth potential of this technology?
	Novelty	What is the uniqueness of this technology?
	Performance	How can the performance of the technology be rated in comparison to alternatives?
	Cost	How costly is this technology?
	Idea concept box	Fill in further aspects relevant to the technology.

These prerequisites are a guiding framework for designing an advanced Technology Canvas, aiming to provide a more comprehensive and holistic description of technologies without compromising simplicity (Table 65). Despite various approaches in literature and practice, known derivations or evaluations of the description tools are scarce. Thus, based on the research findings, the foundational elements, and integrated factors for the Technology Characterization of the TAS Framework are delineated. Initially, a comprehensive understanding of the technology is required, incorporating the following factors: Visualization, Function, Resources, life cycle, Problem, and State of the Art. To facilitate user guidance, relevant questions are embedded for each function. Subsequently, to validate comprehension and establish a solid foundation for team discussions, the acquired insights are distilled into a concise sentence, encapsulating the essence of the given technology. In the third phase, additional aspects are evaluated, some based on assumptions, necessitating a clear distinction from the initial step. Maturity, Potential, Novelty, Performance, and Costs are assessed on scales. Furthermore, a designated space for an Idea Open Space and Concept Box is integrated to accommodate factors pertinent to various technologies. Additionally, this section allows for recording novel ideas or concepts that may emerge during the process. This inclusive approach ensures that relevant factors are considered, and potential applications are explored while providing flexibility for unforeseen aspects.

6.4.2.2 Reflection on Evaluation Criteria for Technology Applications[5]

While no weaknesses were mentioned in relation to the evaluation criteria in EE1, there was a need for refinement due to divergences found in the identified literature. Expert discussions also revealed that these criteria are prioritized differently depending on applications and industries. To tackle this challenge, a study was undertaken to establish the evaluation criteria applied to technology-based ideas. A systematic literature review led to the identification of an extensive range of criteria, which were then grouped together to form 19 dimensions (DIMs) presented in Table 65.

Table 66: Identified Criteria Categorized in DIM

Dimensions	#	Criteria
Market	46	Market Share; Market Size; Market Growth; Market Attractiveness; Market Potential; Market Acceptance; Potential Clients
Novelty	46	Originality; Creativity; Novelty; Paradigm
Economic	36	Costs; Financial; Profitability; Revenue; Sales; Capital; Comparison of profit/costs; Profit
External Environment	36	Risk&Uncertainty; Sustainability; Competition; Politics; Society; Infrastructure; Trends; Partner Organization
Strategy	30	Strategic Fit; Brand Fit; Vision&Goals; Alignment Firm Strategy; Strategic Validity
Resources	28	Availability of Ressources; Monetary Ressources
Quality	27	Specificity; Quality; Completeness; IP
Feasibility	26	Workability; Feasibility; Implementability
Relevance	24	Effectiveness; Relevance; Applicability
Tech. Features	22	Technological Features; Complexity; Maturity; Technical liability
Customer	21	Customer Satisfaction; Customer Acceptance; Others
Advantage	17	Exclusivity; Implementation; Probability of Success; Variety
Technical Feasibility	11	Technical Feasibility; Others
Innovation Type	10	Disruptiveness
Time	9	Time (several)
Organizational Aspects	9	Organizational Aspects (several)
Patent	7	Exclusivity
Quantity	4	Amount of IP
Intuition	2	Gut Feeling

Among the sub-criteria most frequently referenced in the literature, availability of resources, originality, strategic fit, creativity, benefit, technological features, and workability were found to be of particular significance. However, when considering the DIMs, a distinct prioritization became apparent, with novelty, market, external environment, financial and strategic aspects, and resources at the forefront.

[5] The chapter is based on Manthey, Herr, & Henn 2023.

Various terminologies were employed by the authors for the criteria; for instance, creativity was also referred to as imaginativeness and unusualness. Despite the discrepancies, uniform criteria usage is pivotal for replicability. A standardized assortment of leading selection criteria for idea selectors during decision-making is yet to exist. It is evident that the literature on the selection of applications lacks consensual definitions and conceptual clarity, frequently representing criteria as interchangeable. While the number of criteria for idea selection remains uncertain, it is evident that multiple criteria are assessed collectively and can be ranked based on individual importance. These criteria, originating from diverse sources, do not show a correlation with size in their selection. The responsibility for selecting criteria and deciding on ideas is unclear, with various proposed roles. Intuition emerges as a significant factor in decision-making, suggesting a preference for subjective judgment. In technology-based companies, distinct criteria may govern the application selection process, with financial aspects and long-term profitability holding critical importance.

Table 67: Adaption of Evaluation Criteria for Version Two

Evaluation Criteria		
Criteria Version One	**Criteria Version Two**	**Decision**
Technical Feasibility	Technical Feasibility	Kept
Profitability	Profitability	Kept
Market attractiveness	Market attractiveness	Kept
Team Commitment	Resources	Added
Sustainable Value	External Environment	Rephrased
Optional Criteria	Customer	Added
	Relevance	Added

The implementation and refinements of the evaluation criteria are listed in Table 67. It became evident during the analysis that the criteria of technical feasibility, market attractiveness, and profitability were considered to be very important, yet further consideration was given to the evaluation criteria of team commitment and sustainable value. As the external environment tackles sustainability issues while considering other factors such as risk, competition, law, and ethics, the term sustainable value has been refined to include these aspects. The section on team commitment was removed, as the TAS framework is not necessarily designed to be worked on in a team. A second researcher was consulted and integrated regarding resources, customers, and relevance. Given their critical role in technological innovations, resources were separately listed. Customer consideration is often overlooked in technology push projects, so the framework emphasizes its importance. In addition, assessing the importance and impact of an idea is crucial, as researchers are more likely to pursue business ideas with greater intrinsic motivation if they perceive the problem, they are addressing, to be significant and relevant.

6.4.2.3 Reflection on Technology Assessment

The analysis of the EE1 demonstrated that the participants expressed dissatisfaction with the complexity and limited application range of the given technologies. Additionally, they requested a more extensive set of technologies to choose from. As the given technologies used in the field experiments were sourced from the technology stock list provided by the university, representing existing patents in the search for applications, these were considered suitable for testing the TAS framework, where the given technology is chosen based on the technology developed by the researcher. Thus, to determine if it is feasible to evaluate the potential of technology before utilizing the TAS framework, an analysis is performed to identify appropriate technology assessment methods. The ultimate goal is to conduct a pre-assessment of the technology's potential to determine its viability before investing resources towards further development. A SLR was conducted to identify existing methods, resulting in the identification of 32 relevant publications (Table 68).

The methods identified by the analysis of the publications are classified into four sections, which focus on the initial phases of the innovation process. These segments comprise all stages leading to commercialization, commencing with the pre-ideation phase, and culminating in the testing of the final product. Subjective opinions have been excluded, technical abbreviations have been explained, and advanced vocabulary has been avoided to ensure a coherent, logical structure. Davis and Sun (2006) developed this typology to chart the course of technological innovation from the inception of ideas to attaining commercialization preparedness. Establishing an environment conducive to innovation is imperative for the successful implementation of innovative ideas (Sexton & Barrett, 2003; Waldman & Bass, 1991). Thus, it is crucial to provide support for the promotion and creation of innovation. The methodologies used at this stage are detailed in the Pre-Ideation Phase of this thesis. It is critical to the innovation process, according to Waldman and Bass (1991), that the Ideation Phase, where ideas are generated and discussed, is well-executed. Terzidis and Vogel (2018) stress the need for preliminary information screening and project definition in this phase, while avoiding subjective evaluations. It is important to introduce technical term abbreviations and to maintain objective, neutral language with consistent terminology and hedging to avoid bias. Adherence to common academic structures, consistent formatting, appropriate word choice, and grammatical accuracy are key. The subsequent stages concentrate on implementing ideas and refining technology to produce a final product, with clear logical links between statements. The phases denoted here are the Development and Testing Phases, as introduced by Terzidis and Vogel (2018) in their "Technology Application Selection" and "Explorative Development" phases. These phases aim to prioritize the creation of value and technological advancement through iterative testing. It is important to note that the phases outlined here do not extend to commercialization or later stages.

Table 68: Identified Methods in the Literature

Phases with dominent focus	Methods
Pre-Ideation	Noncontextual Drivers (Canestrino et al., 2022) Overseeing Uncertainties (Kapoor and Klueter, 2021) Structural Reconfiguration Efforts (Thai et al., 2022) Impact of Financial Environment (Kapidani and Luci, 2019) Working with Global Indices (Cai and Hanley, 2013) GDP & Technological Innovation (Phoong and Phoong, 2018) Harmonizing Innovations (Battisti and Stonemann, 2021) Success through Future Visioning (Reid and de Brentani, 2010) Internal Business Growth (Davis and Sun, 2006) Influence of Interal & External Factors (Mueller et al., 2013) Sustainably Responsible Vision (Omri et al., 2023) Institutional View of Success Performance (Brockhoff, 2003) Systematic Approach to Decision-Making (Bertoluci et al., 2022)
Ideation	Patent Data as Metric for Success (Altuntas et al., 2015) Measuring Efficiency (Cruz-C´azares et al., 2014) Interactions between Innovation Activities (Bianchini et al., 2018) Dimensions in Product Innovation (Cooper and Kleinschmidt, 1987) R&D Success Parameters (Dvir et al., 1998)
Development	Complexities in Decision-Making (Donne et al., 2023) Civil Implications in Innovation (Flipse et al., 2014) Evaluating Market Viability (Zemlickien˙e et al., 2018) Systematic Self-Evaluation Efforts (D.-Y. Kim and Hwang, 2014) Technology Maturity (Islam and Brousseau, 2014) Impact of Innovative Leaders (Rothwell, 1977)
Testing	Innovative Support by Organizations (Nepelski and Van Roy, 2021) Navigating the Innovation Landscape (Dziallas and Blind, 2019) Addressing Complexities and Uncertainties (Y.-C. Kim et al., 2021) Testing potential Commercial Success (Astebro, 2004) Context specific Success (Blindenbach-Driessen and van den Ende, 2006) Decoding Group Decisions (Galbraith et al., 2010) Successful Technology Transfer (Heslop et al., 2001) Framework of Contradictory Results (Balachandra and Friar, 1997)

While several methods were identified, the investigation of those revealed, that assessing technological innovation readiness and success is a complex task, due to the wide range of gradual and disruptive technologies that exist across different markets. The dynamic and diverse technological landscape exacerbates the challenge of measurement. According to Astebro (2004), a distinction is made between technologies that are designed for mature markets and those that are developed for emerging ones, with solutions ranging from low-tech to high-tech. The multifaceted nature of technology necessitates a nuanced approach to measurement, requiring further research in this domain.

Evolving definitions over time (Battisti & Stoneman, 2023; Cai & Hanley, 2014) reflect the rapid pace of technological progress. This dynamism poses challenges when measuring a technology at a given point, as it may have advanced further during its swift evolution (Cruz-Cázares, Bayona-Sáez, & García-Marco, 2013). However, obstacles arise in creating a standardized and universal measurement tool, as Heslop et al. (2001) and Altuntas et al. (2015) suggest diverse assessment approaches are necessary for technologies with inherently distinct characteristics across domains. The diversity of technologies poses an essential challenge in creating a universal measurement framework. Tailored assessment approaches are required due to the complicated nature of establishing a direct metric for comparing technologies with varying characteristics. Therefore, finding an appropriate measurement technique is necessary to navigate the complicated landscape and to capture the essence of technological innovation in its various dimensions and domains.

When examining the identified methods in the pre-ideation phase, which is aligned with the technologies used in the TAS framework, it is evident that there are both similarities and differences in establishing and describing an innovative environment. The methods have been categorized into themes that relate to the most prominent aspect (see Table 69).

Table 69: Broad Overview of Significant Aspects in Pre-Ideation Phase

Topic	Aspect	Detail
Understanding & Measuring Innovation	Motivation & Process	Motivational drivers + classifying innovation characteristics (Canestrino et al., 2022)
		Integrating both management and technological indicators (Battisti & Stonemann, 2021)
	Noncontextual Drivers	Drivers of innovation independent of time and space (Canestrino et al., 2022)
	Financial Systems & GDP	Connection between financial sector expansion and innovation (Kapidani & Luci, 2019; Phoong & Phoong, 2018)
	Impact of National Culture	Influence of national culture/ socioeconomic impact by exploring different innovations (Mueller et al., 2013)
Refinding & Evaluating Innovation Metrics	Global Indices & Ecodesign	Issues with global competitiveness scores + eco-design's impact on SMEs (Cai & Hanley, 2013; Omri et al., 2023)
Managing Uncertainties in Innovation	Types & Managerial	Addressing + tackling uncertainties in technical innovation (Kapoor & Klueter, 2021)
Research Institutions & Success Factors	Basic vs. Applied Research	Distinction between basic + applied research in R&D (Brockhoff, 2003)
Structural & Organizational Aspects	Structural Reconfiguration	Impact of structural reconfiguration on innovation (Thai et al., 2022)
	Strategic Thinking	Rapid commercialization in IT + importance of relationship engagement (David & Sun, 2006)
		MV + MVC (Reid & de Brentani, 2010)

As all sub-sections emphasize the importance of understanding and measuring the factors driving innovation, each methodology is unique in conducting surveys, data analysis, and expert evaluations due to its investigation of various topics. Each method highlights the significance of collaboration, structured processes, and integration of multiple factors to drive successful innovation. On the contrary, while some techniques focus on specific sectors, others include a broader scope addressing innovation across countries and industries. Thus, data sources vary across methods, with some relying on case studies, others on surveys, and some on financial indicators. Therefore, outcomes and implications differ in providing frameworks or models that over various stable insights into specific factors and suggest strategies for stakeholders. Various methods for assessing technologies are identified, particular for the pre-ideation phase. However, there is a lack of a comprehensive framework for rapid and effective pre-TAS assessment. Current assessment methods may hinder the TAS process instead of providing appropriate pre-framework approaches. However, these methods can still be used by focusing on user needs and emphasizing flexibility in their application.

The introduction of diversity in innovation entails contextual objectives, scopes, and evaluation criteria, indicating that a universal approach may not be appropriate (Kim, Ahn, Kwon, & Lee, 2021). Established frameworks are censured for their excessive theoretical orientation and absence of practicality (Dziallas & Blind, 2019). Success in disruptive projects involves multifaceted components, including technical, managerial, and business performance (Dvir, Lipovetsky, Shenhar, & Tishler, 1998; Galbraith, DeNoble, Ehrlich, & Mesmer-Magnus, 2010). It is influenced by multifaceted factors including market impact and internal or external opportunities, beyond technical performance. The latent and subjective nature of technology presents challenges in measurement (Heslop et al., 2001). A comprehensive method is recommended, taking into account managerial, organizational, and technological elements (Battisti & Stoneman, 2023). Hence, the influence of innovation on company performance is complex; relying solely on financial metrics is inadequate. Agreement in assessment is challenging due to differing stakeholder requirements (Nepelski & van Roy, 2021). Measuring non-technical factors that impact innovation is challenging, and frequently disregarded (Battisti & Stoneman, 2023). The prediction of commercial viability and market acceptance is difficult due to uncertainties (Heslop et al., 2001) and ambiguity in development projects obstructs the establishment of clear metrics for technological improvements (Blindenbach-Driessen & van den Ende, 2006). Perceptions of technology in a competitive environment differ, complicating the assessment of innovation competitiveness (Cai & Hanley, 2014). The impact of external factors, especially customers, is vital but often biased towards internal viewpoints (Rothwell, 1977). Also, early internationalization is considered crucial for successful innovation (Davis & Sun, 2006). Further, there is a deficiency in comprehensive and comparable data, which complicates the identification of influential factors in technology value (Kim et al., 2021). Suggestions for improvement involve the use of self-certification frameworks and exploration of decision-making factors (Vo Thai, Hue, & Tran, 2022).

In summary, the measurement of technological innovation encounters various challenges such as diverse obstacles, real-time emergence and radical innovativeness (Heslop et al., 2001; Nepelski & van Roy, 2021). Challenges arise from the complexity of the evaluation process, variable expert opinions, difficulties in sharing information, knowledge gaps, and uncertainties (Galbraith et al., 2010). To keep pace with developing technologies, evolution of measurement tools is necessary (Cruz-Cázares et al., 2013). An all-inclusive model is required when evaluating the commercial potential of technology in its early stages (Omri, Courrent, & Nemeh, 2023).

Technology assessment is a vast research field that goes beyond the scope of this thesis. While the TAS framework aims to be universally applicable, context-specific evaluations emphasize the need for realism and consequently, do not align with TAS. This implies that a technology's suitability for the TAS process cannot be easily ascertained.

6.4.3 Development

Based on the suggestion phase, the TAS framework version one was re-designed. Action items were incorporated, and with two other researchers, the design decisions were set for the next design. After several sketches of the new design, version two integrated refined objectives (Figure 16), methods (Table 70), and overall design (Figure 17).

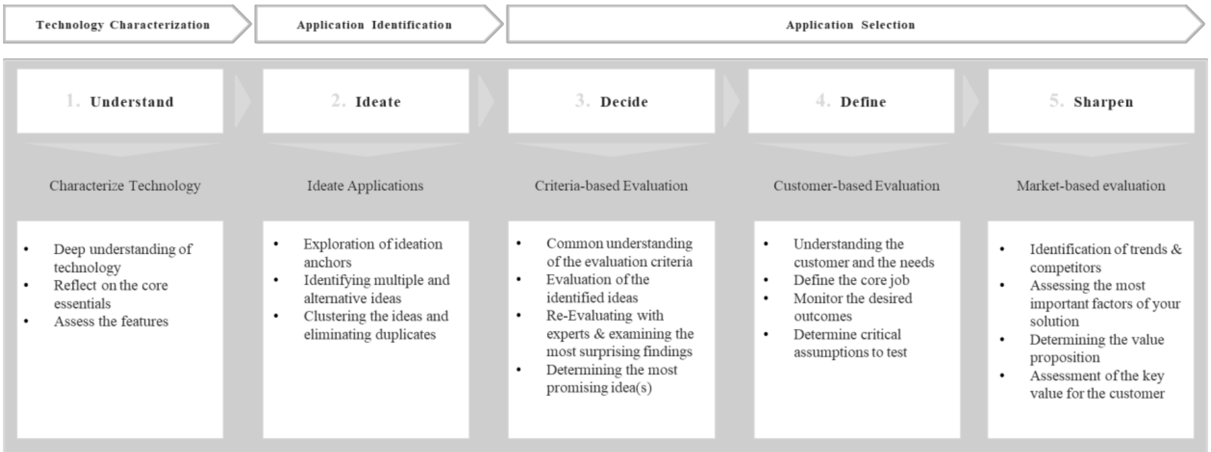

Figure 16: Adapted Objectives of the Five Phases of the TAS Framework Version Two (Own Illustration)

Table 70: Overview of Adapted Methods of Version Two

Segments	Phases	Underlying approaches	Steps
Technology Characterization	Technology Characterization	Technology Canvas (Manthey, 2023)	Step 1: Technology Characterization Step 2: Synthesizing the Information Step 3: Technology Features
Application Identification	Application Identification	Ideation Anchors (Terzidis & Vogel, 2018; Manthey et al., 2022)	Step 1: Ideation Anchors Step 2: Wall of Ideas Step 3: How-Wow-Now-Matrix Step 4: Thematic Cluster
Application Selection	Criteria-based evaluation	Evaluation Criteria Research (Manthey et al., 2023)	Step 1: Evaluation Criteria Step 2: Decision Matrix Step 3: Expert Evaluation Step 4: 3 Most Promising Ideas
	Customer-based evaluation	Adapted version of: Customer Segmentation Persona Canvas Jobs2BeDone Critical Hypotheses (Lau, 2021)	Step 1: Customer Segment Step 2: Persona Step 3: Core Functional Job Step 4: Desired Outcomes Step 5: Critical Hypotheses
	Market-based evaluation	Adapted version of: Competitor analysis framework (Hatzijourdanou, 2019) Value Profile (Terzidis & Vogel, 2018)	Step 1: Trend Radar Step 2: Competitor Analysis Step 3: Value ProfileValue Step 4: Value Proposition Statement

Regarding the overall design, numerous adjustments were implemented (Figure 17). Initially, a color scheme, blending blue and orange, was selected to replace the grey design of the initial version of the TAS Framework. The TAS diagram was removed, and instead, bubbles representing various steps were adjusted. These bubbles are colored and marked by size according to the phase, giving users a quick orientation of their current position. Objectives were also enlarged for better visibility. Symmetry and a clean layout were emphasized in each canvas. Pictograms were incorporated to offer illustrative examples of the required tasks, enhancing the overall visual appeal of the canvas. The order was rearranged to prevent possible confusion. Additionally, time management was integrated, specifying a duration for each method to increase productivity and provide user orientation.

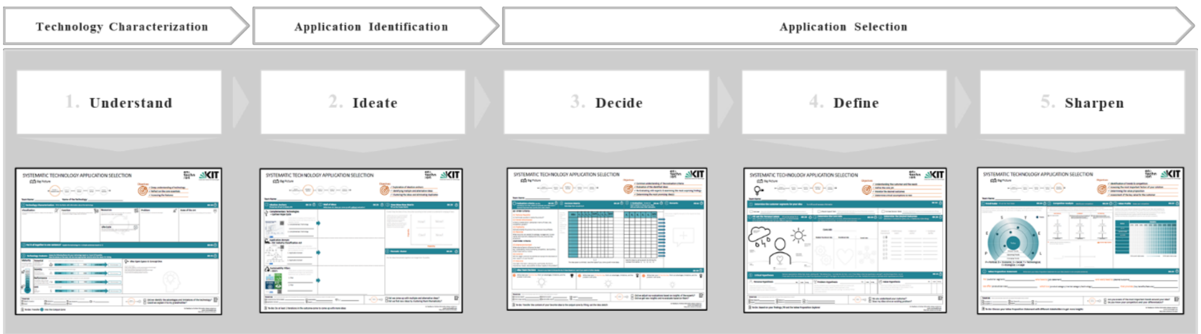

Figure 17: Overview of Adapted Methods and Design of Version Two (Own Illustration)

Apart from the overall design adjustments, "Sources," checkboxes, and to-dos were added to each phase, located at the bottom of the canvas. Sources aim to motivate users to engage with various relevant groups for each phase. Open fields were included alongside predefined groups to accommodate user-specific considerations based on technology, configuration, and application differences. Checkboxes were integrated to provide a metric for users to quickly indicate the completion of a phase, promoting reflection on the phase and its insights. A to-do was also introduced, encouraging users to delve further into the results of the phases and conduct additional research. The specifics of sources, checkboxes, and to-dos vary between the phases.

Figure 18 illustrates that the number of methods was reduced to enhance clarity and simplicity, eliminate repetitions, and differentiate between phases and methods. While methods for phases 2-5 underwent slight adaptations, the content of phase 1 underwent a thorough redesign based on the results of a systematic literature review and expert interviews (Manthey, 2023). Consistency in the design of respective phases was maintained to decrease confusion. Furthermore, objectives were reviewed and adapted if necessary, resulting in Phase 1, Phase 4, and Phase 5 changes.

Further, the action items were adapted, as seen in the example of Phase 1 (Figure 18).

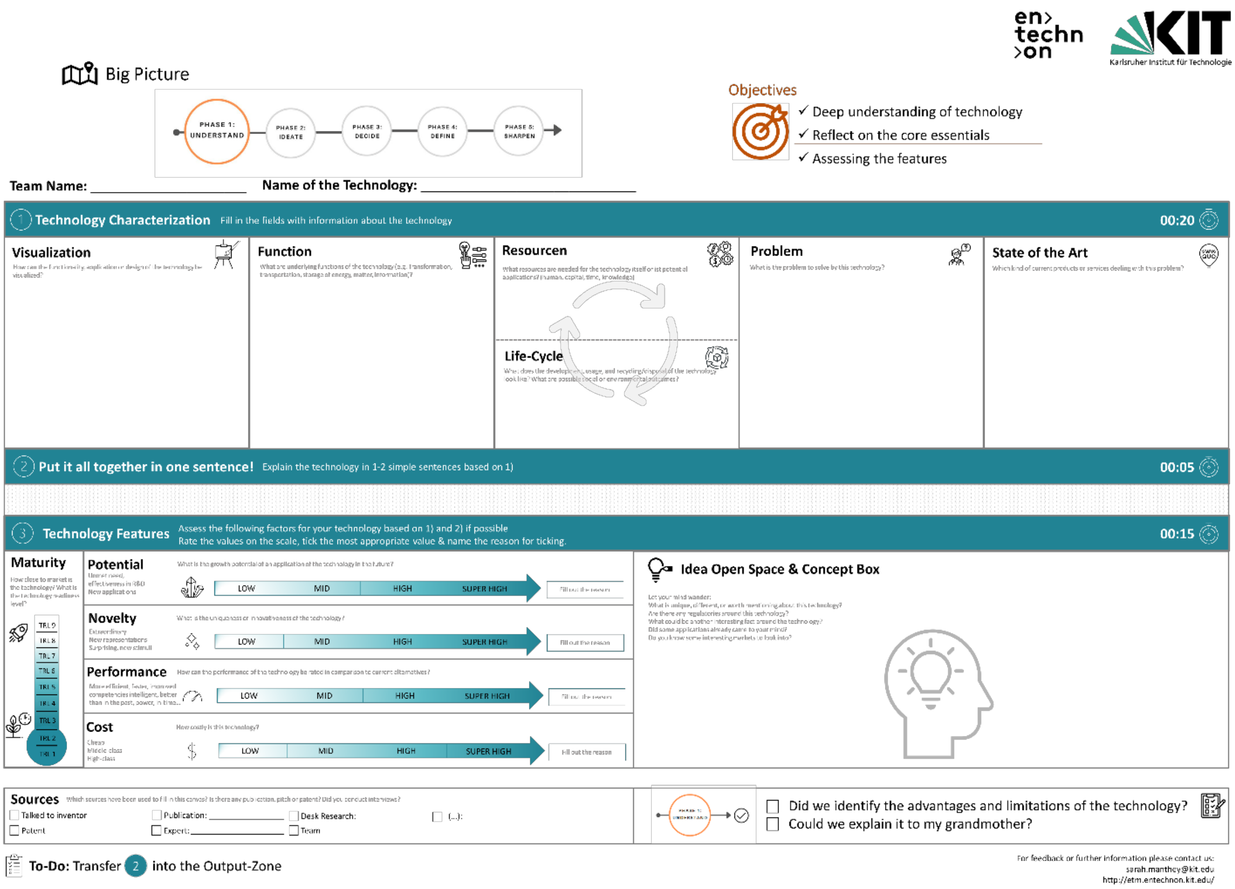

Figure 18: Illustrative Example of the Final Design of Phase One of Version Two (Own Illustration)

Phase 1: Understand

In the initial phase, the primary objective is to characterize the technology from various perspectives comprehensively. This involves an examination of visualization, functionality, available resources, life cycle, problem-solving capabilities, anticipated benefits, and the field's current state. The overarching goal is to summarize the main idea behind the technology in a single sentence and assess the maturity of its features. The output of this phase is a concise two-sentence explanation, facilitating better comprehension within diverse teams and systematic engagement with the technology.

Phase 2: Ideate

The second phase is dedicated to idea generation, utilizing various anchors to foster the generation of diverse applications. Ideation anchors include the Gartner Hype Cycle, a base for exploring complementary technologies, the ISIC Industry Classification 4.0 for identifying application domains, and the SDGs for societal and sustainable considerations. Generated ideas are displayed on an idea wall and refined through iterative brainstorming using the How-Wow-Now-Ciao Matrix. The output is a final wall of ideas, subjected to further exploration through two brainstorming iterations.

Phase 3: Decide

Phase three centers on decision-making, evaluation, and selection of the final application. Subjective decision criteria encompass technical feasibility, market attractiveness, profitability, and available resources, with experts independently validating assessments. A decision matrix scores selected ideas against first and second-order criteria. The output includes documentation of the top three ideas, culminating in an idea sketch visualizing the chosen final application.

Phase 4: Define

Following the selection of the final application, phase four delves into understanding the potential customer base. Identifying potential customer segments is followed by completing the Persona Canvas, detailing core responsibilities and desired outcomes. Critical assumptions are identified and rated for risk, validated through the value proposition explorer. The aim is to thoroughly understand potential customers and how the proposed idea addresses their problems.

Phase 5: Sharpen

The final phase involves examining market trends and competitors related to the idea. Using the Gartner Magic Quadrant, competitor analysis provides insights into the market landscape. Using the Trend Radar and PESTEL approach, trend analysis assesses factors impacting operations. Eight crucial success factors are identified, compared to competitors, and inform the completion of the one-sentenced value proposition. This statement validates the business idea and is a foundation for further discussions within the TAS framework.

6.4.4 Evaluation

Like version one of the TAS framework, its further development, version two, will also be applied in field experiments throughout several workshops. Hence, three of the field experiments were conducted within the same setting as the previous workshops to keep comparability. To align with the formulated action item to put the TAS framework in a more practical setting, two workshops are conducted in collaboration with researcher and their patented technologies, which were used as the given technologies.

Further, expert interviews are conducted with technology transfer managers, aligning with the first action item of suggestion to conduct a comprehensive evaluation of the framework's adequacy as a guiding tool. Thus, the evaluation episode two (EE2) is still artificial but includes a rather practical-oriented and experienced perspective. Hence, by integrating researchers within the field experiments, conclusions can be drawn upon the perceived usability and efficiency of the TAS framework for researchers who represent the intended target group.

Table 71: Evaluation Strategy (Version Two)

Evaluation Strategy (Version Two)	
Explanation of the objectives of the evaluation	**Design requirements** Functional requirements Environmental requirements Structural requirements User requirements
Selection of the evaluation strategy	**Human Risk & Effectiveness** Definition of the evaluation questions Determination of the survey methods Choice of samples Description of the evaluation cycles
Selection of the evaluation strategies	**Field Experiment | Expert Interviews** Setting: Entrepreneurial Education Workshop | Interviews Unit: Students, Researcher | Technology Transfer Manager Treatment: Multiday workshop | 60-minute interview
Data analysis	**Qualitative and Quantitative** Evaluation of the quantitative survey Evaluation of the open text questions | Interviews Comparison with the requirement criteria Deriving suggestions for improvement

6.4.4.1 Field experiments

Three out of five field experiments were conducted in settings similar to those of the evaluation episode 1 field experiments. The design of two field experiments involved collaboration with researchers who expressed interest in the TAS framework but faced resource constraints, leading to their hesitation to conduct the experiments independently. In response, a setting was devised wherein researchers could integrate their technology into the field experiments with limited resources and still obtain validated results from the TAS framework. The researchers were required to contribute resources in the form of information and availability for technical consultation and feedback, particularly concerning technical feasibility. The given technology of the first field experiment was hardware, whereas the second technology was software. The researcher's integration was discussed before the workshop. An informal discussion was held afterwards to get feedback and an evaluation of whether the integration was promising regarding resource utilization and output and how the integration could be improved for future workshops.

The feedback from researchers was informally obtained through bilateral online meetings following the workshop's conclusion. Adequate time was allocated for researchers to review the results generated by the student teams. The feedback from Researcher 1 was generally neutral, as he endorsed the opportunity positively but identified the generated output as impractical. It was recognized that insufficient communication between the researcher and the teams led to the pursuit of technically unfeasible applications. However, the researcher also explained that his technology might not be distributable as a standalone application but as a technology developed for specific purposes across various industries. Based on this feedback, the subsequent workshop was adjusted, and both student teams and the researcher received preparatory training. Emphasis was placed on active communication between both parties to ensure continuous feedback on the technical feasibility of identified applications. During the workshop, various timeslots were designated between the different phases of the TAS Framework, allowing student teams to engage in discussions. All teams consistently utilized this feature. The researcher rated the final results highly and noted that although some applications were self-identified and subsequently discarded, one out of six identified applications was deemed highly promising and is currently under further exploration. Overall, the researcher expressed satisfaction with the collaboration and intends to continue leveraging this approach.

Additionally, based on positive experiences, other colleagues plan to participate in similar workshops. Feedback from the researchers regarding potential improvements focused on extending the application identification phase to identify more innovative ideas potentially. In general, the researchers were uniformly positive about the experience.

Table 72: Sample of Field Experiments (Version Two)

Participants of the evaluation studies (Version two)					
Evaluation Episode	**Setting**	**Date**	**Number of Teams**	**Questionnaire (n)**	**Interview (n)**
2	Students*	Dec 22	5	7	-
2	Students	Jan-23	7	12	-
2	Students	Jan-23	5	4	-
2	Students*	May 23	6	20	-
2	Students	Aug-23	7	8	-

*In the workshops market with * the workshops were designed in collaboration with researchers*

6.4.4.1.1 Quantitative Analysis of the Survey: Scale 1-3

The quantitative analysis of the survey covers Scale 1 to 3, which assesses usability, general feedback on the framework, and overall judgment.

Scale 1: Usability

Scale 1 assesses the usability and comprehensibility of the TAS framework through items 1.1 and 1.2.

Table 73: Item Analysis of Scale 1 Usability (Version Two)

1. Usability (Version Two)	**M**	**SD**	**pi**	**rit-i**
1.1 The framework is easy to use.	4,18	1,027	0,795	0,458
1.2 The framework is easy to understand.	4,20	0,881	0,800	0,458

Remarks: N = 51. coding: 1 (fully disagree), 2, 3, 4, 5 (fully agree). M = mean value; SD = Std. Deviation; pi = item difficulty; rit-i = corrected item selectivity. Cronbach's Alpha = 0.628.

The corrected item-total correlations fall below the threshold of ri = 0.8, and Cronbach's Alpha is α = 0.628, within an acceptable range. With an average rating of 4.19 for the items, participants expressed a positive inclination towards the usability and comprehensibility of the framework.

Scale 2: Evaluation of the Framework

Scale 2 shows the items for the functional requirement assessment. The Cronbach's Alpha has a value of α = 0.687. The mean value is M_7 = 4,147, with a standard deviation of SD^7 = 0,656.

Table 74: Item Analysis of Scale 2 Evaluation of the Framework (Version Two)

2. Evaluation of the framework (Version Two)	**M**	**SD**	**pi**	**rit-i**
2.1 The framework helped us to improve our market knowledge.	4,04	0,799	0,760	0,277
2.2 The framework helped us to gain a profound understanding of the underlying technology.	4,16	0,903	0,790	0,343
2.3 The framework helped us to understand the worth and leverage social capital.	4,08	0,868	0,770	0,315
2.4 The framework helped us to identify various alternatives and multiple applications.	4,16	0,731	0,790	0,521
2.5 The framework provided guidance to evaluate the identified applications.	4,35	0,770	0,838	0,249
2.6 The framework enabled to do the TAS process with limited resources.	3,96	0,774	0,740	0,410
2.7 The framework helped us to understand potential customers and their needs	4,33	0,712	0,833	0,583

Remarks: N = 51. coding: 1 (Fully disagree), 2, 3, 4, 5 (fully agree). M = mean value; SD = Std. Deviation; pi = item difficulty; rit-i = corrected item selectivity. Cronbach's Alpha = 0.687.

Participants provide a positive evaluation of the framework. The results indicate adequate support for functional requirements overall, with room for improvement in item 2.6, specifically regarding users' ability to execute the TAS process within limited resources. Similar to the previous evaluation, item 2.5 holds the highest mean (4.35) and a Pi-value above 0.8, suggesting unanimous agreement among participants reinforcing their alignment with the statement.

Scale 3: General Judgement

Finally, the results of scale 3, "general judgement" with the items 3.1 – 3.3, show a Cronbach's Alpha with a value of 0.694 and none of the Pi-values above 0.8.

Table 75: Item Analysis of Scale 3 General Judgement (Version Two)

3. General judgement (Version Two)	**M**	**SD**	**pi**	**rit-i**
3.1 The framework supported all our relevant purposes for the TAS process.	4,02	0,827	0,755	0,496
3.2 The framework contained all necessary information to complete the TAS proccess.	3,98	0,849	0,745	0,564
3.3 The framework provided clear guidance on the TAS process.	4,18	0,860	0,795	0,470

Remarks: N = 51. coding: 1 (Fully disagree), 2, 3, 4, 5 (fully agree). M = mean value; SD = Std. Deviation; pi = item difficulty; rit-i = corrected item selectivity. Cronbach's Alpha = 0.694.

Finally, the results of scale 3, "general judgement" with the items 3.1 – 3.3, show a Cronbach's Alpha with a value of 0.694 and none of the Pi-values above 0.8. The participants agree that the framework supported all relevant purposes, contained all necessary information and provided clear guidance on the process. Still, improvement should be considered within item 3.2, which relates to the incorporated information within the TAS framework.

Utilizing the statistical outcomes, items from scales 1-3 are translated back into functional and environmental requirements to assess the artifact's compliance, equivalent to EE1. Outlines the transformation of items and their fulfilment status. Environmental requirement ER_7 (Customizability) is associated with four distinct items. The fulfilment is determined by the mean value derived from these four items. A requirement is considered fulfilled if the mean value exceeds M = 4.0.

Table 76: Fulfilment of Requirements (Version Two)

Fulfillment of environmental and functional requirements (Version Two)	**Mean**	**Fulfillment**	**related Item**
ER_1 Usability	4,18	+	1.1.
ER_2 Comprehensibility	4,20	+	1.2.
ER_3 Completeness	4,18	+	3.2.
ER_4 Adequate complexity	3,96	-	2.6.
ER_5 Efficiency	4,18	+	3.3.
ER_6 Suitability	4,02	+	3.1.
ER_7 Customizability	4,11	+	2.1., 2.2., 2.3., 2.4.
FR_1 Enhance market knowledge	4,04	+	2.1.
FR_2 Enhance knowledge about technology	4,16	+	2.2.
FR_3 Improve utilization of social capital	4,08	+	2.3.
FR_4 Provide ideation guidance	4,16	+	2.4.
FR_5 Evaluate applications	4,35	+	2.5.
FR_6 Enable structured process	3,96	-	2.6.
FR_7 Consider customers	4,33	+	2.7.

Given the areas of requirement fulfilment defined above, the overall assessment represents a positive evaluation of the TAS framework. Modestly below the set value of 4.0 are the ER_4 (Adequate complexity) and FR_6 (Enable structured process). These results will be compared to the results of the qualitative data collection. Further, a comparison will be made to the results of EE1.

6.4.4.1.2 Qualitative Analysis of the Survey: Scale 4

Like EE1, scale 4 is analyzed qualitatively, consisting of open-text questions. Table 17 shows the coding of the scale, differentiated into weaknesses, strengths, and suggestions for improvement. The underlying method used to derive the data was following the approach of Gioia et al. (2013).

Table 77: Code System of Scale 4 (Version Two)

Code system of the Scale 4 (Version Two)			
Main Code	**# Codes Sublevel 1**	**# Codes Sublevel 2**	**# Mentions**
Strength	2	8	35
Weaknesses	3	6	17
Improvement areas	2	5	17

The final code system consists of three principal codes subdivided into 7 codes at the first and 19 at the second sublevel. Sixty-nine text passages are assigned to these codes (Table 77).

Strengths

The findings from the open-text section of Scale 4, which corresponds to the Strengths section comments, have been categorized into two principal codes: Framework and Workshop. The Framework code encompasses six subcodes, shedding light on various aspects of the evaluated framework's structural and conceptual components. On the other hand, the Workshop code comprises two subcodes, delving into insights and feedback specifically related to the interactive and practical aspects of the workshop associated with the evaluated system.

The strengths identified in evaluating the TAS framework encompassed several vital aspects. The concept demonstrated robustness in the integration of technology push and collaborative teamwork. Participants recognized the TAS approach as an engaging and intriguing concept for facilitating learning. The practical application of the framework received commendation, emphasizing its hands-on approach and the positive aspects of working through the TAS process. Additionally, the support provided in the ideation phase, particularly the encouragement to generate multiple ideas and select and develop one, was acknowledged. The enhancement of utilizing social capital emerged as a significant positive aspect, contributing to the overall strength of the framework. The educational content of the workshops, which included guest talks, discussions, and shared experiences, was also highlighted positively. The dynamism, group work, and a balanced combination of working sessions and speaker engagements were deemed advantageous.

Table 78: Code System of Strengths (Scale 4 - Version Two)

Main Code: Strengths	
Level 1: Framework	**Mentions**
Level 2: Concept	6
Level 2: Entrepreneurial Input	6
Level 2: Hands-on Approach	2
Level 2: Practical application	2
Level 2: Social capital enhancement	1
Level 2: Support in Ideation	3
Level 1: Workshop	**Mentions**
Level 2: Concept	14
Level 2: Course Intervall	1

Weaknesses

Conversely, the weaknesses identified in the evaluation revealed areas that require attention and improvement. Within the framework, concerns were raised about its limited practical applicability, with a participant expressing disappointment in its perceived lack of practicality. Criticisms also surfaced regarding the overarching concept of technology push and perceived limitations in user experience (UX). The complexity of the given technology emerged as a substantial challenge, impacting participants' ability to navigate the TAS process effectively. Furthermore, feedback indicated redundancy within the workshop concept, with a desire for more practical exercises to enhance engagement.

Table 79: Code System of Weaknesses (Scale 4 - Version Two)

Main Code: Weaknesses	
Level 1: Framework	**Mentions**
Level 2: Limited information	1
Level 2: Limited practical applicability	1
Level 2: Technology push	2
Level 2: UX	1
Level 1: Technology	**Mentions**
Level 2: Complex technology	10
Level 1: Workshop	**Mentions**
Level 2: Concept	2

Improvement Areas

The improvement areas outlined by participants were primarily focused on technological and framework enhancements. Participants expressed a need for greater freedom in choosing technology and emphasized the importance of a more practical approach. Suggestions were made to provide additional information about the given technology to enhance participant understanding. The framework's UX was identified as an aspect requiring attention, with calls for improvements to make it more user-friendly. Participants also recommended incorporating more guidance during interviews as part of the framework.

Table 80: Code System of Improvement Areas (Scale 4 - Version Two)

Main Code: Improvement area	
Level 1: Framework	**Mentions**
Level 2: Improve UX	4
Level 2: More guidance for interviews	2
Level 2: Enhance technology understanding	2
Level 2: Concept	1
Level 1: Technology	**Mentions**
Level 2: Technology Choice	8

Compilation and Comparison

A comprehensive comparison of strengths, weaknesses, and improvement areas underscored the TAS framework's positive aspects, including its educational content, dynamism, and practical approach. Concurrently, identified weaknesses must be addressed, such as limited practical applicability and challenges associated with technology complexity. Calls to action include refining the framework for enhanced user-friendliness, providing additional information on technology, and integrating practical exercises while avoiding redundancy.

6.4.4.2 Expert Interviews

Like EE1, the approach delineated in chapter 4.2.2 serves as the underpinning for the analysis. In contrast to the prior qualitative evaluation involving participants from field experiments, these interviews are conducted with representatives of technology transfer management. This strategic choice aims to gain a more seasoned perspective from stakeholders actively engaged in the TAS process in their routine activities. Aligned with this episode's specific formative evaluation objectives, the interviews undergo scrutiny to identify their potential for refining the artifact. This assessment encompasses negative appraisals, improvement suggestions, and neutral observations that shed light on specific aspects already implemented or neutrally observed. They were following a methodology similar to the previous cycle. A hybrid category-building approach is employed.

Sample Description

From a sample of 16 participation consents, 15 interviews were successfully conducted. The interview participation was voluntary. The interview partner stopped the 16th interview and is therefore not included in the analysis due to incompleteness. The analysis is based on the transcribed completed semi-structured interviews. The interviews were conducted between March 20, 2023, and April 27, 2023. Due to spatial barriers, all interviews were conducted using the Microsoft Teams meeting tool. Since the goal was to conduct interviews with experts to obtain valuable feedback, the interview partners were selected explicitly with desired knowledge in the technology transfer. Because of this, the demographic data of the interviewees was not requested. Instead, they focused on their experience with comparable artifacts such as the TAS. In Table 81, the durations of each interview are described, in addition to the position of the interviewees in the technology transfer.

Table 81: List of Interviews Conducted (Version Two)

List of interviews conducted (Version Two)		
Interviewee (Code)	**Position in Technology Transfer**	**Duration**
Interviewee 1 (I01)	Innovation and Strategy Leader	00:58:27
Interviewee 2 (I02)	Head of Venture Building	01:01:18
Interviewee 3 (I03)	Head of Innovation Management	01:11:07
Interviewee 4 (I04)	Leader of Innovation Department	01:05:43
Interviewee 5 (I05)	Head of Business Development	01:18:34
Interviewee 6 (I06)	Head of Technology and Marketing and Sales	02:04:25
Interviewee 7 (I07)	Head of Technology Transfer at a German university	00:58:17
Interviewee 8 (I08)	Professor at a German university	00:47:00
Interviewee 9 (I09)	Head of Research and Innovation	01:12:42
Interviewee 10 (I10)	Chief Technology Officer (CTO)	00:59:11
Interviewee 11 (I11)	Technology Transfer Manager at a British university	01:02:27
Interviewee 12 (I12)	Professor at a Finish university	00:59:53
Interviewee 13 (I13)	Research and Development (R&D) Manager	00:59:11
Interviewee 14 (I14)	Innovation Manager	01:03:59
Interviewee 15 (I15)	Technology Transfer Office at a German university	00:38:54

The duration of the interviews exhibited variability across sessions. This variance can be attributed to the interview guide predominantly comprising open-ended questions that provide interviewees ample space to articulate their perspectives on TAS within a relaxed and unhurried interview setting. Consequently, the recorded interview durations ranged from 38 minutes and 54 seconds to a maximum of 2 hours, 4 minutes, and 25 seconds. Notably, two out of the 15 interviews required continuation on a subsequent date owing to time constraints and technical challenges.

Interview Guideline

An interview guideline is a structured tool for organizing and noting down questions for the interviewee (Gläser & Laudel, 2010). Rooted in the problem-centered approach by Wirtz et al. (2016), the interview guideline is crucial in ensuring comparability across interviews (Wirtz et al., 2016). Employing inductive and deductive approaches, the guideline aligns with the deductive method driven by the research questions, specifically centered around the TAS framework (Flick, 2012). The inductive approach fosters exploration by capturing individual actions and perceptions without preconceived notions, aiming to unveil new insights during the interview (Flick, 2012). To maintain neutrality and openness to fresh insights, the interview questions encompass different types, primarily focusing on open-ended inquiries such as introductory, experiential, and opinion questions, supplemented by yes/no queries (Gläser & Laudel, 2010). The interview guide underwent evaluation and revision by a second researcher to ensure its effectiveness.

Since the interviewees have not independently navigated the TAS framework but have been introduced to it during the interview, the guideline avoids direct reliance on the TAS process requirements outlined in chapter 6.3.1.6. This precaution minimizes potential bias in assessing the fulfilment of requirements. The questionnaire, synonymous with the interview guideline, comprises six parts derived from the requirements. Before initiating the interview, a brief talk establishes rapport and creates a relaxed atmosphere. The interview starts with a concise introduction, emphasizing the significance of the interviewee's background knowledge and feedback on the latest TAS framework iteration. As per the pre-filled online consent form, anonymity and data protection are reiterated. The introduction outlines the motivation behind developing the TAS framework and the goals of the current work. Subsequently, the questionnaire's first part delves into the interviewee's professional background, engagement with technology transfer, process design, and encountered challenges in this domain. The interview questionnaire can be found in Appendix B1.

Demographic questions are omitted in this context, deeming the interviewee's technological background more pertinent. The questionnaire's second segment delves into the interviewee's familiarity with technology application selection tools, exploring both advantages and drawbacks. The third section unfolds after exploring the interviewee's engagement with TAS tools and technology transfer. Here, the TAS framework is systematically presented phase by phase, allowing the interviewee to provide immediate thoughts after each phase for candid feedback. Yes/no questions on completeness, comprehension, and the logical order of phases are posed after each phase, with clarifications provided as needed. Upon the completion of the TAS framework presentation, the fourth section addresses the effectiveness of the TAS framework. Questions probe its alignment with the purpose of TAS, its target audience, and potential areas for enhancement. Concluding the questionnaire in its fifth section, interviewees are allowed additional comments on the TAS. Supplementary materials or referrals to appropriate contacts are provided if further issues arise.

Analysis

The qualitative analysis of the interviews adheres to the methodology outlined by Gioia et al. (2013). Ensuring interpretive objectivity in the analysis of interview transcripts, including category formation, is achieved by applying the four-eye principle involving two interpreters. The resulting data structure is built upon three levels of codes, with Table 82 offering a partial view of the structure. In total, 17 Codes Sublevel 1 were derived from 89 Codes Sublevel 2, all based on 385 mentions.

Table 82: Code System of the Interviews (Version Two)

Code system of the Interviews (Version Two)			
Main Code	**# Codes Sublevel 1**	**# Codes Sublevel 2**	**# Mentions**
Framework's Strengths	2	7	59
Framework's Weaknesses	1	4	13
Improvement Possibilities Content	9	52	184
Improvement Possibilities Design	3	16	87
Application of TAS	2	10	42

Given the extensive number of principal codes and the respective subcodes, Table 83 presents only the Main code and their corresponding codes sublevel 1. The qualitative content analysis of the interview data is conducted using the web application QCAmap, which facilitates techniques for qualitative content analysis. Subsequent subchapters will delve into the detailed insights of each main code, including the respective codes sublevel 1 and their corresponding codes sublevel 2. The main codes are referred to as dimension in the following text, to prevent confusion.

Table 83: Illustration of Sublevel 1 Codes

Codes Sublevel 1	Main Code
Advantages of the TAS Helpful methods and tools	Frameworks strenghts
Weaknesses of the TAS	Frameworks weaknesses
Improvements for the general framework Team building Completeness Comprehensibility Recommendations for phase one Recommendations for phase two Recommendations for phase three Recommendations for phase four Recommendations for phase five	Improvement possibilities content
Structured order of the process Design of the TAS Workshop design	Improvement possibilities design
Possible target group Alternative use of comparable artifacts	Application of TAS

Framework’s Strengths

The dimension “Framework’s Strengths” is constructed from the subcodes: “Advantages of the TAS” and “Helpful Methods and Tools”, encompassing seven sublevel codes.

Table 84: Frameworks Strengths (Version Two)

Main Code: Strengths	
Level 1: Advantages of the TAS	**Mentions**
Level 2: Completeness of TAS	11
Level 2: Guidance & Documentation	4
Level 1: Helpful methods and tools	**Mentions**
Level 2: Technology Characterization	9
Level 2: Ideation	2
Level 2: Evaluation Criteria	9
Level 2: Customer Understanding	10
Level 2: Market understanding	14

The interviewees generally acknowledge several advantages of the TAS framework. Six respondents agree that the TAS effectively covers all relevant aspects for exploring potential applications and selecting the best ones for technologies. Two interviewees agree with this statement but specify that it may be more applicable to specific technologies. Furthermore, the interviewees appreciate the framework for supporting thought organization, documentation purposes, providing step-by-step guidance, and being academically proven. Additionally, they highlight its role in facilitating knowledge exchange among diverse experts and serving as a communication tool for explaining decisions to external stakeholders.

Regarding feedback on specific phases and the usefulness of methods and tools, a third of the interviewees stressed the importance of establishing a common technological understanding within the team in phase one. Positive feedback is also given for the short one-sentence formulation at the end of the technology discussion in phase one. Aspects such as considering cost in the maturity level and resources are also positively received. In phase two, the methodology of idea generation using ideation anchors is noted for its potential to yield interesting results and foster creativity. For phase three, participants appreciate the predefined evaluation criteria, emphasizing their importance in ensuring objectivity during the evaluation of ideas. Positive comments are made about the decision matrix and the output of the idea as an Idea Sketch. Using evaluation criteria with the decision matrix for idea selection is particularly praised. In phase four, four interviewees found the research of potential customers valuable and crucial. Tools such as classification into core jobs, persona creation, and differentiation between critical, problem, and value hypotheses receive positive feedback. The three angles—end user, lifecycle support team, and purchase decision maker—are also positively acknowledged for their relevance at this stage. Phase five stands out for the one-sentence formulation of the value proposition statement, with three interviewees emphasizing the importance of conciseness.

Additionally, five interviewees affirm that everything necessary for a final application selection phase is provided, and it is not overly extensive. Three interviewees positively commented on the competitor analysis, stating that it is well-placed and sufficient for sharpening an application. There is also one positive remark about the importance of trend analysis.

Framework's Weaknesses

The dimension "Framework's Weaknesses" is based on "Weaknesses of the TAS", comprising four sublevel 1 codes.

Table 85: Framework Weaknesses (Version Two)

Main Code: Weaknesses	
Level 1: Weaknesses of the TAS	**Mentions**
Level 2: Assumption-based framework	6
Level 2: Completeness of TAS	4
Level 2: Complexity	3
Level 2: Missing Team related aspects	1

Concerning the weaknesses of the TAS framework, three interviewees expressed difficulty in assessing whether the framework effectively explores all relevant applications to select the best one. They emphasized the need for practical testing outside of an interview format to validate the framework's efficacy. Additionally, three interview partners criticized the lack of practical considerations, highlighting that the TAS framework is primarily assumption-based. Another aspect raised by three interviewees was the perception that the TAS framework is overly theoretical and more suitable for educational purposes. One interviewee stated a reluctance to use the TAS framework within this context unless a condensed version was available. Two other interviewees concurred, mentioning that the framework is too extensive for day-to-day business operations. Furthermore, it was noted that the TAS framework demands significant time investment for complete comprehension, and the process lacks adequate guidance for selecting team members at the outset.

Improvement Possibilities – Content

The "Improvement Possibilities" dimension comprises nine sublevel 1 codes: Improvements for the General Framework, Team Building, Completeness, Comprehensibility, Recommendations for Phase One, Recommendations for Phase Two, Recommendations for Phase Three, Recommendations for Phase Four, and Recommendations for Phase Five. In total, this dimension encompasses 52 sublevels two codes. To enable an overview, the code systems were separated and the respective recommendations per phase put separately.

Table 86: Improvement Possibilities Content Without Phase Recommendations (Version Two)

Main Code: Improvement possibilities content	
Level 1: Improvements for the general framework	**Mentions**
Level 2: Hybrid approach	2
Level 2: Further testing	5
Level 2: Phase summaries	1
Level 1: Team building	**Mentions**
Level 2: Mutual understanding	1
Level 2: Diverse team	1
Level 2: Prior knowledge of team	4
Level 2: Motivation by team dynamics	2
Level 1: Completeness	**Mentions**
Level 2: TAS is complete	2
Level 2: Phase 1 is complete	1
Level 2: Phase 2 is complete	8
Level 2: Phase 3 is complete	7
Level 2: Phase 4 is complete	9
Level 2: Phase 5 is complete	4
Level 1: Comprehensibility	**Mentions**
Level 2: Phase 1 is clear	3
Level 2: Phase 2 is clear	8
Level 2: Phase 3 is clear	6
Level 2: Phase 4 is clear	6
Level 2: Phase 5 is clear	5

In response to inquiries about general recommendations for the framework, three interviewees expressed that assessing TAS in an interview format was challenging. They suggested that a workshop format would be more effective. A hybrid approach was recommended, suggesting the development of a framework based on both MP and TP approaches to integrate direct market feedback. Additionally, participants proposed that summary sentences at the end of each phase would be beneficial. One interviewee suggested exiting the process with several applications and gathering feedback from different investors to decide the best among them. The selection of team members for TAS was deemed crucial. Including individuals with diverse expertise and application domain experts was recommended to avoid superficial assumptions. Combining a team of creative and realistic individuals was also advised. Developing a common communication language within the team was emphasized to foster a sense of togetherness and shared success. Fixed team constellations were considered beneficial in certain phases, but a balance must be maintained to avoid favoring individual ideas.

In terms of completeness, interviewees ranked the TAS phases as follows (in brackets, the number of mentions from highest to lowest): Phase Four (9), Phase Two (8), Phase Three (7), Phase One (6), and Phase five (4). Regarding comprehensibility, interviewees considered the phases in the following order (from highest to lowest mentions): Phase Two (8), Phase Three (6), Phase Four (6), Phase Five (5), and Phase One (3). However, it is essential to interpret these assessments cautiously, considering the subjective nature of responses and the open-ended interview format. Despite initial challenges in evaluating TAS during interviews, two interviewees agreed that TAS fulfils completeness.

Recommendations Phase 1

Addressing specifically the recommendations for phase one, this sublevel 1 code comprises seven sublevel 2 codes.

Table 87: Improvement Possibilities Content - Phase 1 Recommendations (Version Two)

Main Code: Improvement possibilities content	
Level 1: Recommondations for Phase 1	**Mentions**
Level 2: Adding assumptions	4
Level 2: Additional factors	2
Level 2: Expert inclusion	3
Level 2: Lack of interconnectedness	2
Level 2: Redundancy of phase	1
Level 2: Refinement of terms	4
Level 2: Workload	8

Interviewees provided several recommendations for enhancing Phase One of the TAS framework. Firstly, concerns were raised about the clarity of the headings within the “Function” and “Problem” task boxes, as they were perceived as confusing and not indicative of the required tasks for this phase. Additionally, two interviewees perceived that Phase One involved a substantial workload, and two others asserted that generating a single sentence in response to this workload was insufficient.

One interviewee proposed that the workshop facilitator could facilitate ideation thinking during Phase One, priming applications to stimulate creative thinking. Another noteworthy recommendation was the fundamental importance of examining patents during this phase, with three interviewees considering it an elementary step that had not been adequately addressed previously. Two interviewees emphasized the significance of effective brainstorming by experts in Phase One, as the assumptions generated during this phase could otherwise remain superficial, impacting the subsequent phases that rely on Phase One.

Furthermore, considerations related to risks and potential were suggested for inclusion in the technology evaluation during Phase One. A participant remarked that the interconnection between the various aspects necessary for understanding the technology appeared lacking. In this context, a waterfall approach was suggested as potentially more effective than filling up random boxes.

Additional recommendations encompassed seeking an outside perspective on existing elements, possibly through interviews, even in Phase One. However, one interviewee cautioned about the potential risk of allocating excessive time to this step, with some individuals potentially skipping it due to previous familiarity. It was also advised to enhance specificity in detailing technology characteristics, potentially including assumptions, while emphasizing the possibility of superficiality in these descriptions.

Recommendations Phase 2

The sublevel 1 code, “Recommendations Phase Two”, consists of seven out of 89 sublevel 2 codes.

Table 88: Improvement Possibilities Content - Phase 2 Recommendations (Version Two)

Main Code: Improvement possibilities content	
Level 1: Recommondations for Phase 2	**Mentions**
Level 2: Add ideation method	6
Level 2: Difficult ideation methods	4
Level 2: Integrate documentation	1
Level 2: Refinement of terms	2
Level 2: Unclear structure	2
Level 2: Usage of methods with cuation	5
Level 2: Workload	1

In Phase Two, a recurring theme among the recommendations is the need for ideation anchors to trigger creative thinking effectively. It was emphasized that these anchors should avoid being too obvious to encourage the generation of high-quality ideas. Regarding the Gartner Hype Cycle as an idea anchor, concerns were raised about its potential superficiality, suggesting a more specific Gartner Hype Cycle. For the ISIC Industry Classification 4.0 idea anchor, a recommendation was made to consider the associated impacts of industries as an additional aspect.

Two interviewees proposed the incorporation of additional idea anchors. One suggested considering user opportunities or needs in the environment, while the other recommended exploring radical changes in recent months as a valuable idea anchor. Documentation of team members and the collaborative brainstorming process was highlighted as potentially beneficial. It was emphasized that team members should share a common understanding of the idea anchors to prevent misunderstandings.

An additional consideration suggested for Phase Two is the exploration of trends to stimulate creative thinking. Some interviewees recommended examining which technologies could replace applications rather than merely clustering them. One interviewee proposed the use of the PERCIPIO tool for analyzing trends to gain a better understanding of the ideal direction.

Regarding the How-Wow-Now-Ciao matrix, minimal comments were provided, with one suggestion to replace the classification on the originality axis with the aspect of “impact” for more excellent added value when evaluating ideas. However, two interviewees expressed confusion about the specific steps to follow in Phase Two, noting its perceived time-consuming nature and the extensive preparation and follow-up work required. Practical considerations were raised, with one interviewee emphasizing that, in reality, people may prefer consulting experts rather than relying on a structured approach for generating creative ideas. Additionally, a critique was offered regarding the term "Ideate" for Phase Two, suggesting that it aligns more with the consideration of applications and might be more fitting for Phase Four.

Recommendations Phase 3

The sublevel 1 code within the dimension "Improvement Possibilities for TAS Content," specifically addressing recommendations for Phase Three, consists of six sublevel 2 codes.

Table 89: Improvement Possibilities Content - Phase 3 Recommendations (Version Two)

Main Code: Improvement possibilities content	
Level 1: Recommondations for Phase 3	**Mentions**
Level 2: Diverse experts	1
Level 2: Additional criteria	7
Level 2: Difficult criteria	4
Level 2: In-depth idea exploration	3
Level 2: Indicate data sources	1
Level 2: Workload	5

The sublevel 1 code within the dimension "Improvement Possibilities for TAS Content," specifically addressing recommendations for Phase Three, consists of six sublevel 2 codes. A prominent concern raised by interviewees in Phase Three relates to the evaluation criteria. Recommendations for improvement include the addition of further predefined criteria such as "Size of the problem," "Novelty of the application," or "User attractiveness." Two interviewees highlighted that, in real-life scenarios, the "Customer" criterion would hold higher importance. Another suggestion from two interviewees was to allow teams the flexibility to establish their company-specific criteria, which would then be integrated into the decision matrix evaluation.

One interviewee proposed preparing an idea sketch for each evaluated idea to enhance the evaluation process, similar to the output in Phase Two"s idea sketch zone. This idea sketch, created for all relevant ideas before the decision matrix evaluation, was seen to establish a better-shared understanding of each idea. Additionally, a desire was expressed by one interviewee to have the option of carrying multiple applications forward from Phase Three, providing flexibility to explore each application further in subsequent phases. The integration of a fee-required Failure Mode Effect Analysis (FMEA) for risk analysis in the selected application was recommended by one interviewee.

Concerns were raised about the feasibility of evaluating 20 ideas, with one interviewee deeming it ambitious and unlikely to be realistic in a real-life context. Another interviewee expressed the desire to document the input for the decision matrix, such as interviews or expert brainstorming sessions conducted before the evaluation. Emphasis was placed on the importance of diversifying the expertise of experts in the team, with one interviewee stressing the significance of avoiding bias by not selecting experts from the same research area. Three interviewees characterized Phase Three as busy.

Recommendations Phase 4

This category consists of six sublevel 2 codes.

Table 90: Improvement Possibilities Content - Phase 4 Recommendations (Version Two)

Main Code: Improvement possibilities content	
Level 1: Recommondations for Phase 4	**Mentions**
Level 2: Diverse experts	1
Level 2: Additional criteria	7
Level 2: Difficult criteria	4
Level 2: In-depth idea exploration	3
Level 2: Indicate data sources	1
Level 2: Workload	5

Interviewees underscored the significance of customer research in Phase Four. Four interviewees recommended engaging in intensive discussions, interviews, and real-life analysis with potential customers, emphasizing that such interactions provide more valuable feedback than hypothetical scenarios. Additionally, two interviewees highlighted the importance of involving business partners as another customer segment that should be integrated into this phase. It was noted that the analysis in Phase Four might be more suited to B2C scenarios rather than B2B.

Furthermore, one interviewee recommended using tools tailored to evaluate the idea within the given context and for the specific customer segment, proposing a functional check report. This tool could serve as a means to assess whether the application aligns with functional requirements. If the application fails this test, the suggestion was made to allow a revisit to Phase Three for idea review.

One interviewee put forth an additional recommendation to consider conducting customer analysis earlier in the process, possibly during the ideation phase. Lastly, a critique was raised by one interviewee regarding the terminology used in Phase Four, suggesting that the term “idea” might be misleading, as it represents the final application and should be referred to as the “solution.”

Recommendations Phase 5

“Recommendations Phase Five” consists of eight out of 89 sublevel 2 codes.

Table 91: Improvement Possibilities Content - Phase 5 Recommendations (Version Two)

Main Code: Improvement possibilities content	
Level 1: Recommondations for Phase 5	**Mentions**
Level 2: Adaption of methods	3
Level 2: Change order	2
Level 2: Considerations	4
Level 2: Delete methods	4
Level 2: Further instructions	1
Level 2: Indication of further steps	6
Level 2: Subjective assessment	1
Level 2: Workload	1

"Recommendations Phase Five" consists of eight out of 89 sublevel 2 codes. Phase Five elicited varied opinions among the interviewees, with specific attention drawn to the trend analysis and the value proposition statement. Regarding the trend radar, diverse viewpoints emerged. Some interviewees suggested addressing the trend analysis or even conducting the PESTEL Analysis much earlier in the process. Conversely, one interviewee questioned the added value of the trend analysis in the last phase. Another suggestion was to replace the trend radar with a technology radar. Additionally, a recommendation was made to provide more information on processing the trend radar, as team members might interpret its elements differently.

Concerning the value proposition statement, one interviewee proposed placing it in the output zone rather than within the trend assessment. This interviewee felt that the one-sentence wording of the value proposition statement was insufficient and recommended an outcome similar to a business model canvas for clarity on the project"s direction. One interviewee characterized the value proposition statement as a corset, emphasizing that formulating it becomes more challenging for breakthrough applications where there might be no pre-existing customer need or competitor.

Three interviewees highlighted the importance of preparing for presentations to investors and accelerators in the project"s follow-up. They emphasized the need to avoid overwhelming these stakeholders with excessive information after Phase Five to prevent discouragement. According to one interviewee, financial feasibility was noted as a missing aspect that could be incorporated into this phase. Another interviewee emphasized the need for more detailed documentation, suggesting that a one-sentence statement alone is insufficient.

It was also noted that the value proposition statement analysis might be redundant for breakthrough applications with no competitors in Phase Five. One interviewee commented on the information density in Phase Five, urging caution due to subjective evaluations underpinning some assessment points. Finally, a suggestion was made to appropriately sharpen the last phase's headline.

Improvement possibilities – Design

The dimension “Improvement Possibilities Design” comprises three sublevel 1 codes: “Structured Order of the Process,” “Design of the TAS,” and “Workshop Design,” encompassing 16 sublevel 2 codes.

Table 92: Improvement Possibilities Design (Version Two)

Main Code: Improvement possibilities design	
Level 1: Structured order of the process	**Mentions**
Level 2: Jump back and forth	10
Level 2: Change order	4
Level 2: TAS structure is good	2
Level 2: Order of Phase 1 makes sense	8
Level 2: Order of Phase 2 makes sense	5
Level 2: Order of Phase 3 makes sense	9
Level 2: Order of Phase 4 makes sense	8
Level 2: Order of Phase 5 makes sense	8
Level 1: Design of the TAS	**Mentions**
Level 2: Simplification	8
Level 2: No improvement needed	9
Level 2: Layout adaptions	4
Level 2: Further guidance	1
Level 1: Design of the TAS	**Mentions**
Level 2: Creative breaks	2
Level 2: Guidance helpful	5
Level 2: Include literature	1
Level 2: No improvement needed	3

These insights comprise a total of 87 mentions in the respective areas (Table 92). They collectively emphasize the preference for a structured order while recognizing the importance of flexibility, allowing iterative movement between phases for a more dynamic and adaptive exploration process. Further, it is recommended to collectively aim to improve the user experience by providing clear guidance, simplifying visual elements, and making the TAS framework more adaptable to diverse user needs and preferences. Still the overall assessment is positive.

Application of TAS

The “Application of TAS” dimension encompasses two sublevel 1 codes: possible target groups, and alternative use of comparable artifacts, constituting ten sublevel 2 codes.

Table 93: Application of TAS (Version Two)

Main Code: Application of TAS	
Level 1: Target group	**Mentions**
Level 2: Researchers	8
Level 2: R&D	2
Level 2: Enterprises	1
Level 2: Technology transfer	4
Level 2: Research Institutions	1
Level 2: Technical innovators	1
Level 2: Investors	1
Level 1: Comparable artefacts	**Mentions**
Level 2: No TAS process known	10
Level 2: Own framework	10
Level 2: Comparable framework	4

When examining the interviewees as potential users of the TAS framework concerning their technology transfer approaches, the Market Pull (MP) approach was the most frequently mentioned, followed by a hybrid approach combining MP and Technology Push (TP). Only one participant mentioned TP; the remaining interviewees did not explicitly reference this aspect. Over half of the participants stated they do not utilize TAS-like tools or frameworks in technology transfer. When asked about awareness of TAS-like artifacts, one-third of the interviewees were unfamiliar with similar frameworks. Three interviewees reported using tools provided by their respective companies. Alternative methods mentioned included direct communication with companies, conducting seminars, and employing leading questions to structure the process. Known frameworks such as lean canvas, business canvas, and technology radar were mentioned, along with proposed tools like PERCIPIO and the toolbox of the Strategizer company. Regarding the design of known artifacts, feedback from two interviewees indicated that some were browser-based or had a diverse design, though specific details were not provided.

Regarding potential target groups for the TAS framework, researchers and technology transfer offices were the most frequently mentioned by a total of twelve interviewees. Overall, the TAS framework was perceived to hold value for researchers, technology transfer offices, research institutions, investors, enterprises and R&D departments. The distinction between SMEs, small companies, and large companies was noted. In conclusion, the TAS framework was perceived as valuable across different segments.

Summary of the Analysis Results

To provide a clear overview of interviewee feedback, sublevel 1 code and the corresponding dimensions were categorized into negative, positive, and neutral aspects based on the interview results (Table 94). The classification is further discussed below. The qualitative analysis primarily aimed to evaluate the TAS framework by identifying potential weaknesses; hence, most codes are classified as unfavorable. The dimension "framework's weaknesses," indicating identified weaknesses in the TAS framework, is classified as a negative aspect. Critics emphasized that practical considerations are not given enough attention and that the process relies heavily on assumptions. The extensive scope of the process was also criticized as potentially discouraging the target group. The dimension "frameworks' strengths" contains positive feedback from experts categorized under helpful methods and tools and advantages of the TAS, thus representing positive aspects. Helpful tools appreciated by experts are listed, demonstrating the added value of the TAS framework. It is important to note that this positive categorization does not imply negativity toward other tools; instead, these highlighted tools stood out as particularly appreciated, contributing to the overall effectiveness of the framework.

Table 94: Classification of Results of the Interviews (Version Two)

Negative aspects	**Positive aspects**	**Neutral aspects**
Frameworks Weaknesses	**Frameworks strenghts**	
Weaknesses of the TAS	Helpful methods and tools	
	Advantages of the TAS	
	Improvements for the general framework	
Recommendations for phase one	Completeness	Team building
Recommendations for phase two	Comprehensibility	
Recommendations for phase three		
Recommendations for phase four		
Recommendations for phase five		
	Improvements design	
Structured order of the process		
	Design of the TAS	
		Workshop design
	Application of TAS	
	Possible target group	Alternative use of comparable artifacts

The aggregated dimension "improvement possibilities content" is divided into negative, positive, and neutral aspects. The codes represent experts' suggestions for improving the TAS framework—improvements for the general framework recommendations for each phase—are classified as negative aspects, indicating potential weaknesses. The code's comprehensibility and completeness, reflecting experts' assessments of individual TAS framework phases, are considered positive, indicating positive results. The code team building is classified as a neutral aspect, as it provides tips on team-related considerations without practical workshop implementation experience. The dimensions "improvements possibilities design" codes are also classified as positive, negative, or neutral. The structured order of the process is criticized for being inflexible, contributing to its classification as a negative aspect.

Feedback on the workshop design is positive and neutral, emphasizing the importance of breaks and continuous moderation, with the workshop process considered an appropriate methodology. The design of the TAS framework receives both positive and negative feedback, with some experts noting its extensive scope and expressing a desire for a simpler alternative. In the “Application of TAS” dimension, the second-order categories alternative use of comparable artifacts are classified as neutral aspects based on expert experiences unrelated to the TAS framework. However, according to experts, the code's possible target group is positive, indicating a broad potential target group for the TAS framework.

Building upon the insights, suggestions for improving the TAS framework can be derived, either based on interviewees' expressed recommendations and feedback or conclusions based on the comments. While the recommendations are primarily influenced by negatively classified aspects from the interview results, other factors are also considered. The improvement suggestions can be differentiated into content-specific and design-specific categories.

Content-Related Improvement Areas

Several improvement possibilities are identified based on interviewee feedback. In phase one, adding technology-characterizing aspects based on company-specific needs could be beneficial. Emphasizing the importance of each aspect and reviewing team knowledge or composition in phase one could enhance the understanding and characterization process, particularly when gaining deep technology understanding is challenging. Additionally, considering valuable aspects like “risks” during technology characterization and linking them to application-specific risks during selection was suggested by an interviewee. For phase two, the option of adding specific idea anchors based on personal or company-specific needs and retaining predefined idea anchors could be considered. Guiding participants through the process, emphasizing the importance of moderation, and adding an idea anchor to explore radical changes in the last few months could address confusion and foster creative thinking. Ensuring a common understanding of idea anchors among team members is crucial. An improvement for phase three involves reviewing evaluation criteria by considering “customer” criteria as a first-order criterion.

Offering the option to add evaluation criteria based on company-specific requirements ensures an objective evaluation process, providing diverse insights. Regarding the decision matrix, lowering the target of twenty ideas for evaluation could lead to developing individual idea sketches for fewer ideas, enhancing team clarity and simplifying the evaluation process. In phase four, ensuring intensive customer analyzes through in-depth research, including interviews and surveys, is recommended. Involving business partners in the customer research process can provide valuable insights. If no profitable customer segment is identified, revisiting idea selection from phase three is suggested as an alternative to proceeding with several selected applications. For phase five, improvements depend on specific circumstances. Reassessing trends by allowing the assessment of trends in previous phases and considering emerging trends is essential. Considering the technology as an alternative tool for analysis is suggested. For competitor analysis, allowing for more detailed statements, if desired, could be beneficial. Enhancing the value proposition statement by providing the option to include more details and offering guidance on creating a business model, financial plan, and presentation strategies is recommended. Final suggestions for creating a business model or presentation to investors and accelerators without overwhelming them are worth considering.

Table 95 summarizes the improvement suggestions separated into recommendations for Phase One, Phase Two, Phase Three, Phase Four, and Phase Five within the aggregated dimension "improvement possibilities content."

Table 95: Excerpt of Improvement Suggestions for the Content Based on the Interviews (Version Two)

Sublevel 1 Code	Improvement suggestions
Recommondations for phase 1	Provide possibility to add company-specific aspects for technology characterization
	Revising team constellation if it's challenging to build a deep technology understanding
Recommondations for phase 2	Provide possibility to add personal or company-specific idea anchors
	Adding idea anchor 'Radical changes/Trends'
	Ensuring good guidance on the workflow of phase two
	Clarification about mutual understanding about the idea anchors within the team prior to brainstorming
Recommondations for phase 3	Classifying the evaluation criteria 'customer' as first order criteria
	Option to add company-specific/personal evaluation criteria
	Minimizing number of ideas and rather creating idea sketches for fewer ideas
	If desired continuing to phase four with more than one selected application
Recommondations for phase 4	Conducting in-depth customer research with potential customers
	Involving business partners in customer research process
	Possibility to jump back to phase three, if no customer segment could be identified and revise idea
Recommondations for phase 5	Offering possibility to assess trends in previous phases
	Possibility for more details in the value proposition statement
	Final suggestions for the presentation for investors, incubators

Design-Related Improvement Areas

The interview results had limited comments on the design, posing difficulties in providing specific improvement recommendations based solely on interviewees' statements. Despite the paucity of comments on the design, it could be considered, apart from enhancing the TAS framework itself, to create an alternative simplified framework for day-to-day business use. This simplified version would allow team members to choose between optional and fixed tasks within phases, reducing the workload. Such a framework might cater to additional target groups that lack the time or resources to navigate the entire TAS framework process. During workshop conduction, careful consideration should be given to team constellation. Ensuring a diverse team with experts from different fields, including a mix of creative and practical individuals, could be a condition for effective team composition. This aspect may be incorporated into the initial stages of the workshop process. The TAS framework process should adopt a more flexible structure, allowing teams to move back and forth between phases. For instance, if no potential customer segment is identified in phase four, the team can revert to phase three to revise the selected idea. This supports exploiting acquired information across phases, regardless of the process sequence. Table 96 summarizes the improvement suggestions for the second-order categories of team building and design of the TAS within the aggregated dimension “improvement possibilities design.”

Table 96: Excerpt of Improvement Suggestions for the Content Based on the Interviews (Version Two) - continued

Sublevel 1 Code	Improvement suggestions
Team building	Ensuring a diverse team with expertise in the application field
	Ensuring a team constellation of creative and practical experts
	Creating a harmonic team collaboration
Design of the TAS	Offering a simplified TAS framework version for the daily business use
	Further investigations on the TAS framework with the focus on design
	Offering the option to jump back and forth between the phases, rather than an iterative order

Discussion

The effectiveness of the interview process is underscored by the diverse range of experts representing various international and technologically advanced entities, including companies and universities. This diversity enriches the insights gathered and contributes to the TAS framework's overall applicability and refinement. By eliminating geographical barriers, the online interview format facilitates engagement with experts in different regions, fostering a comfortable environment for participants and promoting meaningful discussions. Constructive criticism from experts presents valuable opportunities to enhance the practical applicability of the TAS framework, leveraging their deep understanding of the research field. However, the virtual nature of the interview investigation, without a practical workshop component, imposes constraints related to spatial and time barriers. This limitation hinders the generalization of results and potentially overlooks opportunities for experts to provide additional feedback through direct interaction with the framework.

Furthermore, considerations regarding the sample size's representativeness in terms of expertise within technology transfer are pertinent. Some experts may lack familiarity with comparable artifacts, influencing the subjective nature of the feedback provided. The interpretive examination introduces an inherent bias, involving transcription and analysis of semi-structured interviews. Addressing the need for design-specific insights to enhance the appeal of the TAS framework to external stakeholders, potential avenues for exploration include conducting guided workshops focusing on design. This could provide valuable insights into the framework's attractiveness. Given the limited direct interaction of experts with the TAS framework, organizing workshops with the target group becomes crucial. Additionally, post-enhancement focus group workshops with experts may yield further valuable feedback.

6.4.4.3 Fulfillment of Requirements

The interviews were evaluated by utilizing their identified strengths and weaknesses to conduct a qualitative assessment of requirement fulfilment (Table 97, Table 98). This involved incorporating only the dimensions of strengths and weaknesses, facilitating a comparative analysis for gauging the extent to which requirements were met. While other relevant aspects were acknowledged, they were not directly linked to the identified strengths or weaknesses of the artifact. Therefore, they were not considered in this specific assessment. However, all aspects, including those not explicitly addressed, will be duly considered for the improvement and ongoing development of the artifact. It is important to note that in the field of qualitative analysis, certain elements may not be immediately considered but will be considered for thorough improvement.

Table 97: Assignment of Codes to Requirements – Strengths (Interviews - Version Two)

Strengths	Requirements	
Level 1: Advantages of the TAS		**Mentions**
Level 2: Completeness of TAS	ER_2, ER_3, UR_1, UR_2, UR_3, UR_4, UR_5	11
Level 2: Guidance & Documentation	UR_1, UR_2, UR_3, UR_5, ER_1, ER_2, ER_3, ER_4, ER_5, ER_6	4
Level 1: Helpful methods and tools		**Mentions**
Level 2: Technology Characterization	FR_2	9
Level 2: Ideation	FR_4	2
Level 2: Evaluation Criteria	FR_5	9
Level 2: Customer Understanding	FR_7	10
Level 2: Market understanding	FR_1	14

Table 98: Assignment of Codes to Requirements – Weaknesses (Interviews - Version Two)

Main Code: Weaknesses	Requirements	
Level 1: Weaknesses of the TAS		**Mentions**
Level 2: Assumption-based framework	ER_1	6
Level 2: Completeness of TAS	ER_2, ER_3, UR_1, UR_2, UR_3, UR_4, UR_5	4
Level 2: Complexity	ER_4	3
Level 2: Missing Team related aspects	ER_3	1

A score was then calculated based on the counts, indicating whether the requirement was met (Table 99), thus indicating the extent to which each requirement was met. Some requirements lacked specificity and were not evaluated, resulting in a neutral score.

Table 99: Comparison of Assigned Codes (Interviews - Version Two)

Code	Requirement	Strength (#)	Weaknesses (#)	Sum	Fulfilment
ER	**Environmental Requirements**				
ER_1	Usability	-	6	-6	-
ER_2	Comprehensibility	11	7	4	+
ER_3	Completeness	15	5	10	+
ER_4	Adequate complexity	4	3	1	+
ER_5	Efficiency	4	-	4	+
ER_6	Suitability	4	-	4	+
ER_7	Customizability	-	-	-	/
FR	**Functional Requirements**				
FR_1	Enhance market knowledge	14	-	14	+
FR_2	Enhance knowledge about technology	9	-	9	+
FR_3	Improve utilization of social capital	-	-	-	/
FR_4	Provide ideation guidance	2	-	2	+
FR_5	Evaluate applications	9	-	9	+
FR_6	Enable structured process	-	-	-	/
FR_7	Consider customers	10	-	10	+
SR	**Structural Requirements**				
SR_1	Coherence	-	-	-	
SR_2	Conciseness	-	-	-	
UR	**User Requirements**				
UR_1	Comprehensive process and method description	15	4	11	+
UR_2	Guiding poster (Canvas-like structure)	15	4	11	+
UR_3	Include supporting methods for each component	15	4	11	+
UR_4	Prioritization of components possible	11	4	7	+
UR_5	Usable without external expert guidance	15	4	11	+

Based on the comparison of strengths and weaknesses, the interviews revealed that each requirement, except the inclusion of ER_1 (Usability), has been fulfilled. Exceptions include ER_7 (Customizability), FR_3 (Improving the Utilization of Social Capital), and FR_6 (Enabling structured processes), as these were not mentioned in either the strengths or weaknesses. Thus, no assessment could be done.

While this positive assessment paints an overall favorable picture of the second version of the TAS Framework, a closer examination of the specific factors underlying each requirement is warranted. While the strengths provided a clear depiction and praised the comprehensiveness of the TAS Framework—especially in terms of integrating all relevant steps, providing documentation capabilities, and offering a straightforward guide to enhance understanding—the accompanying weaknesses shed light on a different focus. A significant critique revolved around interviewees perceiving the TAS Framework as assumption-based, casting doubt on its practical applicability. However, it was emphasized that the framework can still deliver substantial value in an educational context. Additionally, interviewees expressed uncertainty about their ability to assess the completeness of the TAS Framework based solely on the introduction provided during the interview, highlighting the need for practical application for a more accurate evaluation. This uncertainty extended to the perceived complexity, which was challenging to gauge through this evaluation form.

Nevertheless, these points were classified as weaknesses, as, conversely, other interviewees emphasized these aspects—adequate complexity and completeness—indicating that an assessment is possible, and the respondents should negatively interpret these aspects. Another aspect associated with ER_3 is the "Missing Team-related Aspects." As the interview analysis revealed, considerable attention was paid to the team aspect despite not being a TAS Framework component. Consequently, the absence of team-related considerations was perceived as a negative aspect. The analysis of interviews also suggested the integration of this team dimension.

6.4.5 Conclusion

Following an analysis of Design Cycle 1, the second cycle began with a review and discussion of the evaluation analysis of EE1. The aim was to determine which insights and findings should be incorporated into TAS Version Two. This process involved translating these insights into actionable items, which were then discussed with a second researcher. In addition to deciding to adjust the TAS Framework with these formulated action items, extensive research in Technology Characterization to improve and reconstruct Phase 1 was conducted. Further research was conducted in Technology Assessment as feedback highlighted limitations and perceived complexity of the technology in application fields.

Furthermore, adjustments were made to the evaluation criteria based on further research to align them with technology-based concepts. These findings and the corresponding action items were subsequently integrated into Version Two of the TAS Framework. TAS Framework version two underwent evaluation in a total of five field experiments. The setting mirrored that of EE1, with two experiments involving collaboration with researchers. While not part of the teams, these researchers provided their technology for the teams to develop their ideas. They were consistently available for technical inquiries to ensure a comprehensive understanding of the technology. Feedback gathered from both researchers after completion indicated a highly positive sentiment. Some applications are being pursued internally, and additional collaborations with colleagues' technologies are planned. The field experiments were evaluated quantitatively and qualitatively, using the same survey as in EE1 to enable comparability. Furthermore, interviews were conducted with 15 stakeholders from the Technology Transfer Management sector to derive practical areas for improvement for the TAS Framework. The results from the survey and interviews were applied to the requirements to estimate their fulfilment.

Moreover, additional improvement potentials were identified for implementation in Version three. Overall, the examination of the final results of EE2 paints a positive picture (Table 100). Except for FR_6 (Enable structured process), the evaluation is consistently positive or neutral. The neutral evaluations pertain to ER_1 (Usability) and ER_4 (Adequate complexity). All user requirements are marked as fulfilled.

Table 100: Evaluation of the Requirements of the TAS Framework (Version Two)

Code	Requirement	Questionnaire		Interviews	Logical	Overall
ER	**Environmental Requirements**					
ER_1	Usability	4,18	+	-		o
ER_2	Comprehensibility	4,20	+	+		+
ER_3	Completeness	4,18	+	+		+
ER_4	Adequate complexity	3,96	-	+		o
ER_5	Efficiency	4,18	+	+		+
ER_6	Suitability	4,02	+	+		+
ER_7	Customizability	4,11	+	/		+
FR	**Functional Requirements**					
FR_1	Enhance market knowledge	4,04	+	+		+
FR_2	Enhance knowledge about technology	4,16	+	+		+
FR_3	Improve utilization of social capital	4,08	+	/		+
FR_4	Provide ideation guidance	4,16	+	+		+
FR_5	Evaluate applications	4,35	+	+		+
FR_6	Enable structured process	3,96	-	/		-
FR_7	Consider customers	4,33	+	+		+
SR	**Structural Requirements**					
SR_1	Coherence				+	+
SR_2	Conciseness				+	+
UR	**User Requirements**					
UR_1	Comprehensive process and method description			+		+
UR_2	Guiding poster (Canvas-like structure)			+		+
UR_3	Include supporting methods for each component			+		+
UR_4	Prioritization of components possible			+		+
UR_5	Usable without external expert guidance			+		+

Comparing the outcomes of EE1 and EE2 highlights a noteworthy enhancement with Version Two (Table 101). ER_7, FR_2, FR_3, and UR_4 are now noted as fulfilled prerequisites. Furthermore, ER_3, ER_5, ER_6, and FR_7 have advanced from neutral to fulfilled requirements. Conversely, FR_6 transformed from fulfilled to unfulfilled, and ER_1 and ER_4 received inferior evaluations in this assessment episode compared to the previous one. Accordingly, the upcoming design cycle should emphasize these aspects to fulfil the specified requirements.

Table 101: Evaluation of the Requirements of the TAS Framework (Version One vs. Version Two)

Code	Requirement	Questionnaire		Interviews		*Logical*	Overall	
ER	**Environmental Requirements**	**Version One**	**Version Two**	**Version One**	**Version Two**		**Version One**	**Version Two**
ER_1	Usability	+	+	+	-		+	o
ER_2	Comprehensibility	+	+	+	+		+	+
ER_3	Completeness	-	+	+	+		o	+
ER_4	Adequate complexity	+	-	+	+		+	o
ER_5	Efficiency	-	+	+	+		o	+
ER_6	Suitability	-	+	+	+		o	+
ER_7	Customizability	-	+	-	/		-	+
FR	**Functional Requirements**							
FR_1	Enhance market knowledge	+	+	+	+		+	+
FR_2	Enhance knowledge about technology	-	+	-	+		-	+
FR_3	Improve utilization of social capital	-	+	o	/		-	+
FR_4	Provide ideation guidance	+	+	+	+		+	+
FR_5	Evaluate applications	+	+	+	+		+	+
FR_6	Enable structured process	+	-	+	/		+	-
FR_7	Consider customers	+	+	-	+		o	+
SR	**Structural Requirements**							
SR_1	Coherence					+	+	+
SR_2	Conciseness					+	+	+
UR	**User Requirements**							
UR_1	Comprehensive process and method description			+	+		+	+
UR_2	Guiding poster (Canvas-like structure)			+	+		+	+
UR_3	Include supporting methods for each component			+	+		+	+
UR_4	Prioritization of components possible			-	+		-	+
UR_5	Usable without external expert guidance			+	+		+	+

The interviews conducted in EE2 with stakeholders in the field of Technology Transfer Management provided a practical perspective on the TAS Framework and critically examined areas of potential improvement. The analysis of the interviews revealed numerous specific potentials in each phase but also uncovered challenges in the realm of technology transfer and the TAS framework. It reassessed the target audience as well. While the initial target group of researchers was reaffirmed (with 5 out of 15 respondents), start-ups and universities were notably identified as crucial target groups (with six mentions each out of 15). This introduces a new perspective on the previously conducted evaluation episodes, primarily involving students, and includes them as potential users of the TAS Framework. However, it also underscores that focusing on researchers and nascent spin-offs aligns with the TAS Framework's development and objectives. Furthermore, the interviews have introduced new aspects of the design development that were not previously considered. The team level, in particular, was frequently mentioned in the interviews, emphasizing the need for its integration into the TAS Framework. The workshop design itself was also revisited and critiqued. Moreover, criticism was directed at the TAS Framework from the perspective of technology transfer managers, asserting that it relies on assumptions and is impractical for real-world applications. Additionally, concerns about its resource-intensive nature were raised, making it impractical for day-to-day business. Contrary to this, the interviews confirmed the completeness of the TAS Framework, attributed it with good guidance and comprehensibility, and saw it as adequate for the underlying task.

An essential point highlighted in the interviews was the necessity of User Experience, particularly in terms of usability and design, to motivate users to engage with the TAS Framework. Therefore, the findings from the interviews and the open-text scale in the survey need to be analyzed and reflected upon to derive suggestions for the development of Version Three of the TAS Framework. According to the interview findings, particular emphasis should be placed on the UX perspective, which also aligns with the overall goal of the TAS Framework to be used autonomously in order to be useful for researchers.

6.5 Design Cycle 3

Based on the preceding design cycle, it was observed that the framework aligns well with the requirements. However, a crucial aspect is the User Experience (UX), particularly considering the target group's limited experience with such formats and artifacts and their limited awareness of their utility. Therefore, ensuring a highly effective UX is essential to make the TAS Framework applicable and appealing to the target audience. It is crucial to contextualize the TAS Framework, given its development over two design cycles, to assist researchers in identifying technology applications. The primary challenge is guaranteeing that the artifact is compelling from the outset for effective utilization. Lack of persuasiveness and researcher awareness might result in the artifact being perceived as less valuable, leading to neglection of usage or dissatisfaction. Hence, alongside persuasion and marketing efforts, an optimal UX is of paramount importance. Neglecting a user-centric perspective could result in an artifact that ultimately adds no value to users or even discourages them from using the framework. Such products can cause frustration and dissatisfaction among users, which may lead them to stop using the product (Abras, Maloney-Krichmar, & Preece; Jordan, 1998). It is therefore vital to put the user at the center of development considerations and strike a balance between content refinement and practical usability.

6.5.1 Problem Awareness

The previous evaluation episode, besides the survey to test the fulfilment of the specified requirements, focused on potential improvements within the TAS Framework. Interviews with technology transfer experts provided a practical perspective on the TAS Framework to improve its applicability and practicality, and the general findings have already been highlighted in the evaluation of the second design cycle. The following discussion reiterates the specific improvement factors identified for each phase, and actionable items are derived for improvement and organized into categories. Hence, a comprehensive overview is provided for each phase.

Phase 1

The evaluation of Phase 1 of the TAS Framework has identified a number of areas for improvement, covering various aspects of the process. A fundamental theme is the emphasis on process efficiency and structure. Recommendations include streamlining the process to avoid excessive effort, adopting a more structured waterfall approach, and advocating against spending too much time on this phase, highlighting the need for a balanced and efficient workflow. Ideation and creativity play a crucial role, with suggestions to incorporate brainstorming from a pool of experts and to proactively envision the end result. Recognizing the role of the facilitator in priming ideation thinking these recommendations aim to stimulate a more creative exploration of potential application areas. Therefore, external perspectives and insights are considered invaluable. The inclusion of external viewpoints, achieved by researching existing technical competitors and conducting interviews, is suggested to provide a richer understanding of the technological landscape.

Documentation and detail are also highlighted, with the importance of including specific details, such as financial resources, and separately describing potential aspects that may be overlooked. A renaming of “function” to “functionalities” is suggested to motivate deeper and more detailed information. Consideration of the technology description and terminology is recommended, urging against limiting it to a single sentence and emphasizing the need to address issues related to the technology itself by clarifying the term “problem”. A category focusing on risk and improving the assessment suggests introducing an open space box for “risks” to improve the assessment process and emphasizing the inclusion of assumptions. This will ensure a comprehensive evaluation that anticipates potential challenges and risks.

Collaboration and redundancy are also addressed by cautioning against collaborating with those who filed the patent, as this may involve redundant efforts. This recommendation emphasizes the use of existing prior art to streamline the process. Consideration of alternatives is recommended, particularly in the state-of-the-art phase. The suggestion is to explore “alternative technologies” rather than just applications, encouraging a broader and more innovative perspective. Finally, the importance of time management and individual preferences is recognized. Recognizing that some may prefer to skip this phase, it is emphasized that the process should be efficient and accommodate different working styles.

Table 102: Improvement Areas for Phase 1 Derived from EE2

Phase	Code	Action Item	Description
Phase 1	**Add Interview Instruction**	Contact inventor	Collaborating with those who have filed for the patent involves redundant efforts, as the groundwork has already been completed by them.
Phase 1	**Add further tools/options**	Ideation with experts	Consider incorporating brainstorming from an expert pool to explore potential areas where the technology could be beneficial.
Phase 1	**Add further tools/options**	Add solution outlook	Proactively envisioning the end success is nessential rather than solely focusing on the problem.
Phase 1	**Add further tools/options**	Screen close patents	Exploring existing patents and technical competitors, and seeking external perspectives through interviews, can provide valuable insights.
Phase 1	**Add Interview Instruction**	Add practical insights	Separately describing the potential is an overlooked aspect that needs attention.
Phase 1	**Add further tools/options**	Add potential	In the 'State of the Art,' considering 'alternative technologies' rather than just applications could be beneficial.
Phase 1	**Add further tools/options**	Add "alternative technologies"	It appears that the evaluation involves loosely interconnected aspects, requiring thorough brainstorming for a successful follow-up process.
Phase 1	**Guidance and explanations**	Show relation between factors	The moderator can prime ideation thinking in this phase to stimulate creative exploration.
Phase 1	**Guidance and explanations**	Include in instructions the importance	Specific details such as financial resources should be included while acknowledging them as assumptions or hypotheses.
Phase 1	**Guidance and explanations**	Trigger creative thinking	The process could be streamlined to avoid excessive effort for generating a single sentence.
Phase 1	**Guidance and explanations**	Integrate more factors; make sure everything is hypothesis based	Introducing an open space box for 'Risks' with the question "where can it go?/why could it fail?" could enhance the evaluation.
Phase 1	**Modify criteria**	Shorten TC	Adopting a more structured waterfall approach, rather than filling in random boxes, may improve efficiency.
Phase 1	**Modify criteria**	Add risk box	The technology description should not be limited to one sentence, depending on its complexity.
Phase 1	**Modify criteria**	Redesign TC	Some individuals might prefer to skip this phase, emphasizing the importance of not spending excessive time on it.
Phase 1	**Modify criteria**	Extend short description of technology	Additionally, incorporating assumptions and clarifying the term 'Problem' in Phase 1 to address issues related to the technology itself.
Phase 1	**Modularity**	Integrate modularity	Renaming 'Function' to 'Functionalities' can motivate individuals to delve deeper and provide more detailed information.
Phase 1	**Set time limit**	Set time limit	Not spending too much time on this phase
Phase 1	**Modify criteria**	Specify description factor problem	Term 'Problem' does not really implicate problems being solves rather than problems of the technology itself
Phase 1	**Modify criteria**	Change function to functionalities	Changing the name 'Function' in 'Functionalities' as it motivates the people to dig deeper and be more detailed

Phase 2

In the dynamic landscape of technology assessment and solution ideation, certain key improvement factors have been identified for Phase 2 of the TAS Framework: Engaging in real-life discussions with technology experts, fostering dynamic interactions and allowing for potential deviations from structured processes. Early consideration in this phase is suggested to identify technologies that the application could replace, providing a proactive approach to technology exploration. Encouraging consideration of trends during the ideation phase is highlighted as a means of stimulating creativity and innovative thinking. It is also seen as crucial to address potential challenges where team members lack consistent knowledge of ideation anchors, and measures to promote mutual understanding are recommended. Caution is also advised against superficial use of the Gartner Hype Cycle, emphasizing the need for a nuanced and strategic approach to industry analysis tools. Exploring both ISIC industry analysis and assessing potential industry impact is suggested for a more holistic understanding of the technology landscape. To ensure optimal outcomes, extensive pre- and post-work preparation is advocated at this stage, recognizing the importance of a well-prepared ideation process. A balance between creativity and clarity is essential, emphasizing that idea anchors should encourage creative thinking without being too obvious. Suggestions include documenting team brainstorming for clarity, using tools such as PERCIPIO to check trend associations, and replacing “originality” with “impact” in matrices for better strategic alignment. The terminology used should be consistent with the phase's focus on potential applications. Addressing gaps in the overall impact analysis and adopting a customized Gartner Hype Cycle for technology-specific insights are critical steps. In addition, incorporating “user opportunities/needs” as a key anchor for a user-centric approach is recommended. In addition, the inclusion of “user opportunities/needs” as a central anchor is recommended for a user-centered approach. Anchors for radical changes in the technological landscape should be considered, and there is an emphasis on clarity in the sequence of steps to streamline the ideation process. Overall, a structured sequence of steps is considered essential for success in Phase 2 of the TAS framework.

Table 103: Improvement Areas for Phase 2 Derived from EE2

Phase	Code	Action Item	Description
Phase 2	**Add Interview Instruction**	Contact technology experts	Consider engaging in discussions with technology experts during real-life scenarios, allowing for potential deviations from structured processes.
Phase 2	**Integrate ideation methods**	integrate technology screening	Suggest an early examination in this phase to identify potential technologies that the application could replace.
Phase 2	**Integrate ideation methods**	Integrate trend screening	Encourage the consideration of trends during the ideation phase as a means to stimulate creativity.
Phase 2	**Guidance and explanations**	Enable mutual understanding of anchors	Highlight the potential challenges when team members lack uniform knowledge about ideation anchors, and suggest measures to foster a mutual understanding.
Phase 2	**Guidance and explanations**	Include in instructions the caution	Caution on the usage of the Gartner Hype Cycle due to its superficial nature.
Phase 2	**Guidance and explanations**	Include in instructions the impact factor	Recommend exploring both industry analysis (ISIC) and assessing the potential impact of industry areas.
Phase 2	**Guidance and explanations**	Include in instructions to take time	Propose considerable preparation before and after working in this phase for achieving better results.
Phase 2	**Guidance and explanations**	Trigger creative thinking	Emphasize the importance of ensuring that idea anchors encourage creative thinking without being overly obvious.
Phase 2	**Guidance and explanations**	Enable documentation for ideation	Suggest documenting how team members collectively engage in brainstorming for clarity.
Phase 2	**Integrate ideation methods**	Integrate trend screening	Recommend using the tool PERCIPIO, incurring costs, to check trends associated with idea anchors.
Phase 2	**Change terms**	Exchange How-Wow-Now-Ciao descriptions	Propose replacing 'Originality' with 'Impact' in the How-Wow-Now-Ciao Matrix.
Phase 2	**Change terms**	Rethink term ideation	Note that the term "Ideate" may not entirely match the focus of this phase, which centers more on potential application areas.
Phase 2	**Guidance and explanations**	Indicate impact of idea anchors	Highlight the observed gap in the overall impact analysis of idea anchors and their potential implications in different areas.
Phase 2	**Guidance and explanations**	Include in instructions the caution	Advocate for choosing a more specific Gartner Hype Cycle tailored to the specific technology in consideration.
Phase 2	**Integrate ideation methods**	integrate User opportunities/ needs in environment	Suggest adding 'user opportunities/needs in the environment' as an additional idea anchor.
Phase 2	**Integrate ideation methods**	Integrate trend screening	Propose an additional idea anchor focused on radical changes in recent months that could influence idea generation, such as political or economic shifts (e.g., COVID).
Phase 2	**Integrate guidance of step**	Set clear guidance of steps	Highlight the lack of clarity regarding the order in which to work through the steps in this phase.
Phase 2	**Integrate guidance of step**	Set clear guidance of steps	Acknowledge the substantial work to be done in this phase, emphasizing the need for a clearer understanding of the sequence in which steps should be executed.

Phase 3

In Phase 3 of the TAS Framework, a number of comprehensive suggestions have been made to refine and improve the evaluation process. First and foremost, there is a call for thoughtful consideration of team composition, assessing the adaptability of established criteria based on the different roles within the team, including researchers and industry experts with high levels of expertise. There is a strong emphasis on promoting diversity of expertise by cautioning against the exclusive inclusion of experts from the same domain. This recommendation aims to mitigate bias and encourage a diversity of perspectives, thereby enhancing the robustness of the evaluation. Recognizing the dynamic nature of ideation, the framework proposes the introduction of options, allowing teams to continue their current path or to explore alternative ideas (Plan A, Plan B and Plan C). Clarity is seen as essential in the decision matrix, leading to the specification of recommended inputs such as interviews and engagement with a pool of experts. Recognizing the practical challenges of generating a significant number of ideas, a pragmatic approach is proposed that recognizes the ambitious nature of idea generation in the real-world application context. To enhance visualization and understanding, the framework introduces the concept of idea sketching for each evaluated concept, considering the different imaginations and perceptions within the team. Customization and adaptability are encouraged through the addition of company-specific evaluation metrics, accompanied by thorough documentation of the rationale behind decisions. New criteria, including the assessment of the “size of the problem” and the “novelty of the application”, are proposed to add depth to the evaluation process and ensure a comprehensive exploration. The challenges associated with the evaluation criteria, particularly in areas such as “resources” and “viability”, are highlighted, and evaluators are urged to navigate these complexities with care. Risk assessment strategies, such as the use of Failure Mode and Effect Analysis (FMEA), are suggested to provide a systematic approach to anticipating and managing potential challenges. A user-centered approach is advocated through the introduction of “user attractiveness”, which focuses the evaluation process on the needs and preferences of end users. The central role of the “customer” criterion is emphasized, and evaluators are urged to give it significantly more weight in practice, reflecting its critical influence on the success of the application. By recognizing the relative importance of “application novelty” compared to “technical feasibility” in the context of customer perception, the framework positions novelty as a critical factor in evaluation. Finally, the proposals express an interest in a comparative analysis of the evaluation criteria with other methods to ensure a comprehensive exploration of potential business opportunities. Taken together, these recommendations aim to enrich and refine the evaluation process, promoting a more robust and effective Phase 3 within the TAS framework.

Table 104: Improvement Areas for Phase 3 Derived from EE2

Phase	Code	Action Item	Description
Phase 3	**Modify criteria**	Modify evaluation criteria based on target group	Considering whether the evaluation criteria need adaptation based on team constellations, particularly if participants are researchers or industry experts with high knowledge.
Phase 3	**Add Interview Instruction**	More diverse experts	Avoiding inclusion of experts solely from the same area to prevent a strong bias towards pre-existing notions.
Phase 3	**Guidance and explanations**	Option to work on further ideas	Offering the option to continue working on or decide on alternative ideas (Plan A, Plan B, Plan C).
Phase 3	**Guidance and explanations**	Ensure clarity how to get insights about ideas	Clarifying the input for the decision matrix, specifying recommended inputs such as interviews, a pool of experts, etc.
Phase 3	**Guidance and explanations**	Integrate instructions for amount of ideas	Acknowledging that coming up with at least 20 ideas is ambitious and difficult to realize in real-world applications.
Phase 3	**Add further tools/options**	Let each team member design an own idea sketch	Creating an idea sketch for each evaluated idea, recognizing diverse imaginations and suggesting methods like post-it notes.
Phase 3	**Guidance and explanations**	Inform about workload	Recognizing that Phase 3 is a busy step in the process.
Phase 3	**Add further tools/options**	Integrate individual evaluation criteria	Providing the possibility to add company-specific evaluation criteria and encouraging the documentation of reasons.
Phase 3	**Add further tools/options**	Add evaluation criterion	Considering additional evaluation criteria such as the 'Size of the problem.'
Phase 3	**Add further tools/options**	Integrate validation of criteria fulfillness	Offering hints to check if the evaluation criteria are comprehensive for the specific technology being used.
Phase 3	**Modify criteria**	Difficulty of assessment of evaluation criteria	Highlighting the challenges in judging criteria like 'Resources' and 'Profitability.'
Phase 3	**Add further tools/options**	Integrate FMEA	Suggesting the use of Failure Mode and Effect Analysis (FMEA) to assess the risk of application failure and reviewing ideas in Phase 3 in case of failure.
Phase 3	**Add further tools/options**	Add evaluation criterion	Introducing an additional criterion, such as 'User Attractiveness,' to determine if there will be a potential user of the application.
Phase 3	**Modify criteria**	Enable different weighting of criteria	Stressing the importance of rating the evaluation criterion 'Customer' much higher in practice.
Phase 3	**Add further tools/options**	Add evaluation criterion	Proposing an additional criterion, 'Novelty of the Application,' as more crucial than 'Technical Feasibility,' emphasizing the novelty to the customer.
Phase 3	**Add further tools/options**	Reflect on usage of evaluation criteria	Expressing interest in comparing evaluation criteria to other methods to ensure comprehensive consideration of business opportunities.

Phase 4

Suggestions for improving Phase 4 of the TAS Framework revolve around various considerations aimed at improving customer understanding and optimizing the ideation-to-implementation process. A key recommendation is to replace the term “idea” with “solution” to align the terminology with the end product. Early customer involvement, especially during the ideation phase, is strongly advocated in order to integrate different perspectives into the solution development process. Team dynamics play a crucial role at this stage. Maintaining consistent teams throughout the process is suggested to minimize the need for explanation and ensure a more cohesive collaborative environment. In terms of customer analysis, it is recommended that a more in-depth analysis of customer segments be undertaken, using methods such as interviews, statistics and demographics to gain a comprehensive understanding. Quality planning and functional reviews are also highlighted. The use of advanced quality planning processes, particularly for promising ideas, and tools such as Failure Mode and Effect Analysis (FMEA) are recommended. In addition, it is suggested that a Functional Check Report be carried out to ensure seamless integration into the overall business processes. Decision making and involvement are emphasized. Deciding on an idea, understanding the customer and conducting an FMEA are highlighted, with the flexibility to revisit the previous phase if required. It's also recommended to involve business partners, companies, or experts in the customer analysis phase to enrich the perspectives. Involvement with the real world and customer feedback is optimized. Involving potential customers in the phase, beyond fictional steps, is encouraged to add real-world value. Working with customers who really need the product and have a budget is seen as more beneficial than focusing on potential customers who have no immediate need. The importance of gathering customer feedback and testing is optimized in the TAS Framework. In essence, these suggestions aim to refine Phase 4 of the TAS Framework by addressing terminology, team dynamics, customer analysis, quality planning, decision making, and the actual use of customer feedback.

Table 105: Improvement Areas for Phase 4 Derived from EE2

Phase	Code	Action Item	Description
Phase 4	**Change terms**	Exchange wording	Consider replacing the term 'idea' with 'solution' to align with the final solution.
Phase 4	**Add further tools/options**	Integrate customer aspect earlier	Advocate for involving the customer earlier in the process, particularly during the ideation phase.
Phase 4	**Guidance and explanations**	Ensure clarity on terms	Suggest maintaining fixed teams throughout the entire process to reduce the need for explanations and potential attachment to individual ideas.
Phase 4	**Modify criteria**	Exchange customer segments for B2B	Note that customer analysis may be more applicable to B2C rather than B2B scenarios.
Phase 4	**Guidance and explanations**	Ensure clarity how to get insights about customers	Propose conducting a deeper analysis of customer segments using interviews, statistics, and demographics.
Phase 4	**Add further tools/options**	Integrate FMEA	Recommend implementing an advanced quality planning process (APQP), particularly for the most interesting ideas, using tools like FMEA.
Phase 4	**Add further tools/options**	Integrate Functional Check Report	Suggest conducting a Functional Check Report to ensure the application fits into the company's feeding line.
Phase 4	**Add further tools/options**	Integrate FMEA	Emphasize the importance of deciding on an idea, understanding the customer, and conducting FMEA, with the option to go back to the previous phase if necessary.
Phase 4	**Add further tools/options**	Add industry partners	Recommend including business partners, companies, or experts in the customer analysis phase.
Phase 4	**Guidance and explanations**	Ensure clarity how to get insights about customers	Stress the importance of involving the potential customer in the phase, going beyond fictional steps to gain real-world value.
Phase 4	**Guidance and explanations**	Ensure clarity how to get insights about customers	Highlight the significance of going out and talking to customers who genuinely need the product and have a budget, rather than engaging with potential customers with no immediate need.
Phase 4	**Guidance and explanations**	Ensure clarity how to get insights about customers	Emphasize the crucial role of gathering feedback from customers and testing in the Technology Assessment and Selection (TAS) process.

Phase 5

In refining Phase 5 within the TAS Framework, several strategic considerations are suggested to optimize the outcome and streamline the process. The primary recommendation is to place the value proposition statement in the output zone rather than the trend assessment. Trends, it is argued, do not add significantly to the refinement of the idea, and could be more effectively used in an earlier stage, such as Phase 2, where landscape exploration takes place and provides valuable inspiration. The use of PESTEL analysis, although valuable in earlier stages, is suggested to be omitted from this step, in order to streamline the information and make the process more focused and efficient. It is recognized that the assessment in this step involves a considerable amount of information, emphasizing the need for careful management of resources. Critically, trends in this step are seen as time consuming and of little value. It is suggested that trends should be replaced by a focus on exploring technologies related to technology anticipation, favoring the Technology Radar over the Trend Radar. The subjective nature of the assessments in this step is highlighted, and a cautious approach is suggested. Adding an assessment of whether the outcome forms a robust business model, possibly using tools such as the Business Model Canvas, is recommended for a more comprehensive analysis. To sharpen the idea, a key suggestion is to go out into the field to get customer feedback through interviews, adding a valuable real-world dimension that is currently missing from this step. There is also a recommendation to link to the value proposition statement canvas for clarity, similar to developing a business model. It is suggested that the completion of the Trend Radar should be more comprehensive, including aspects such as cost planning and minimal prototyping for a more holistic perspective. A specific tool, PERCIPIO, is recommended for conducting a trend assessment. The importance of considering the presentation of results is emphasized, with a warning not to overwhelm stakeholders with too much information. View competitors not as adversaries but as potential technology collaborators, suggesting a shift to an earlier stage, such as Phase 4. Including more details about the idea, such as design decisions or general choices made, is suggested to enrich the outcome. It is suggested that financial feasibility should be considered before engaging with accelerators or investors. The integration of the Technology-Task-Fit method into the process is advocated as a strategic enhancement for Phase 5. These suggestions from the interviewees collectively aim to refine and optimize the outcome of the TAS framework in Phase 5.

Table 106: Improvement Areas for Phase 5 Derived from EE2

Phase	Code	Action Item	Description
Phase 5	**Modify criteria**	Output Zone needs to be modificated	In the Output zone, the value proposition statement should be placed, not the trend assessment.
Phase 5	**Add further tools/options**	Delete trend screening	Trends do not contribute to the sharpening of the idea; it would be more beneficial in an earlier phase, for example, in Phase 2, where landscape exploration occurs, providing inspiration.
Phase 5	**Add further tools/options**	Delete trend screening	The use of the PESTEL Analysis is recommended in earlier phases, but it is omitted from this step.
Phase 5	**Guidance and explanations**	Inform about workload	There is a considerable amount of information in this step.
Phase 5	**Add further tools/options**	Delete trend screening	Trends do not bring value to this step and consume too much time.
Phase 5	**Add further tools/options**	Exchange trend with technology screening	Consider replacing trends with an exploration of technology anticipation-related technologies, favoring the technology radar over the trend radar.
Phase 5	**Guidance and explanations**	Ensure clarity how to get insights about market	Exercise caution as the assessment in this step can be very subjective.
Phase 5	**Add further tools/options**	Add Business Model Canvas	Consider adding an assessment of whether the outcome forms a good business model, possibly by incorporating tools like the business model canvas.
Phase 5	**Add Interview Instruction**	Add practical insights	The idea can be sharpened by going out and obtaining customer feedback through interviews, which is currently missing.
Phase 5	**Guidance and explanations**	Integrate explanations	Suggest adding a link to the value proposition statement canvas for clarity on its meaning, akin to developing a business model.
Phase 5	**Add further tools/options**	Delete trend screening	Propose providing additional information on filling in the Trend Radar, recognizing varying interpretations.
Phase 5	**Add further tools/options**	Add Financing and prototyping	Suggest incorporating aspects such as cost planning and minimal prototyping in this step.
Phase 5	**Integrate ideation methods**	Integrate trend screening	Recommend conducting a trend assessment using the tool PERCIPIO.
Phase 5	**Guidance and explanations**	Ensure participants can present findings in adequat way	It is crucial to consider the presentation of the outcome, avoiding overwhelming stakeholders with excessive information.
Phase 5	**Modify criteria**	Switch Phase 4 and 5	View competitors as potential business partners in technology collaboration, making it part of an earlier phase, such as Phase 4, instead of setting a trend.
Phase 5	**Add further tools/options**	Integrate decision collection	Bring out more details about the idea, including design decisions or general decisions made, in this step.
Phase 5	**Add further tools/options**	Integrate financial thinking	Before engaging with accelerators or investors, contemplate the financial feasibility.
Phase 5	**Add further tools/options**	Integrate Technology-Task-Fit Method	Integrate the Technology-Task-Fit Method into the process.

The specific action items were discussed within the recommendations during three iterative sessions involving four researchers, aiming to assess which ones should be incorporated into the development of the subsequent artifact and to establish the methodology for implementing this integration.

6.5.2 Suggestion

Focusing on possible solutions for a revised and improved artifact, two different data collections were used to propose the design of the TAS framework. Firstly, the expert interviews discussed earlier, which were derived from the second design cycle. Secondly, a focus group workshop was conducted. This workshop focused on the design and improvement of the UX of the current TAS Framework.

6.5.2.1 Suggestions from Expert Interviews of Design Cycle Two

The improvement areas identified in EE2 by means of the expert interviews, translated into action items, undergo reflection during the suggestion phase of the third design cycle. These recommendations collectively aim to refine the TAS framework, ensuring it becomes more user-centric, efficient, and aligned with user expectations and requirements. Given the recognized action items, a comprehensive reflection on the background and implications of each was conducted. Collaborative discussions were initiated with a total of four researchers, spanning three iterative sessions. This process aimed to delve into design decisions, identify further actions for valuable items, and assign a "no action" status to others. The reflection results are presented in Table 107.

Table 107: Reflection Results of the Expert Interviews for Improving the TAS Framework

Phase	Code	Action Item	Reflection	Design Decision
Phase 1	**Add Interview Instruction**	Add practical insights	Should be integrated in TAS Framework.	Integrate in Canvas
Phase 1	**Add further tools/options**	Add potential	Should be integrated in TAS Framework.	Integrate in Canvas
Phase 1	**Add further tools/options**	Add "alternative technologies"	Should be integrated in TAS Framework.	Integrate in Canvas
Phase 1	**Guidance and explanations**	Integrate more factors; make sure everything is hypothesis based	Should be integrated in TAS Framework.	Integrate in Canvas
Phase 1	**Modify criteria**	Add risk box	Should be integrated in TAS Framework.	Integrate in Canvas
Phase 1	**Modify criteria**	Extend short description of technology	Should be integrated in TAS Framework.	Integrate in Canvas
Phase 1	**Set time limit**	Set time limit	Should be integrated in TAS Framework.	Integrate in Canvas
Phase 1	**Modify criteria**	Specify description factor problem	Should be integrated in TAS Framework.	Integrate in Canvas
Phase 1	**Modify criteria**	Change function to functionalities	The term "function" is selected as "functionalities" narrows down the scope.	Integrate in Canvas
Phase 2	**Guidance and explanations**	Enable documentation for ideation	Should be integrated in TAS Framework.	Integrate in Canvas
Phase 2	**Integrate ideation methods**	Integrate trend screening	Should be integrated in TAS Framework.	Integrate in Canvas
Phase 2	**Integrate guidance of step**	Set clear guidance of steps	Should be integrated in TAS Framework.	Integrate in Canvas
Phase 2	**Integrate guidance of step**	Set clear guidance of steps	Should be integrated in TAS Framework.	Integrate in Canvas
Phase 3	**Add Interview Instruction**	More diverse experts	Should be integrated in TAS Framework.	Integrate in Canvas
Phase 3	**Guidance and explanations**	Option to work on further ideas	Should be integrated in TAS Framework.	Integrate in canvas
Phase 3	**Guidance and explanations**	Ensure clarity how to get insights about ideas	Should be integrated in TAS Framework.	Integrate in Canvas
Phase 3	**Add further tools/options**	Add evaluation criterion	Should be integrated in TAS Framework.	Integrate in Canvas
Phase 4	**Change terms**	Exchange wording	Should be integrated in TAS Framework.	Integrate in Canvas
Phase 4	**Guidance and explanations**	Ensure clarity how to get insights about customers	Should be noted in Manual.	Integrate in Canvas
Phase 5	**Add further tools/options**	Delete trend screening	Transfer trends in Phase 2.	Integrate in Canvas
Phase 5	**Add further tools/options**	Delete trend screening	Transfer trends in Phase 2.	Integrate in Canvas
Phase 5	**Add further tools/options**	Delete trend screening	Transfer trends in Phase 2.	Integrate in Canvas
Phase 5	**Add further tools/options**	Add Business Model Canvas	Recommondation to follow up with BMC should be integrated.	Integrate in Canvas
Phase 5	**Add Interview Instruction**	Add practical insights	Should be integrated in TAS Framework.	Integrate in Canvas
Phase 5	**Guidance and explanations**	Integrate explanations	Recommondation to follow up with BMC should be integrated.	Integrate in Canvas
Phase 5	**Add further tools/options**	Delete trend screening	Transfer trends in Phase 2.	Integrate in Canvas
Phase 5	**Add further tools/options**	Integrate financial thinking	Recommondation to follow up with BMC should be integrated.	Integrate in Canvas
Phase 5	**Add further tools/options**	Integrate Technology-Task-Fit Method	Should be integrated in TAS Framework.	Integrate in Canvas

6.5.2.2 Improvement of the UX of the TAS Framework

As the third design cycle focuses not only on content improvement, taking into account the suggestions derived from the evaluation of the second design cycle, but also on the UX of the TAS framework, it is first necessary to define the essential key terms. To ensure a strong UX in the further development of the TAS Framework, the concept of the HCD process is introduced, which will be used in combination with the DSR approach.

Usability

Usability is a central concept in the design process and used to be derived from the human-computer interaction field (Soares, Rebelo, & Ahram, 2022). It aims to make applications as simple as possible to use by making them intuitive and user-friendly (Jacobsen & Meyer, 2019). The International Organization for Standardization (ISO) standard describes usability as the "extent to which a system, product or service can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use" (ISO 9241-11, 1988). Regarding the definition, a high level of usability is achieved when the system is appropriate in terms of effectiveness, efficiency, and satisfaction. In this context, effectiveness means that users achieve their goals with accuracy and completeness (ISO 9241-11, 1988). Efficiency, on the other hand, refers to the ratio of resources expended to the goals achieved, while also providing comfort and acceptance for the use of the product for satisfaction (ISO 9241-11, 1988).

According to Richter and Flückiger (2016), usability is understood as a quality criterion for designing an interface. This includes for example the arrangement of control elements, the number of necessary clicks, and the understandability of the displayed information (Richter & Flückiger, 2016). The authors believe that the usability of a system must be assessed in the context of its use. It stands for how well a user could use this tool in its environment to accomplish its tasks (Richter & Flückiger, 2016). So, the designed application or system must be adapted to the user's world in its context of use. To determine whether the user has been able to accomplish their goals and tasks, there must be a coherent interface design and suitable functions to achieve them (Richter & Flückiger, 2016).

Jacobsen and Meyer (2019) point out that good usability is often not explicitly noticed, it is the poor that stands out. In the past, many products were designed with less focus on the user, leading to user frustration and wasted time due to poor usability (Soares et al., 2022). It is essential to place usability as a top priority when designing the interface for the TAS framework, both to facilitate its use and to avoid discouraging users. Although many points relate to the design of digital interfaces, these concepts can still be transferred to the design of analog media such as the TAS framework, which is also used in digital interfaces, by integrating it in digital collaboration spaces like Mural (Finner & Manthey, 2023). This can help users to understand and use the framework more easily, promoting effectiveness and serving as a motivational factor. The potential outcome can lead to a reduction of errors, ultimately increasing the overall productivity of the framework.

User Experience

In the context of usability, the idea of UX is also mentioned. UX extends the concept of usability by emphasizing the creation of an exceptional user experience (Soares et al., 2022). Generally, it is described as the users' overall experience when interacting with a system (Jacobsen & Meyer, 2019). The ISO standard encompasses the usability concept by a "person's perceptions and responses resulting from the use and/or anticipated use of a product, system, or service" (ISO 9241-210, 2010). It includes the user's complete behavioral experience before, during, and after the use of the product, system, or service.

The goal of UX is to create an overall experience with a product that also encompasses emotional aspects. Ideally, users should leave an application feeling content and satisfied and, in the best case, be motivated to return to (Jacobsen & Meyer, 2019). When positive feelings of happiness are evoked, it leads to a desire to repeat positive experiences while negative ones are avoided (Moser, 2012). Jacobsen and Meyer (2019) also point out that for an optimal UX, the design, functionality, and performance features must appeal to the user on an emotional level. This is also supported by Richter and Flückiger (2016), who mention "Joy of Use" in this context. This should clarify the span of UX again, as it is much broader than just functional factors and includes emotional and aesthetic aspects. As seen in the previous outline for usability, the term UX builds upon and extends the concept of usability.

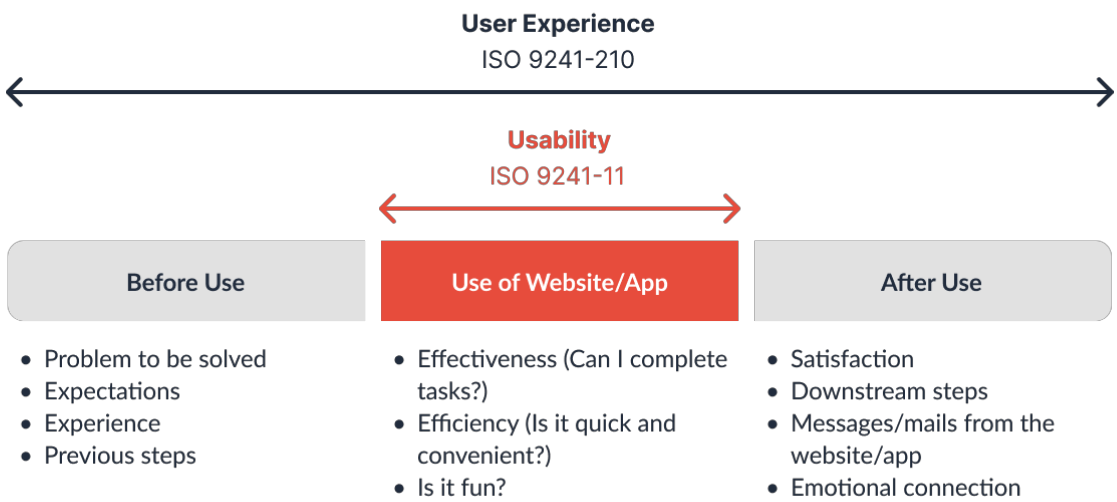

Figure 19: Usability and UX (adapted from Jacobsen & Meyer, 2019)

UX not only plays a pivotal role in enhancing customer satisfaction but also makes a valuable economic contribution, influencing customers to repurchase a product (Jiao, Zhou, & Chu, 2017; Kujala, Roto, Väänänen-Vainio-Mattila, Karapanos, & Sinnelä, 2011; Moser, 2012). By customizing products to meet customer expectations, UX contributes to increase satisfaction levels (Moser, 2012). Additionally, Moser (2012) emphasizes that satisfied customers recommend the product to others, which is a valuable marketing strategy.

Moreover, the design of the experience depends on the entire situation, since users have different expectations of their mobile phone, for example, when they use it for business or for pleasure (Moser, 2012). This can also be concluded for the redesign of the TAS framework, which is currently used in digital, as well as in printed analog format. However, both types have different requirements based on the context and environment in which they are employed. Given that the objective of this work is to enhance the UX of the TAS, these considerations should be taken into account during the redesign process

Human-Centered Design

User needs and desires must be prioritized during development to create optimal products. HCD, also known as user-centered design, is combined with the DSR methodology to ensure a user-centered perspective in the redesign of the TAS framework. It provides several guidelines, methods and artifacts for the design of a prototype and complements the DSR methodology to focus on the participants (Rauschenberger & Baeza-Yates, 2020). The process of HCD serves as a valuable tool for achieving good usability and UX (Beyer & Mentler, 2020; Maguire, 2013). It encompasses various phases in the design life cycle, with a central focus on gaining a thorough understanding of the product's intended users. As outlined by ISO 9241-210 (2010) is Human-centered design an approach to the development of interactive systems that prioritizes usability and usefulness through a focus on users, their needs and requirements, and the application of knowledge and techniques from human factors / ergonomics and usability. It supports effectiveness and efficiency, improves human welfare, user satisfaction, accessibility and sustainability, while reducing potential negative impacts on human health, safety and efficiency.

The process of the HCD adopts an iterative approach and is illustrated in Figure 20. The process begins with a deep understanding of the user, identifying the tasks they must accomplish, and comprehending the environment of the intended application (Jacobsen & Meyer, 2019; Maguire, 2013). This foundation is built upon research and investigation in the context of the product. Sometimes users can play co-creating roles through the design process and become co-designers themselves (Sanders & Stappers, 2008). It's crucial to maintain consistent user involvement during the conceptualization and implementation phases (Jacobsen & Meyer, 2019). Jacobsen and Meyer (2019) also recommend several methods for user inclusion, such as focus groups, card sorting, prototyping tests, usability tests with mockups, and click dummies. By evaluating design solutions with users, it is possible to test whether the product serves its intended purpose and uncover incorrect assumptions that may be made about user groups (Preece, Rogers, & Sharp, 2015).

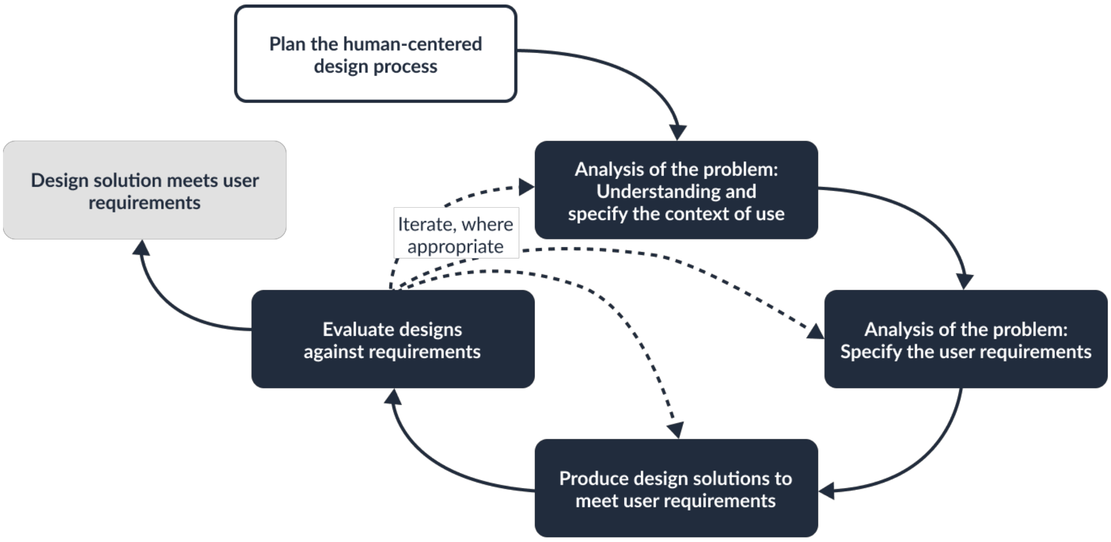

Figure 20: Overview of the HCD Process (adapted from ISO 9241-21, 2010)

Designs based on human-centered principles offer the potential for more user-friendly, efficient, and effective systems (Watson, Rusnock, Colombi, & Miller, 2017). In the context of the redesign process, DSR guides the overall development of the TAS framework, while the application of HCD ensures that the framework is truly human centered. The fusion of DSR and HCD ensures that the revised TAS framework is compelling in both theoretical rigor and practical relevance.

6.5.2.3 Focus Group Workshop

Besides the expert interviews, a focus group workshop was initiated to evaluate the TAS framework design. While the expert interviews focused on the improvement of the content and design of the TAS framework in general, a focus on the visual presentation of the content, which is crucial for the optimization of the UX, is absent. For this reason, an additional focus group workshop was initiated to evaluate the design of the TAS framework.

6.5.2.3.1 Methodology

The focus group workshop, anchored among others in the principles of the HCD process, serves as a fundamental instrument to collect data on the feedback to the TAS framework. This method is a well-suited qualitative method for exploring new ideas, perceptions, and feelings while offering deeper insights into a new or existing product (Morgan, 1997). What makes focus groups different from other qualitative data collection techniques such as observation, interviews, and questionnaire surveys is the procurement of information through group dynamics and interaction (Morgan, 1997).

In general, focus groups consist of group discussions involving five to ten people who are familiar with the subject, deliberating a defined topic under the guidance of a moderator (Jacobsen & Meyer, 2019; Krueger & Casey, 2015). The discussions are relaxed while the moderator should create a permissive environment that encourages participants to share their perceptions and points of view without putting them under pressure (Krueger & Casey, 2015). This is important to get free opinions and to know what people really think and feel (Krueger & Casey, 2015). It also provides the collection of data based on multiple viewpoints (Preece et al., 2015). Focus groups also have the best use when there is little knowledge about the target group while this is a crucial aspect in the research phase of HCD (Goodwin, 2009). Furthermore, Preece et al. (2015) stated that focus groups should take place early in the stage of the design cycle.

Even if the focus group is a suitable tool for data collection, limitations should also be considered. A significant point is that in focus groups, the moderator has less control over the data generated (Morgan, 1997). Here, the nature requires that the moderator allow interactions among participants, even if they deviate from the main topic. In addition, there is also the risk that participants join group opinions and do not express their own opinions (Jacobsen & Meyer, 2019; Preece et al., 2015). In this case, the workshop should be designed to encourage participants to reflect on their thoughts in advance (Jacobsen & Meyer, 2019).

6.5.2.3.2 Participants

In the context of the HCD process, the involvement of the user plays a central role throughout the design process. Eason (1987, as cited in Abras et al., 2004) distinguished three types of users in this context: primary users are people who use the artifact directly and regularly, secondary users use the artifact occasionally, while tertiary users are affected by the use of the artifact or make the decision about its acquisition. The workshop was conducted with six people, who have already worked with the TAS framework. Notably, one participant had to leave half an hour earlier. Participants were thus a mix of primary, secondary, and tertiary users. Among the participants, there were three students from a technological background, while the other three were research associates, specifically PhD candidates. They all had in common that they had either previously worked with the TAS framework to conceptualize ideas from existing technologies, or had been directly involved in the development of the framework itself. This prior experience was the main criterion for participants. The intention behind this was to ensure that participants could identify problem areas and opinions from their own use of the framework. Due to time constraints, this allowed the focus to be on collecting feedback on the canvases rather than on introducing and explaining the framework. In addition, all participants were informed that the data collected during the workshop would be kept confidential.

6.5.2.3.3 Process and Structure

The goal of the workshop was to identify weaknesses and strengths within the canvas design. To achieve this objective, the workshop structure was designed to facilitate engaging discussions and encourage open feedback among participants. Conducted in a seminar room at the KIT, the workshop spanned a duration of two hours. Table 108 presents the agenda of the workshop. Essential materials for the workshop included printed A3 canvases representing each phase, which were placed on a whiteboard within the seminar room. The focus group workshop was protocolled by two observers.

Table 108: Agenda of the Focus Group Workshop

Agenda	Duration
1. Introduction	~ 10 min
2. TAS Framework Overview	~ 5 min
3. Canvas Design Review	~ 75 min
a. Identification of negative aspects: What is not well realized?	~ 55 min
b. Identification of potentials: What is alredy well realized	~ 20 min
4. Brainstorming Session	~ 20 min
5. Summary & Feedback	~ 10 min

The workshop began with an introduction where participants were welcomed, and the objective of the workshop was explained. Following this, a brief overview of the TAS framework was provided to ensure all participants were familiar with the current version. During the third agenda item, participants were divided into two groups, each comprising three individuals. Each group was assigned specific phases of the TAS framework to examine weaknesses and strengths as part of the "Canvas Design Review". The first group focused on phases 1-3, while the second group concentrated on phases 4-5, with the latter limited to two phases due to their high intensity. The initial task in this agenda item involved each group identifying negative aspects of the design for their assigned phases. For this item, a 10-minute silent brainstorming session followed by a 45-minute group discussion was allocated. The brainstorming session was conducted, allowing participants to reflect on weaknesses individually. The personal thoughts were then documented on post-it notes and placed beside the designated canvas. This structured activity empowered participants to form their opinions before the influence of the group. Following this, the ensuing discussion among participants fostered additional conversation, creating an environment for collaborative feedback. Once all negative aspects for each phase had been collected, participants were instructed to repeat the exercise. This time, the focus shifted to identifying strengths and positive aspects of the design for the assigned phases. Given the emphasis on weaknesses and the relative ease of providing positive feedback, a shorter timeframe of 5 minutes was allocated for the silent brainstorming part followed by a 15-minute group discussion. Upon completion of this exercise, participants shared their insights once again with their respective groups.

In the fourth agenda item, a brainstorming session involving all participants of the workshop took place. The objective of this session was to generate various proposals for concepts and ideas for the redesign of the canvas, directly originating from the participants themselves. Drawing inspiration from the Design Studio Method (Kaplan, 2017), participants were encouraged to sketch their own ideas. Each participant received paper, pencils, and an assigned phase with a three-minute drawing window. The short amount of time was intentional for letting people get creative without getting lost in the details. Next, everyone got two minutes to share and pitch their own design. Following each presentation, the group discussed what they liked or disliked about each design. This exercise aimed to diversify the feedback process by gaining inspiration for the design from the users' perspective. Figure 21 illustrates an example of a participant's design for the first phase of the TAS framework. An overview of all results from the brainstorming session can be found in Appendix B2.

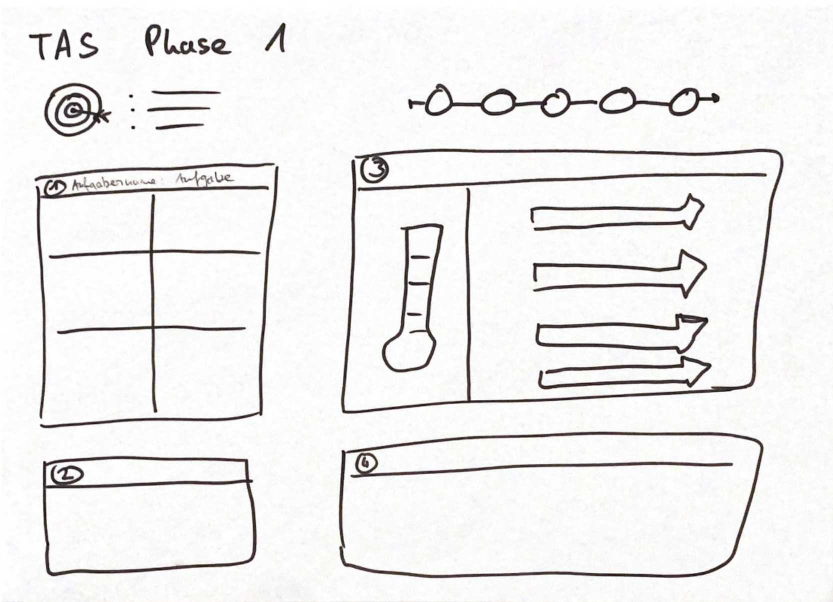

Figure 21: Exemplary Design for Phase 1 by a Participant (Illustration from the Focus Group Workshop)

Finally, the workshop concluded with a summary and feedback from each participant.

6.5.2.3.4 Focus Group Workshop Findings

A qualitative content analysis was conducted, following the method outlined in 4.2.2. In the data analysis, two researchers were involved to reduce subjectivity and ensure consistent coding. In total, 115 codes at the second sublevel, 14 codes sublevel 1, and four main codes were identified. Given the extensive number of codes sublevel 2, Table 109 only provides an overview of the detected main codes and their corresponding codes sublevel 1. In the following, the findings are presented in the context of the three code levels.

Table 109: Main Codes and Corresponding Codes Sublevel 1 from the Focus Group Workshop

Codes Sublevel 1	Main Code
Content revision Framework guidance Uncertainty about necessity of elements Wording	Improvement content
Aesthetic design Coloring Iconography Layout structure Need for better visual representation Removal of elements	Improvement design
Approval of content Approval of design	Strengths
Information overload Navigation flow	Weaknesses

Improvement Content

The "Improvement content" main code comprises four codes sublevel 1 and 25 codes sublevel 2 concepts (Table 110). Additionally, the associated phase for each concept is recorded, enabling referencing to the corresponding canvas. Overall, this main code compiles all the data gathered about the improvement of the content in the canvases.

Table 110: Codes Sublevel 1 and Corresponding Codes Sublevel 2 for the "Improvement content" Main Code

Phase	Code Sublevel 1	Code Sublevel 2
Phase 1	Preference to define first problem and then function	Content revision
Phase 1	Desire to remove ressources and life cycle	Content revision
Phase 1	Need for consistent sentence structure	Content revision
Phase 1	Desire for an explanation of the technology readiness level	Content revision
Phase 1, 2	Unclear about necessity of "To Do" section	Content revision
Phase 2, 3	Mixed feedback on time specifications	Content revision
Phase 3	Lack of personalization of the ideas	Content revision
Phase 3	People don't care about filling in the team name	Content revision
Phase 4	Desire for example on how to fill in desired outcomes with colored arrows	Content revision
Phase 4	Uncertainty about reflection questions are good or not good	Content revision
Phase 5	Difficulty and criticism regarding the PESTEL content	Content revision
Phase 5	Preference for a technology-centric approach for the PESTEL	Content revision
All	Request to enter individual names that have collaborated on the canvas	Content revision
Phase 5	Lack of guidance and context explanation	Framework guidance
Phase 5	Need for concrete next steps after the Value Proposition statement.	Framework guidance
All	Suggestion to make general intro to the phase model	Framework guidance
Phase 2	Questioning the redundancy between the reflection questions and objectives	Uncertainty about necessity of elements
Phase 3	Uncertainty about placement and necesssity of remarks	Uncertainty about necessity of elements
Phase 4	Uncertainity about necessity of reflection questions	Uncertainty about necessity of elements
Phase 4	Desire to avoid unnecessary wording	Wording
Phase 4	Confusion about "the thing" wording	Wording
Phase 4	Desire for a consistent task description	Wording
Phase 4	Concern about biased hypotheses	Wording
Phase 5	Lack of clarity about purpose of many points	Wording
Phase 5	Confusion about the terms of reference and wording for value profile	Wording

In order to improve the content, the workshop identified several issues for content revision. In relation to phase one, suggestions were made that when characterizing the technology, the problem should be defined first and then the function, also considering the removal of items such as resources and life cycle. At this stage there was also a need for a more consistent sentence structure as the sentences were structured differently. There was also a desire to explain the level of technology readiness in the task. In phase one and two, there were questions about whether it would be better to remove the to-do section, and there were different opinions about the time constraints and their usefulness. In phase three, it was noted that the ideas were no longer personalized and the team's name did not seem important to some. In phase four, there was a desire for examples of how to complete the desired outcomes, particularly in relation to the arrows presented. Participants found the reflection questions uncertain and potentially of little value. In phase five, the content of the PESTLE was criticized, with a desire for a greater focus on technological aspects. In addition, participants suggested that the names of individual contributors be added to the canvas. In terms of guidance for the framework, participants raised concerns about the guidance and contextual explanation in phase five and asked for concrete steps to be included after the final step. In general, it was suggested that a general introduction be provided for all phases. Within the framework, there were uncertainties about the necessity of certain elements, in particular the redundancy between reflection questions and objectives, as well as concerns about the placement and necessity of remarks in phase three. Regarding the use of terms, the desire was expressed not to use irrelevant or confusing wording and to maintain consistency throughout the task description. Regarding the hypotheses in phase four, it was noted that they were formulated in such a way that biased hypotheses could arise. In phase five, certain points lacked clarity due to insufficient explanation and unclear meaning.

Improvement Design

The “Improvement Design” main code consists of six codes sublevel 1 and 57 codes sublevel 2 (Table 111). The corresponding phase is also listed, where the collected feedback was remarked. This main code collects all the feedback that was made according to the visualization of the canvases. Upon improving the design, concerns about the aesthetic design of the TAS framework. Phase two revealed confusion about the visual arrangement within the canvas, particularly the dotted lines between the ideas. Phase three and five uncovered issues related to alignment within the canvas, while phase four expressed a desire for an overall consistent design, emphasizing the importance of a consistent style for fonts and lines.

Table 111: Sublevel Codes for “Improvement Design”

Phase	Code Sublevel 1	Code Sublevel 2
Phase 2	Confusion about the dotted lines between the ideas	Aesthetic design
Phase 3	Alignment issues within the canvas	Aesthetic design
Phase 4	Desire for design consistency and avoidance of mixed styles within fonts and lines	Aesthetic design
Phase 5	Allignment issues within the title and the description	Aesthetic design
Phase 1	Desire for a more uniform color scheme	Coloring
Phase 1	Desire for visual highlights	Coloring
Phase 1	Difficulty reading the gray font	Coloring
Phase 1	Desire for color psychological consideration	Coloring
Phase 2	Need for color differentiation between matrix and description	Coloring
Phase 2	Dislike of color combination of orange and red	Coloring
Phase 3	Need for color consistency based on function	Coloring
Phase 4	Desire for a consistent color scheme for task descriptions	Coloring
Phase 4	Dislike with the color scheme used in the framework	Coloring
Phase 3	Confusion about decreasing light size in point 5	Iconography
Phase 3	Too many icons causing confusion	Iconography
Phase 3	Mixed feedback on disturbing black icons and gray icons in the fields	Iconography
Phase 4	Confusion caused by pictograms not matching corresponding hypotheses	Iconography
Phase 4	Suggestion to use pictograms only if there is a recognition value	Iconography
Phase 1	Need for flexible starting points	Layout structure
Phase 1	Need for better use of space for texts	Layout structure
Phase 2	Desire for clear text placement over the HOW-WOW-NOW matrix	Layout structure
Phase 2	Desire to swap objectives and phase cycles	Layout structure
Phase 3	Suggestion to swap rows and columns in the matrix to accommodate criterias	Layout structure
Phase 3	Desire for better text positioning in decision matrix	Layout structure
Phase 4	Need for clear block associations and task structure consistency across the interface	Layout structure
Phase 4	Unclear placement of task instructions within fields	Layout structure
Phase 1	Desire to visually mark fields that are mandatory to fill in	Need for better visual representation
Phase 1	Desire for stronger distinction of elements in the second point	Need for better visual representation
Phase 1	Need for expanding the space for important fields	Need for better visual representation
Phase 1	Contradicting design for technology readiness levels and arrows	Need for better visual representation
Phase 2	Preference for single mode for graphical access	Need for better visual representation
Phase 2	Uncertainty about field size consistency	Need for better visual representation
Phase 2	Need for visual seperation of the reflection row with "To Dos" and reflection questions	Need for better visual representation
Phase 2	Need for a single and global QR code	Need for better visual representation
Phase 3	Suggestion to number ideas for better tracking among phases	Need for better visual representation
Phase 3	Unclear role of the evaluation criteria since this is an explanation and not a task	Need for better visual representation

Phase 3	Suggestion for a QR code for 1st & 2nd order criteria	Need for better visual representation
Phase 3	Confusion about time specification format	Need for better visual representation
Phase 4	Suggestion to rearrange elements	Need for better visual representation
Phase 4	Desire for a more professional layout in the persona canvas	Need for better visual representation
Phase 4	Desire for clear association of the first line in the first point	Need for better visual representation
Phase 4	Confusion about the checkboxes in the customer segment	Need for better visual representation
Phase 4	Desire for more space in core job and an example	Need for better visual representation
Phase 4	Desire for more space to fill in the hypotheses	Need for better visual representation
Phase 5	Uncertainty about where to fill out the PESTEL	Need for better visual representation
Phase 5	Difficulty finding and reading the phase overview and numbers	Need for better visual representation
Phase 5	Confusion about arrow at the end of the phase model	Need for better visual representation
Phase 1,2,3	Need that the sources field is not lost in the lower part of the canvas	Need for better visual representation
All	Desire for clear phase indicators on all canvases	Need for better visual representation
All	Dislike of space and visual representation within objectives	Need for better visual representation
Phase 1	Desire to remove unnecessary elements like non-essential icons	Removal of elements
Phase 3	Unnecessary dividing line between points 2 and 3	Removal of elements
Phase 3	Arrows can be removed with number system	Removal of elements
Phase 4	Desire to remove lamp icon	Removal of elements
All	Desire to remove the KIT logo and keep Entechnon	Removal of elements
All	Desire to remove big picture wording from all canvases	Removal of elements
All	Desire to remove the STAS title and redefine header	Removal of elements

Some issues were raised regarding the color usage in the canvases. During phase one, a desire was expressed for a consistent color scheme and the inclusion of visual highlights. In addition, the readability of the gray font was questioned. Participants emphasized the importance of considering psychological factors when choosing a new color palette. In phase two, participants criticized the lack of color differentiation between the matrix and its description. Furthermore, the combination of orange and red was not appreciated. In phase three, the need for color consistency based on function became apparent, and in phase four participants expressed a desire for a consistent color scheme for task descriptions in general. There was also a distaste for the current color scheme used in the framework. In terms of iconography, there were uncertainties in phase three regarding the decreasing size of the bulbs and the use of too many icons potentially leading to confusion. There was mixed feedback on the use of black and gray icons in the fields. Additionally, in phase four confusion was caused by pictograms not matching their corresponding hypotheses, leading to the suggestion that pictograms should only be used with recognizable values. There were also concerns regarding the layout structure. In phase one, participants expressed a desire for more flexible starting points and more efficient use of space for the text. In phase two, a clearer placement of the text in the How-Wow-Now-Ciao matrix was requested and it was proposed that the positions of objectives and phase cycles be swapped. In phase three, it was suggested to swap the rows and columns in the matrix to accommodate the criteria. Additionally, an improved text positioning within the decision matrix was requested. In phase four, the importance of clear block associations and consistent task structures throughout the canvas interface was highlighted. Negative feedback was received about the unclear placement of instruction within the fields. In addition, demands for a better visual representation were emphasized. In phase one, requests were made to visually distinguish mandatory fields, to stronger distinct elements and expand the space for important fields. Furthermore, concerns were raised about conflicting design elements in relation to the technology readiness level and arrows. Phase two emphasized the desire for a single mode for graphical access that requires a global QR code. Participants also expressed uncertainty regarding the consistency of field sizes and the need for visual separation between "To Dos" and reflection questions. In phase three, suggestions were made to implement a numbering system for the ideas. Concerns were raised about the evaluation criteria task as is it for explanatory purposes and not seen as a task. In addition, it was recommended to incorporate a QR code to enable access to the first and second order criteria and to remove confusion over the format of the timings. During phase four, several suggestions were made, including the rearrangement of elements and the request for a more professional layout of the persona canvas. Participants desired clear associations of the first task. In addition, confusion was expressed regarding the checkboxes in the customer segments, and their purpose was questioned. In the "Core Jobs" task, examples and more space were requested, as well as in the formulation of hypotheses. In phase five, participants encountered challenges in filling out the PESTLE content. Further difficulties were encountered in finding and reading the phase overview and numbering. There was also confusion about the placement of a continuous arrow within the reflection questions, as it is the last task in the phase. In general, concerns were expressed about the source field being somewhat obscured in the lower part of the canvas. Participants stated a need for phase indicators on all canvases and expressed dissatisfaction with the use of space and visuals within the objectives. Several suggestions were made regarding the removal of certain elements. In phase one, there was a desire to remove unnecessary elements, particularly non-essential icons. In phase three, participants suggested that the dividing line between the second and third tasks, as well as the arrows, should be removed. In phase four, there was an agreement to remove the lamp icon next to the phase cycles. Overall, there was a common desire to remove the KIT logo and the use of the big picture wording, while the EnTechnon logo[6] should be retained. Moreover, participants expressed a desire to remove the title and redefine the header.

Strengths

The dimension "Strengths" encompasses two codes sublevel 1 and 25 codes sublevel 2. Table 112 provides an overview of these, with the respective phase in which they were detected. In this main code, positively remarked aspects of the TAS framework were included. Positive feedback was given on various aspects of the content. In particular, the introduction of technology characterization in phase one was praised. Phase two was commended for its graphical display of the industry classification, digital "To Dos" and phase goals. During phase four, it was observed that some task headings provided work instructions, which were positively emphasized. Additionally, the placement of the central value proposition at the end of phase five was praised. In general, the contact information at the bottom of the canvas was also well received.

[6] EnTechnon is representing the institute, where the TAS Framework was developed.

Table 112: Sublevel Codes for "Strengths"

Phase	Code Sublevel 1	Code Sublevel 2
Phase 1	Positive start with the technology characterization	Approval of content
Phase 2	Positive on the second graphic of the industry classification	Approval of content
Phase 2	Appreciation for digital "To Dos"	Approval of content
Phase 2	Positive on phase goals	Approval of content
Phase 4	Positive that headline is at the same time also work instruction	Approval of content
Phase 5	Positive on central Value Proposition statement at the end	Approval of content
All	Positive to the contact information at the bottom	Approval of content
Phase 1	Clarity about the left to right flow	Approval of design
Phase 1	Positive on the color separation with bars between each points	Approval of design
Phase 1	Appreciation for uniform representation (3 points, objectives and icons should be kept)	Approval of design
Phase 1	Positive on gray icons in open space	Approval of design
Phase 1	Appreciation for gradient design at technology features	Approval of design
Phase 2	Positive on the clear layout	Approval of design
Phase 2	Positive on time specification and the corresponding icon	Approval of design
Phase 2	Appreciation for slim and clear representation	Approval of design
Phase 2	Positive on the use of arrows for direction	Approval of design
Phase 3	Positive on speech bubble icon next to the remarks	Approval of design
Phase 3	Positive on the visual highlights with the orange font	Approval of design
Phase 3	Positive on the visualization of point 5	Approval of design
Phase 3	Positive on the table form	Approval of design
Phase 3	Positiv about arrows within the table	Approval of design
Phase 4	Appreciation for consistent icons	Approval of design
Phase 4, 5	Positive feedback on the structured layout with objectives and numbers	Approval of design
Phase 4, 5	Positive on navigation guidance from left to right and then down with horizontal color sections	Approval of design
Phase 5	Agreement with the intuitive order and division	Approval of design

Regarding the design, several aspects were evaluated positively. In phase one, the workflow from left to right was praised for its clarity. In addition, participants appreciated the color separation with bars between the individual points and the uniform representation of the canvas. The use of gray icons in the open space and the gradient design for technological features was also complimented. In phase two, the clear layout, the time specification, and the corresponding time icon were commended. Participants gave positive feedback for the slim and clear representation within the canvas and the effective use of arrows for guidance. During phase three, the speech bubble icon next to remarks, visual highlighting, and the visual presentation of the fifth point were positively highlighted. The table format and arrows within it were also well-received. In phase four, the consistent use of icons was appreciated. Positive feedback was received in both phases four and five regarding the structured layout with objectives and numbers, as well as the left-to-right navigation. The horizontal color sections and dividers were highlighted for their positive impact. Phase five was particularly commended for its intuitive order and division.

Weaknesses

The "Weaknesses" main code consists of a total of two codes sublevel 1 and nine codes sublevel 2. Table 113 shows an overview of these, as well as the corresponding phases in which the issues were detected. This main code provides an overview of the weaknesses identified in the TAS framework.

Table 113: Sublevel Codes for "Weaknesses"

Phase	Code Sublevel 1	Code Sublevel 2
Phase 3	Conflicting views on the number of rows in the decision matrix	Information overload
Phase 3	Overload on 1st & 2nd order criteria	Information overload
Phase 4	Discomfort with the perceived information overload	Information overload
Phase 4	Overload due to too many leading questions in the hypotheses	Information overload
Phase 5	Overload due to the number of factors in the value profile	Information overload
Phase 1	Difficulty starting with visualization, rather start with basics	Navigation flow
Phase 1	Confusion about the left to right flow	Navigation flow
Phase 2	Unclear about the flow direction	Navigation flow
All	Inconsistency in the order in which the individual canvases are to be edited	Navigation flow

A notable weakness of the canvases was the information overload. During phase three, there were conflicting views about the number of rows in the decision matrix and an information overload in both the first and second order criteria. In phase four, participants expressed discomfort about perceived information overload, regarding too many leading questions in the hypotheses task and the number of factors in the value profile. Furthermore, issues were identified with the navigation flow throughout the framework. In phase one, participants experienced challenges to start with the visual representation of the technology and preferred to start with basic elements. There was also confusion regarding the left-to-right flow in this phase. In phase two, the direction of flow was unclear due to how the canvas was displayed. In addition, there were inconsistencies discovered in all phases regarding the general order in which each canvas should be worked on.

6.5.2.4 Suggestions from the Focus Group Workshop

Through the focus group workshop, particular attention was placed on identifying strengths and weaknesses in the framework design. Following consultation with two researchers, the collected data was discussed and evaluated to determine which aspects should be integrated for the redesign of the framework. The following tables summarize the workshop findings that is to be considered for the improved artifact. To facilitate subsequent implementation, all identified concepts and categories were translated into action items. The codes sublevel 2 were also provided for ease of reference. Table 114 provides suggestions for the overall framework and Table 115 for the individual phases.

Table 114: Design Decisions "Integrate in Canvas" – all Phases

Phase	Code Sublevel 2	Action Item	Design Decision
All	Content revision	Delete reflection questions	Integrate in Canvas
All	Framework Guidance	Integrate introduction into the phases	Integrate in Canvas
All	Wording	Integrate consistent task description	Integrate in Canvas
All	Coloring	Integrate a more uniform color scheme	Integrate in Canvas
All	Coloring	Integrate psychological considerations about colors	Integrate in Canvas
All	Layout structure	Swap objectives and phase cycles	Integrate in Canvas
All	Need for better visual representation	Add clear phase overview	Integrate in Canvas
All	Removal of elements	Delete logos in the header	Integrate in Canvas
All	Removal of elements	Delete big picture wording	Integrate in Canvas
All	Approval of Content	Keep objectives	Integrate in Canvas
All	Approval of Design	Keep left to right flow	Integrate in Canvas
All	Approval of Design	Keep horizontal color sections	Integrate in Canvas
All	Approval of Design	Keep time specifications	Integrate in Canvas

Table 115: Design Decisions "Integrate in Canvas" - Individual Phases

Phase	Code Sublevel 2	Action Item	Design Decision
Phase 1	Content revision	Define first problem and then function	Integrate in Canvas
Phase 1	Content revision	Integrate consistent sentence structure	Integrate in Canvas
Phase 1	Content revision	Delete "To Do" section	Integrate in Canvas
Phase 1	Coloring	Integrate visual highlights	Integrate in Canvas
Phase 1	Coloring	Delete gray font for task descriptions	Integrate in Canvas
Phase 1	Layout structure	Allow more space for texts	Integrate in Canvas
Phase 1	Need for better visual representation	Differentiate point 2 more clearly	Integrate in Canvas
Phase 1	Need for better visual representation	Integrate uniform design for graphics	Integrate in Canvas
Phase 1	Removal of elements	Delete non-essential icons	Integrate in Canvas
Phase 1	Approval of Content	Keep start with technology characterization	Integrate in Canvas
Phase 1	Approval of Design	Keep color separation between each points	Integrate in Canvas
Phase 2	Improvement Design	Delete dotted lines between ideas	Integrate in Canvas
Phase 2	Coloring	Add color differentiation between matrix and description	Integrate in Canvas
Phase 2	Coloring	Delete color combination of orange and red	Integrate in Canvas
Phase 2	Layout structure	Add clear text placement in matrix	Integrate in Canvas
Phase 2	Navigation Flow	Integrate clear flow direction	Integrate in Canvas
Phase 3	Improvement Content	Add team value fit	Integrate in Canvas
Phase 3	Improvement Content	Delete team name	Integrate in Canvas
Phase 3	Improvement Design	Elimination of alignment problems	Integrate in Canvas
Phase 3	Iconography	Delete decreasing light icon	Integrate in Canvas
Phase 3	Layout structure	Add better text placement in matrix	Integrate in Canvas
Phase 3	Layout structure	Swap rows and columns in matrix	Integrate in Canvas
Phase 3	Need for better visual representation	Revise task with evaluation criteria	Integrate in Canvas
Phase 3	Need for better visual representation	Number ideas	Integrate in Canvas
Phase 3	Need for better visual representation	Revise time specification format	Integrate in Canvas
Phase 3	Removal of elements	Delete dividing line between points 2 and 3	Integrate in Canvas
Phase 3	Removal of elements	Delete arrows	Integrate in Canvas
Phase 3	Approval of Design	Keep speech bubble icon in remarks	Integrate in Canvas
Phase 3	Approval of Design	Keep table form	Integrate in Canvas
Phase 4	Content revision	Add example for desired outcomes	Integrate in Canvas
Phase 4	Wording	Delete confusing wording	Integrate in Canvas
Phase 4	Need for better visual representation	Revise customer segment task	Integrate in Canvas
Phase 4	Need for better visual representation	Integrate professional layout for persona canvas	Integrate in Canvas
Phase 4	Need for better visual representation	Add example and space for core jobs	Integrate in Canvas
Phase 4	Removal of elements	Delete lamp icon	Integrate in Canvas
Phase 4	Information overload	Reduce number of leading questions in hypotheses	Integrate in Canvas
Phase 5	Framework Guidance	Integrate guidance and context explanation	Integrate in Canvas
Phase 5	Framework Guidance	Add next steps after value proposition statement	Integrate in Canvas
Phase 5	Wording	Add better explanations	Integrate in Canvas
Phase 5	Aesthetic design	Add clean alignment	Integrate in Canvas
Phase 5	Approval of Content	Keep value proposition statement as the last step	Integrate in Canvas

6.5.3 Development

Building upon earlier proposals and design considerations, the third version of the TAS Framework will be developed. Thus, the general design process will be described, followed by the visual design of the framework in the context of a style guide and finally, the results of the final implementation of the TAS framework are presented. Hence, the general design is described first, followed by an introduction to the design of each phase of the framework.

6.5.3.1 General Approach

The third version of the TAS framework follows the design decisions made in 6.5.2. These decisions resulted from extensive qualitative data analysis, including both expert interviews and a focus group workshop. The expert interviews provided an informed evaluation of the framework as a whole, allowing a focus on both content and design aspects. The focus group workshop provided the opportunity to explore facets of visual and functional design, contributing to a thorough investigation. The integration of feedback from these two data sources is therefore crucial. Through the incorporation of expert interviews and user involvement in the focus group workshop, the framework undergoes a redesign process guided by the principles of the HCD process. This inclusion of different perspectives serves as the foundation for improving the UX and the overall usability of the TAS framework. The objective is to create an optimized framework that meets the needs of the user while also equally focusing on content-related factors, as well as aesthetics and user interaction. Thus, before diving into the design process, the design considerations should be addressed.

6.5.3.2 Preliminary Design Considerations

The selection of an appropriate design tool for the redesign of the TAS framework is a decisive factor in the development process. For the realization of the improved version of the artifact, Figma (Figma, 2023), a freely accessible design tool, has been selected as the preferred software for the visual design. This decision is due to Figma's comprehensive suite of design tools that allows the creation of simple and complex user interfaces and the ability to collaborate in real-time, enabling the gathering of feedback during later design stages (Staiano, 2022).

Another crucial factor to consider when developing the design of the TAS framework is the intended use of the framework in printed form. The design of the canvases requires careful consideration of various aspects. According to Parker (2004), there are general design principles that play a crucial role in creating effective and appealing printed materials. Among these, typography and legibility are crucial aspects of printed products. Therefore, the used font should be carefully chosen to ensure readability (Parker, 2004). Additionally, color management is also important since printers use the cyan, magenta, yellow, and key (CMYK) color space, while digital displays use the red, green, and blue (RGB) color space (TechSmith, 2023). It should be noted that digital representations of colors may differ from their printed form due to different color spaces. Sufficient contrast also plays an important role in enabling clear distinctions between elements (Parker, 2004). Furthermore, it is advisable to include a safety margin when designing printed media to prevent any important information from being cut off. Taking these factors into account, it is recommended to conduct test prints to assess how the design transfers to the print format. Based on these consideration, the following designs are chosen in a print format of A3 for the canvases.

6.5.3.3 General Design Process

Following the preliminary design considerations, the actual design process was initiated. First, research was conducted for inspiring examples and similar canvases to explore a visual direction. However, the identified examples were either limited or simple in visual design, such as the Business Model Canvas by Pigneur and Osterwalder (2011). Consequently, it was decided to make its own considerations for the visual design. To gain additional inspiration for the placement of possible elements in each phase, the results of the participants' focus group workshop from the brainstorming session were taken into consideration. The first step in the design process was to select colors that should be used in the TAS framework. This was accomplished by experimenting with different color combinations. At the same time, other visual elements were considered, including the choice of font, the use of visual separators, and the integration of icons. The final decisions on the visual design are documented below in Chapter 6.5.3.4. Considering the fundamental decisions regarding the visual design, an iterative process for each phase of the TAS framework was initiated. This process progressed chronologically throughout all phases. The designs from each phase were continuously checked against the insights gained from expert interviews and the focus group workshop in the previous Chapter 6.5.2. This ensured that all design decisions from the suggestions were integrated into the designs of each phase.

In a series of iterative cycles, the development phase involved collaborative and continuous feedback from a total of six researchers. Initially, three researchers reviewed the TAS framework in multiple iterations until it reached a reasonably mature state. Following this, two additional researchers conducted evaluations, focusing on spelling inconsistencies and identifying problems that might not have been apparent earlier. Finally, a third researcher conducted a comprehensive review, contributing to the refinement of the TAS framework's usability and overall UX. The subsequent sections present the final version resulting from these iterations.

6.5.3.4 Style Guide

To establish a consistent overall visual appearance, a design style guide is defined. This contributes to ensuring a sustainable and consistent design (Moser, 2012). In general, a style guide serves as a compilation of visual and functional elements that should ensure consistency across different applications (Gale, 1996). The following style guide defines and describes the application of colors, fonts, iconography, and visual elements used in the TAS framework.

Colors

The colors used in the TAS framework consist of a total of five main colors. An overview of the colors used is shown in Figure 22. When selecting the color harmonies, a semi-complementary style was chosen, blending monochromatic and complementary color schemes. The chosen style was selected to achieve a calm and consistent color palette, while also providing contrast with the coral red color for highlighting specific visual elements (Moser, 2012).

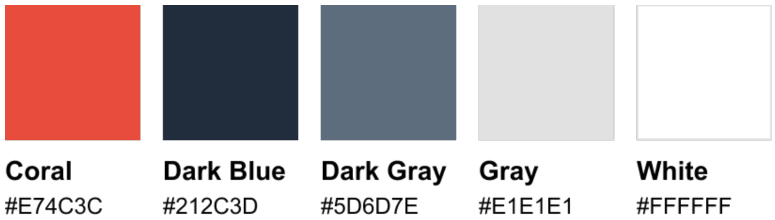

Figure 22: Overview of the Colors Used in the TAS Framework (Own Illustration)

The color scheme of the TAS framework is characterized by a prevalent use of dark blue and shades of gray and white, which are quite similar in tone. The purposeful addition of coral, which lies in the red color spectrum, is intended to break through this scheme and draw the focus to specific elements. The color red is commonly associated with aggression, danger, and love (Moser, 2012; Welsch & Liebmann, 2012), but also with excitement and happiness (Boyatzis & Varghese, 1993 as cited in Gaines & Curry, 2011). In addition, red has the strongest signaling effect of all colors (Moser, 2012). In contrast, blue, which forms the basis for the dark blue color, stands for calmness, confidence, and seriousness and can have a calming effect on heart rate and respiratory (Engelbrecht, 2003 as cited in Gaines & Curry, 2011). The deliberate combination of the main coral and dark blue color in the canvas's visual design set accents to break up the otherwise calm design.

The colors used also serve functional purposes, which are shown in Figure 23. The coral color serves as a contrasting color to create highlights in the canvas, especially for texts or other visual elements such as iconography. The font colors encompass dark blue, dark gray, and white. Dark blue and white are used for larger headings and text, while dark gray is used for task descriptions. Furthermore, the three background colors dark blue, gray, and white are used in the canvas. Other visual elements are composed of a mixture of coral, dark gray, and gray color.

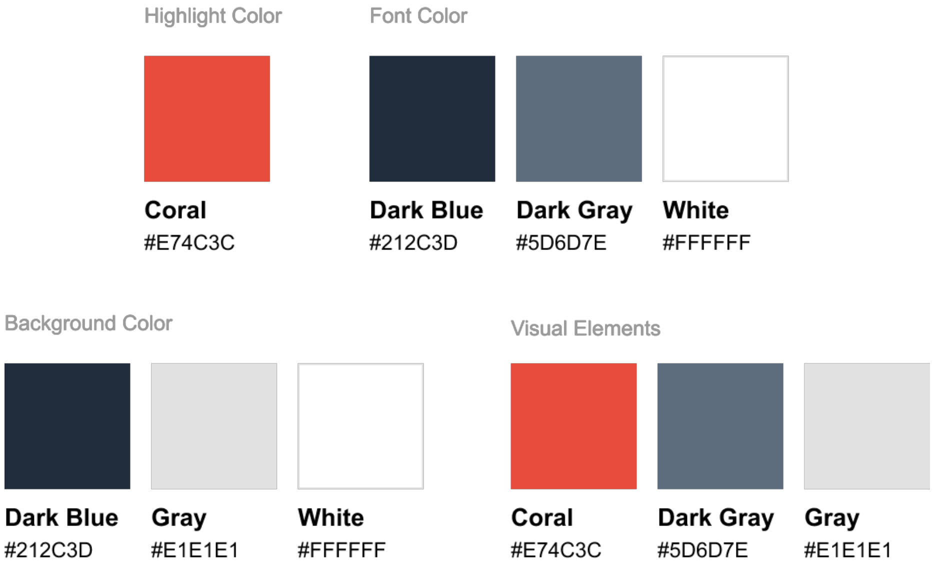

Figure 23: Colors and Their Functional Purpose (Own Illustration)

Fonts

In terms of typography, the freely available fonts "Lato Bold" and "Lato Regular" from Google Fonts were used, as shown in Figure 24.

Figure 24: Font Type (Own Illustration)

The fonts are presented in eight different sizes, as shown in detail in Figure 25. These font sizes follow a hierarchical structure in which the fonts "H1" to "H4" are used for headings, while the fonts "Body 1" to "Body 4" are used for body texts. The pixel (px) values define the font sizes to align with the standard conventions used in the Figma software. Special attention was given to ensuring the readability of the font sizes at the main print size of A3 during the selection process, with test prints as a basis for the decision.

Figure 25: Font Hierarchy and Sizes (Own Illustration)

Iconography

A collection of icons was integrated for the further design of the canvases. These serve as supporting visual elements allowing direct association with the corresponding tasks and thus creating cognition value. The icons used are license-free and originate from Google Fonts. Furthermore, some icons were put together individually. Figure 26 provides a detailed overview of the used iconography. The coral red icons serve as primary icons, supporting specific tasks, and are used on a white background. The icons on a gray and dark blue background serve as visual assistance for the overall use of the canvases.

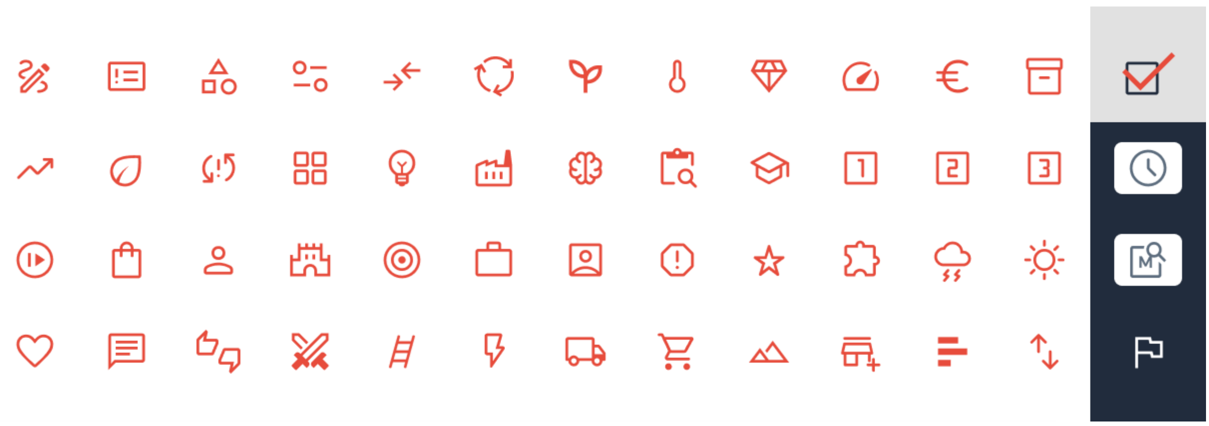

Figure 26: Overview Iconography (Own Illustration)

Visual Elements

Additional visual elements are integrated to enhance the user-friendliness of the canvas design. The integration of these elements aims to make the design more attractive and to illustrate different types of tasks. An extract of some of these supporting visual elements is shown in Figure 27.

Figure 27: Extract from Supporting Visual Elements (Own Illustration)

6.5.3.5 Results

The design of the third version of the TAS framework was reviewed and improved during the development process through multiple iterations by six researchers. Thus, the revised design is presented in the following, starting with an overview of the adaptions of the objectives and underlying methods, followed by an overview of the visual design, and then a detailed presentation of the individual phases.

After several sketches of the new design, version three incorporated refined objectives Figure 28 and methods (Table 116).

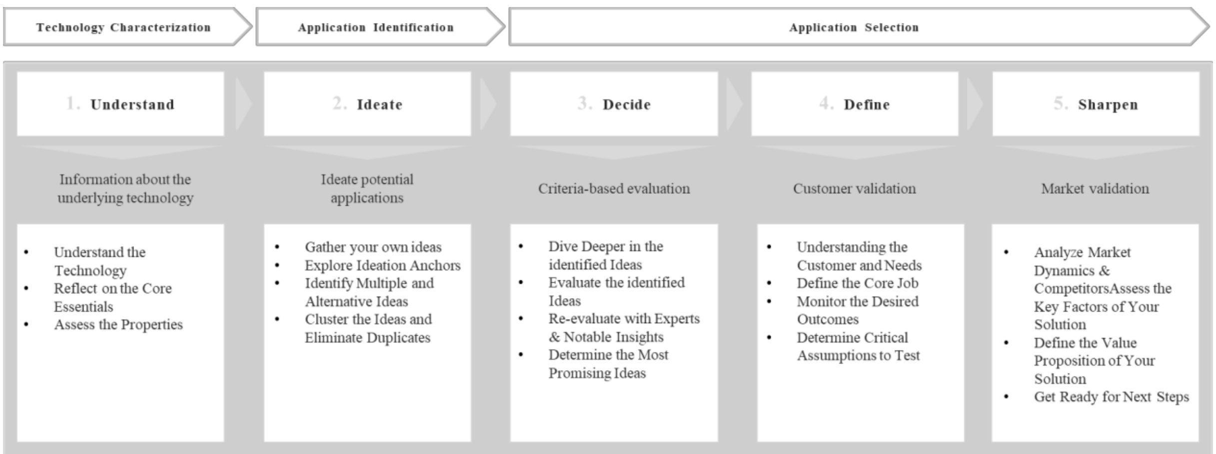

Figure 28: Adapted Objectives of the Five Phases of the TAS Framework Version Three (Own Illustration)

The third design cycle primarily concentrated on enhancing the user experience (UX), resulting in minor refinements. Objectives were reformulated for better clarity and comprehension of the intended message. During phases 4 and 5, methods recommended by experts were introduced. Notably, these phases now include a reflection component at their conclusion, prompting an assessment of whether to proceed, refine the idea further, or explore alternative directions.

Table 116: Overview of Adapted Methods of Version Three

Segments	Phases	Underlying approaches	Steps
Technology Characterization	Technology Characterization	Technology Canvas (Manthey, 2023)	Step 1: Technology Characterization Step 2: Synthesizing the Information Step 3: Technology Features
Application Identification	Application Identification	Ideation Anchors (Terzidis & Vogel, 2018; Manthey et al., 2022)	Step 1: Initial Idea Generation Step 2: Ideation Anchors Step 3: Wall of Ideas Step 4: How-Wow-Now-Matrix
Application Selection	Criteria-based evaluation	Evaluation Criteria Research (Manthey et al., 2023)	Step 1: Decision Matrix Step 2: Expert Evaluation Step 3: 3 Favorite Ideas
	Customer-based evaluation	Adapted version of: Customer Segmentation Persona Canvas Jobs2BeDone (Ulwick, 2016) Critical Hypotheses (Lau, 2021) TTF Fit (Goodhue & Thompson, 1995)	Step 1: Customer Segment Step 2: Core Job Step 3: Desired Outcomes Step 4: Persona Step 5: Critical Hypotheses Step 6: Task-Solution-Technology Fit
	Market-based evaluation	Adapted version of: Competitor analysis framework (Hatzijourdanou, 2019) Porters Five Forces (Porter, 1979) Value Profile (Terzidis & Vogel, 2018)	Step 1: Competitor Analysis Step 2: VRIO Model Step 3: Porters Five Forces Step 4: Value Profile Step 5: Value Proposition Statement Step 6: Outlook

General Design

At first, the layout format was adapted from the previous version as part of the design revision. The content is no longer placed within a frame but uses the entire canvas space instead. A visual comparison of the old and new designs is shown in Figure 29. Despite the full use of space, a safety margin of 24px was ensured around all pages. Subsequently, the header was redefined, which is consistent throughout all phases and only differs in terms of content. The header on the left side contains the framework title, the name of the current phase, and an introductory text that is tailored for the current phase. On the right side of the header, objectives for the phase and a visual representation of the entire phase cycle are included, with the current phase being visually highlighted. The header is intended to assist users in getting familiar with the canvas. The introductory words serve to introduce the topic, while the goals outline the phase's overall objectives, providing an overview of what is being worked on in the phase. The visual representation of the phase cycle enables the user to assess their position within the overall process. The big picture wording, KIT and EnTechnon logo, team name, and the name of the technology have been removed from the upper section. The sources, reflection questions, and the “To Dos” have been removed from the lower area. This resulted in an overall leaner design of the canvas.

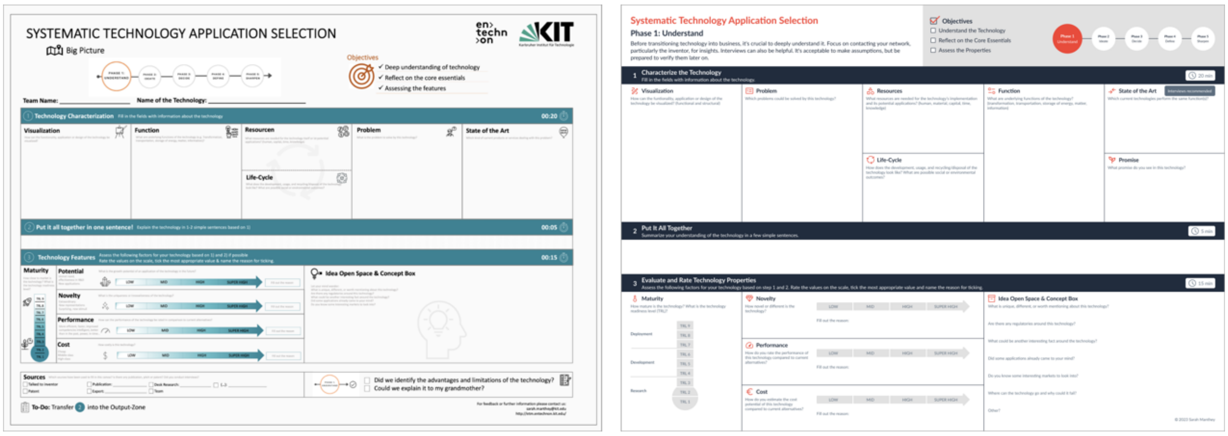

Figure 29: Basic Comparison of Old and New Design (Own Illustration)

In the general layout, the horizontal separators have been retained to provide a visual demarcation. These separators contain the current task number, the task title formulated to encompass the action of the task, and a brief general description of the task. Within the separators are additional elements, referred to as "tags" in the following text, which serve to support the solution of the current task. An example of this is illustrated in Figure 30. The first tag on the dark gray background provides additional information on how best to solve the task (interviews). This type of tag can also occasionally appear outside the separator to offer reference or support for subtasks. The following tag represents the manual symbol. This is inserted whenever the researchers who evaluated the framework suggest that the task would be best solved by consulting the framework's additional manual. The final tag next to it indicated the time specification on how much time should be planned for this task.

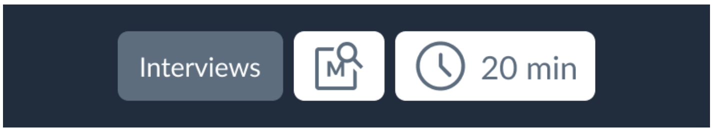

Figure 30: Example of Elements That Could Be in the Separator (Own Illustration)

The main task, presented in the dark blue separator, is divided into specific subtasks, which are displayed on a white background. These subtasks represent specific tasks that aim to resolve the overall task. Each subtask is accompanied by a corresponding icon, which was introduced in Chapter 6.5.3.4. When formulating the tasks, it is ensured that they are left-aligned to guarantee better readability (Moser, 2012).

Furthermore, the navigation flow is also adapted in the layout of the canvases. All canvases follow the principle from left to right and then from top to bottom to correspond to the natural Western reading direction (Moser, 2012). This ensures that users do not have to learn a new flow that could cause confusion.

Special attention was given to designing the canvases with a consistent layout that makes the use of colors, fonts, and visual elements uniform across the canvases. This is intended to increase recognizability and minimize the learning effect between the canvases. It is also taken care of that the interaction between the and the canvas is intuitive and user-friendly. This is accomplished by formulating work instructions in a comprehensible manner and ensuring consistent navigation through the canvases. Given the potential complexity of the phases four and five, this ensures that users have already familiarized themselves with the flow and the design in the previous phases.

In addition to using the canvases, a one-pager has been created to detail the usage of the TAS framework. It is recommended to read this one-pager before using the TAS framework with the canvases. The one-pager features a brief introduction to the TAS framework, presenting general information and explaining the overall phases. It further explains the detailed elements of the canvases, outlining their intended use and interpretation. The illustrated one-pager can be found in Appendix B3.

Phase 1: Understand

In the initial phase of the canvas design, the content remained principally similar compared to the previous version. The header emphasizes the importance of this phase, reminding users of the need to first develop an understanding of the technology. The users are encouraged to conduct interviews and it is made clear that all information is based on assumptions that need to be verified later. The first task to characterize the technology includes aspects such as visualization, problem, resources, life-cycle, function, state of the art, and promise. The second task has been adapted in the wording allowing users more space, no longer restricting to one to two sentences to summarize the technology, but instead allowing for a few sentences. The third task also offers additional space for answers on the technology features, including novelty, performance, and cost of the technology. Additionally, the structure of the Idea Open Space & Concept Box has been altered. This no longer consists of a block of questions, but rather the questions have been broken down with sufficient space in between. This allows users to write their answers directly below the questions and create a closer context. The development version of phase one of the TAS framework can be seen in Figure 31.

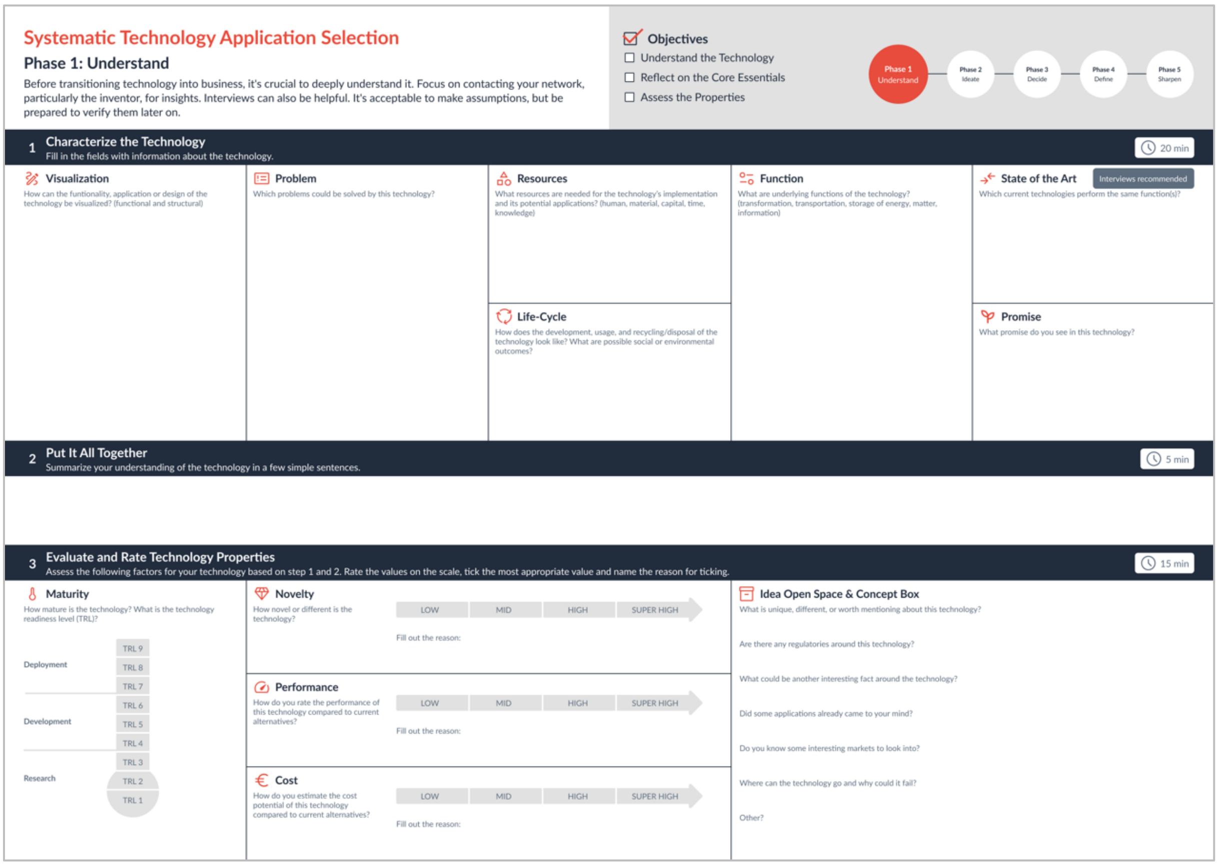

Figure 31: Development Version of Phase 1 of the TAS Framework (Own Illustration)

Phase 2: Ideate

In the second phase, the processing direction was adjusted to align with all canvases, reading from left to right and top to bottom, ensuring a consistent structure throughout. The introduction of the header encourages users to start with an individual brainstorming session and not to evaluate at this stage. Following this, a new task has been introduced in which users begin with an intuitive session for initial idea generation. This task has a designated time frame of five minutes, allowing to gather and record ideas without extensive evaluation. In the second task, idea anchors are used. The previous graphics have been removed due to their lack of updated information. The idea anchors should serve for idea generation, including complementary technology, application domain, sustainability goals, and recent and upcoming trends. All emerging ideas can be written down in task three, with a numbering up to ten. This serves to create a central collection point where all ideas that arise are noted at once. This numbering is also used in the fourth task to reference ideas in the How-Wow-Now-Ciao matrix and for the later phase three. The development version of phase two of the TAS framework can be seen in Figure 32.

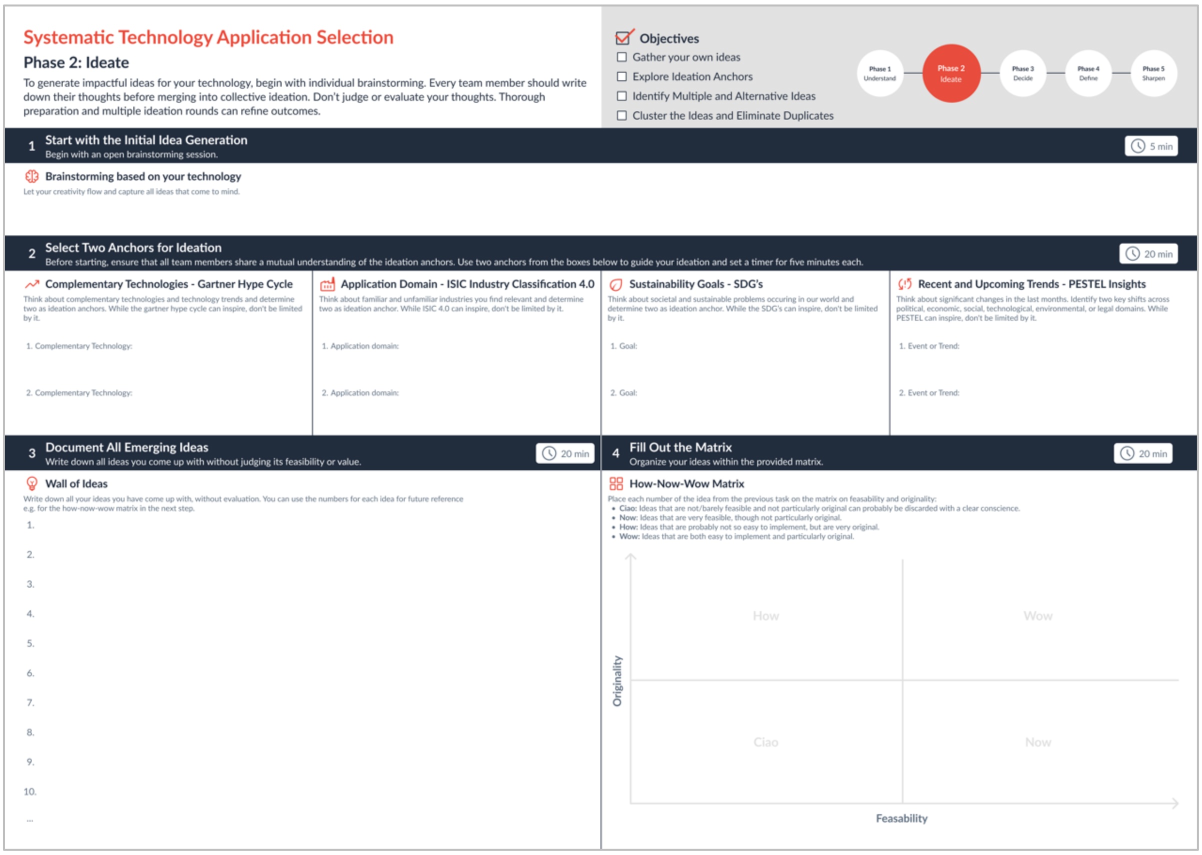

Figure 32: Development Version of Phase 2 of the TAS Framework (Own Illustration)

Phase 3: Decide

In the third phase, the focus is on evaluating the ideas that have emerged. The header introduction specifies that this evaluation should first take place individually and then in a collaborative form. Overall, this phase was reduced to a total of three tasks. The evaluation criteria were removed as a separate task and merged with the decision matrix as the first task. The matrix has also been modified by swapping the previous rows and columns. This creates more space on the left-hand side (for the rows) dedicated to describing the criteria, while the numbering of the ideas remains at the top (for the columns). The displayed tag states that the reverse side can be used for other criteria or ideas so that users are not limited to the predefined criteria and idea numbering. Task two represents the expert evaluation, using the same matrix as in task one. The respective experts are assigned on the left, and the numbering of the ideas is retained at the top. Task three finally complies with the three most favored ideas based on the criteria and the expert evaluation from the previous tasks. The development version of phase three of the TAS framework can be seen in Figure 33.

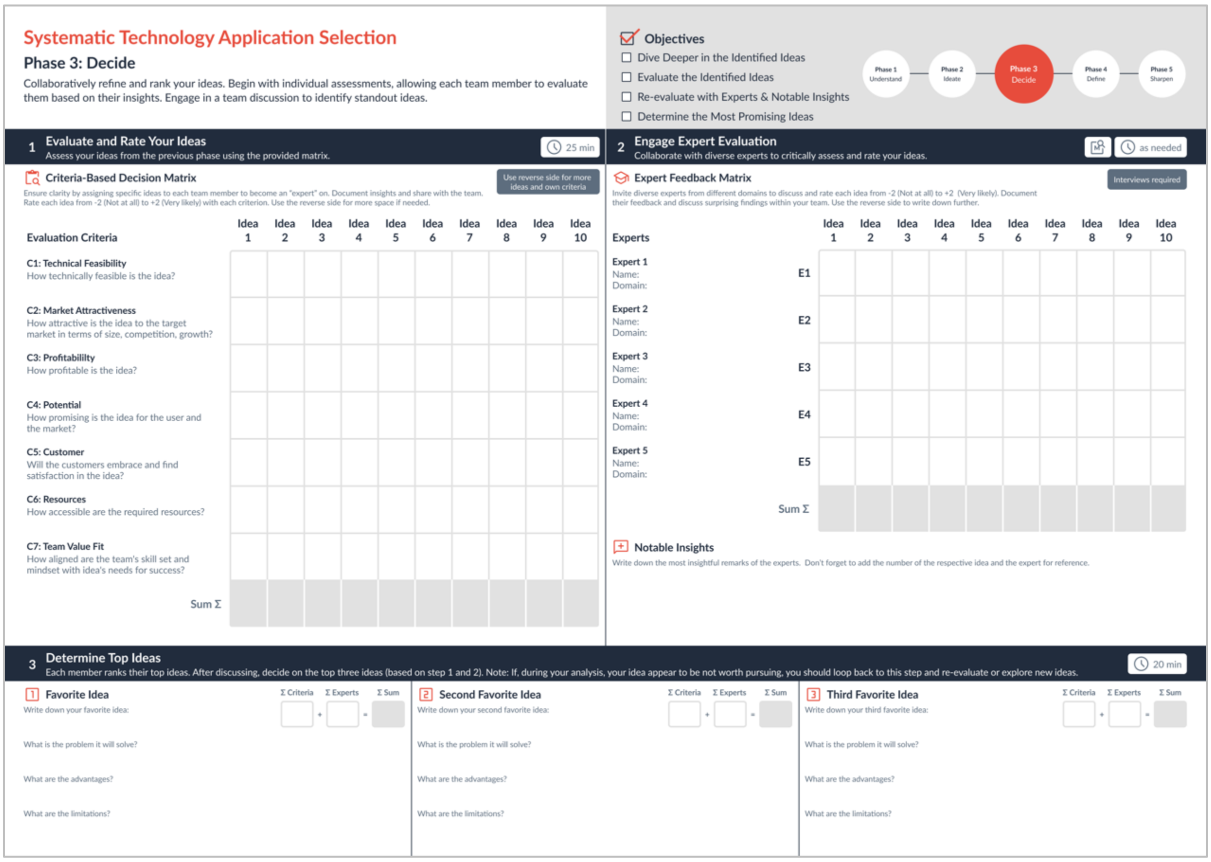

Figure 33: Development Version of Phase 3 of the TAS Framework (Own Illustration)

Phase 4: Define

In the fourth phase, the introduction emphasizes the replacement of the term "idea" with the term "solution", as the process is already in a solution-oriented space. Here, the favored idea from the previous phase is to be examined in more detail. The header also mentions that further research, such as interviews, is needed and that users can go back and continue with another idea at any point in the process if the current one is perceived inappropriate. Task one, which has been adapted to the Buying Center, comprises six roles that can be described for the solution found. While these roles are B2B-focused, they can also be used for B2C roles by excluding roles that are not required. Tasks two and three apply the Jobs-to-be-Done approach to core jobs and desired outcomes. Task four involves the creation of the buyer persona according to the Buying Center, whereby the persona design was adapted and presented in a more formal style. Task five remains as a task for formulating hypotheses and was only adapted in terms of design. At the end of the phase, a new task six was introduced, the task-solution-technology fit. This aims to offer a final assessment of the solution by the conclusion of the phase, ensuring its optimal support with customers' needs and desires. Additionally, it assesses whether the given technology is truly the best for the task. The development version of phase four of the TAS framework can be seen in Figure 34.

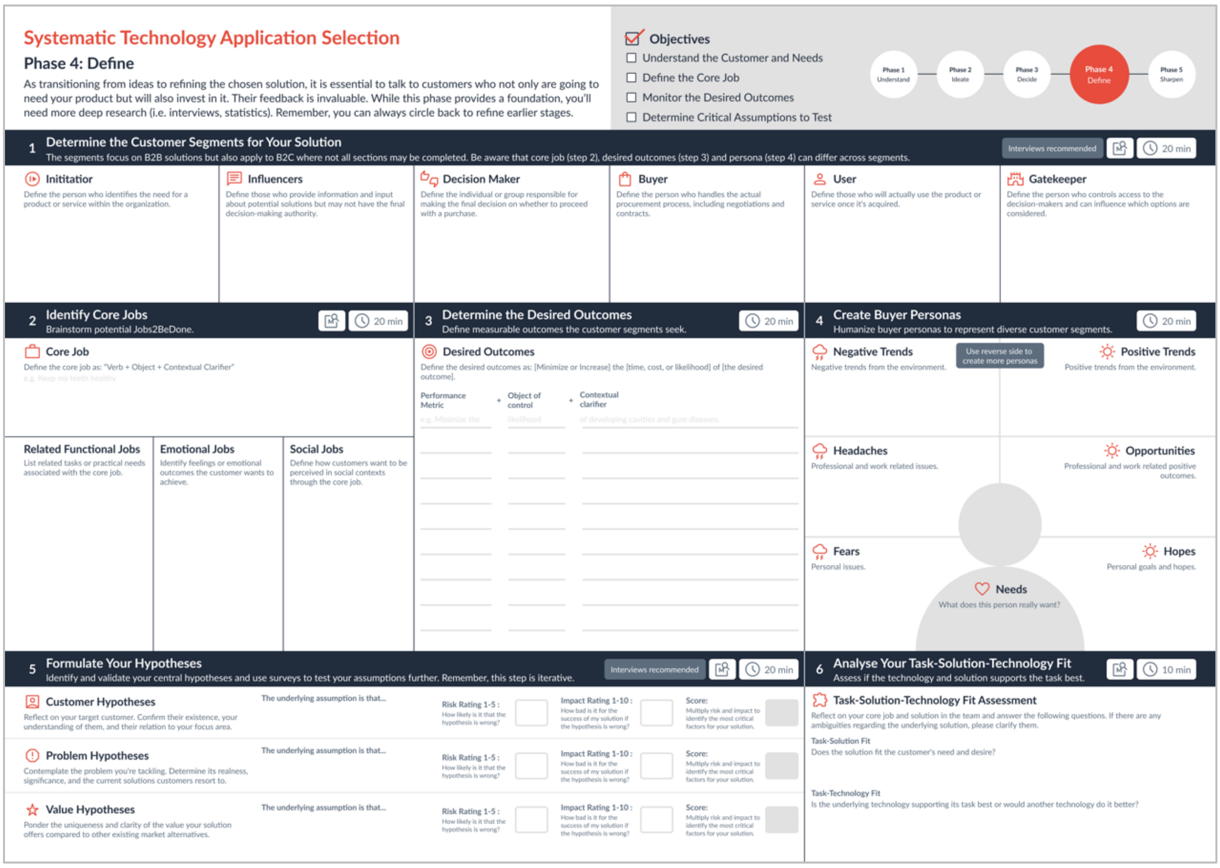

Figure 34: Development Version of Phase 4 of the TAS Framework (Own Illustration)

Phase 5: Sharpen

In the fifth phase, the header introduces the intricacies of the market for one's solution, creating fundamental knowledge for the future competitive landscape. In the new version of the artifact, the PESTLE trend radar has been removed. Instead, the first task focuses on analyzing the competition. The second task introduces a new concept, the Valuable, Rare, Inimitable, and Organized (VRIO) analysis, which evaluates resources and capabilities in relation to the developed solution. This identifies unidentified competitive advantages that could be used, as opportunities and threats that could be recognized (Messineo, 2023). In the third task, a new analysis is also added, namely Porter's Five Forces competitive analysis model. The model examines five factors (threat of new entrants, threat of substitute products, bargaining power of customers, bargaining power of suppliers, rivalry among competitors) to determine whether the developed solution can be profitable compared to other companies in the industry (Martin, 2023). The fourth task aims to evaluate the value profile that has been customized in the design. For tasks two and four, additional visual examples have been added to show how these models should be filled. The final task concludes with the value proposition statement. Finally, the canvas proposes the next steps that can be taken after accomplishing the canvas. The development version of phase five of the TAS framework can be seen in *Figure 35*.

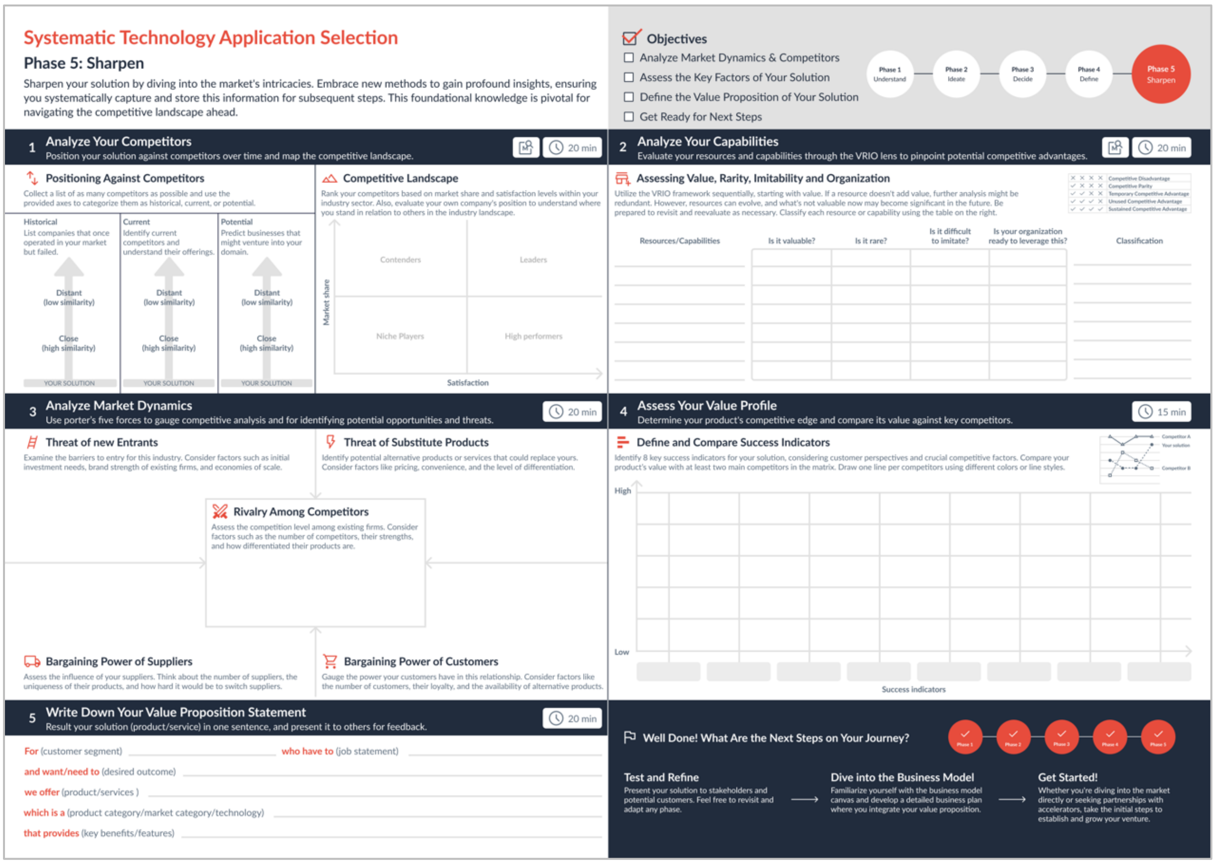

Figure 35: Development Version of Phase 5 of the TAS Framework (Own Illustration)

6.5.4 Evaluation

In the final evaluation phase of this thesis, a field experiment was conducted with the intended target group, researchers. In addition, focus groups were carried out with various stakeholders in order to systematically gather feedback on the final version. This inclusive approach included the perspectives of students, entrepreneurial educators, innovation managers, researchers and entrepreneurship professors.

The field trials provided quantitative analysis to compare results with previous evaluations. Meanwhile, the focus groups provided a qualitative analysis by asking participants to evaluate the fulfilment of the requirements and to integrate their views quantitatively.

In line with the overall aim of enabling independent use of the TAS framework without guidance, the focus group participants were given a brief presentation of the purpose and development of the TAS, but were asked to evaluate it as if it were self-guided.

Therefore, the final evaluation episode (EE3) includes both artificial and natural elements, providing practical and experienced perspectives. By using the TAS framework within the target group and engaging with influential stakeholders through focus groups, conclusions can be drawn about the perceived usability and effectiveness of the TAS framework in practice.

Table 117: Overview of the Evaluation Strategy of Evaluation Episode Three

Evaluation Strategy (Version Three)	
Explanation of the objectives of the evaluation	**Design requirements** Functional requirements Environmental requirements Structural requirements User requirements
Selection of the evaluation strategy	**Human Risk & Effectiveness** Definition of the evaluation questions Determination of the survey methods Choice of samples Description of the evaluation cycles
Selection of the evaluation strategies	**Field Experiment | Focus Group** Setting: Entrepreneurial Workshop | Focus Group Workshops Unit: Researcher | Several stakeholder in the TAS nexus Treatment: Multiday workshop | 120-minute workshops
Data analysis	**Qualitative and Quantitative** Evaluation of the quantitative survey Evaluation of the open text questions | Focus Group Comparison with the requirement criteria Deriving suggestions for improvement

6.5.4.1 Field experiments

In the final evaluation episode, one field experiment was conducted, with the target group of the TAS framework, researchers. The setting was similar to the previous field experiments.

Table 118: Sample of Field Experiments of Version Three

Participants of the evaluation studies (Version three)					
Evaluation Episode	**Setting**	**Date**	**Number of Teams**	**Questionnaire (n)**	**Interview (n)**
3	PhD	Oct 23	5	17	-

6.5.4.1.1.1 Quantitative Analysis of the survey: Scale 1-3

The quantitative analysis of the survey covers Scale 1 to 3, which assesses usability, general feedback on the framework, and overall judgment.

Scale 1: Usability

Table 119: Item Analysis of Scale 1 Usability (Version Three)

1. Usability (Version Three)	M	SD	pi	rit-i
1.1 The framework is easy to use.	4,47	0,717	0,868	0,637
1.2 The framework is easy to understand.	4,29	0,772	0,823	0,637

Remarks: N = 17. coding: 1 (fully disagree), 2, 3, 4, 5 (fully agree). M = mean value; SD = Std. Deviation; pi = item difficulty; rit-i = corrected item selectivity. Cronbach's Alpha = 0.777.

Scale 1, with items 1.1 and 1.2, measures usability and comprehensibility in the assessment of the TAS framework. The corrected item total correlations, which are below the threshold of ri = 0.8, are of an acceptable standard. The calculated Cronbach's alpha, α = 0.777, is acceptable. Participants, on average, provide a positive rating of 4.38 for the items, indicating a favorable inclination towards the framework's usability and comprehensibility.

Scale 2: Evaluation of the framework

Table 120: Item Snalysis of Scale 2 Evaluation of the Framework (Version Three)

2. Evaluation of the framework (Version Three)	**M**	**SD**	**pi**	**rit-i**
2.1 The framework helped us to improve our market knowledge.	4,41	0,795	0,853	0,674
2.2 The framework helped us to gain a profound understanding of the underlying technology.	4,35	0,786	0,838	0,392
2.3 The framework helped us to understand the worth and leverage social capital.	4,18	0,728	0,795	0,329
2.4 The framework helped us to identify various alternatives and multiple applications.	4,35	0,862	0,838	0,454
2.5 The framework provided guidance to evaluate the identified applications.	4,59	0,618	0,898	0,188
2.6 The framework enabled to do the TAS process with limited resources.	4,29	0,772	0,823	0,574
2.7 The framework helped us to understand potential customers and their needs	4,47	0,624	0,868	0,157

Remarks: N = 17. coding: 1 (Fully disagree), 2, 3, 4, 5 (fully agree). M = mean value; SD = Std. Deviation; pi = item difficulty; rit-i = corrected item selectivity. Cronbach's Alpha = 0.689.

Scale 2 shows the functional requirements items. Cronbach's alpha value is α = 0.689. The mean score is M7 = 4.38 and the standard deviation is SD7 = 0.556. Participants evaluate the framework positively. The findings indicate that the functional requirements are generally effectively met. Item 2.5 has the highest mean (4.59), similar to the previous evaluation. The lowest mean has item 2.3, but is still above 4.0.

Scale 3: General judgement

Table 121: Item Analysis of Scale 3 General Judgement (Version Three)

3. General judgement (Version Three)	**M**	**SD**	**pi**	**rit-i**
3.1 The framework supported all our relevant purposes for the TAS process.	4,18	0,728	0,795	0,134
3.2 The framework contained all necessary information to complete the TAS proccess.	4,41	0,618	0,853	0,206
3.3 The framework provided clear guidance on the TAS process.	4,35	0,702	0,838	0,424

Remarks: N = 17. coding: 1 (Fully disagree), 2, 3, 4, 5 (fully agree). M = mean value; SD = Std. Deviation; pi = item difficulty; rit-i = corrected item selectivity. Cronbach's Alpha = 0.411.

Finally, a Cronbach's alpha value of 0.411 was obtained for the results of Scale 3 "General judgement" with items 3.1 - 3.3. The participants agree that the framework supports all relevant purposes. It contains all necessary information and provides clear guidance on the process.

On the basis of the statistical results, the items from scales 1-3 are transformed back into functional and environmental requirements to assess the compliance of the artifact, equivalent to EE1 and EE2. The transformation of the items and their fulfilment status is shown in Table 122. Environmental requirement ER_7 (Customizability) is associated with four distinct items. Fulfilment is determined by the average of these four items. A requirement is in compliance if the mean value is greater than M=4.0.

Table 122: Fulfilment of Requirements (Version Three)

Fulfillment of environmental and functional requirements (Version Three)			
	Mean	**Fulfillment**	**related Item**
ER_1 Usability	4,29	+	1.1.
ER_2 Comprehensibility	4,47	+	1.2.
ER_3 Completeness	4,41	+	3.2.
ER_4 Adequate complexity	4,29	+	2.6.
ER_5 Efficiency	4,35	+	3.3.
ER_6 Suitability	4,18	+	3.1.
ER_7 Customizability	4,32	+	2.1., 2.2., 2.3., 2.4.
FR_1 Enhance market knowledge	4,41	+	2.1.
FR_2 Enhance knowledge about technology	4,35	+	2.2.
FR_3 Improve utilization of social capital	4,18	+	2.3.
FR_4 Provide ideation guidance	4,35	+	2.4.
FR_5 Evaluate applications	4,59	+	2.5.
FR_6 Enable structured process	4,29	+	2.6.
FR_7 Consider customers	4,47	+	2.7.

Taking into account the areas of fulfilment of the requirements as defined above, the overall assessment represents a positive evaluation of the TAS framework. These results will be compared with the results of the focus group data collection. These results will also be compared to those obtained for EE1 and EE2.

6.5.4.1.1.2 Qualitative Analysis of the Survey: Scale 4

Similar to EE1 and EE2, Scale 4 is analyzed qualitatively as it consists of open-ended questions. Table 123 shows the coding of the scale, differentiated into weaknesses and strengths. Improvement areas are not included, as the participants of the field experiment did not fill out this section.

Table 123: Code System of Scale 4 (Version Three)

Code system of the Interviews (Version Three)			
Main Code	**# Codes Sublevel 1**	**# Codes Sublevel 2**	**# Mentions**
Framework's Strengths	3	5	13
Framework's Weaknesses	3	5	13

The final code system consists of two main codes, each of which is further subdivided into three codes at the first sublevel and five codes at the second sublevel. A total of 26 text passages are assigned to these codes (Table 123).

Strengths

Table 124: Code System of Strengths (Scale 4 - Version Three)

Main Code: Strengths	
Level 1: Guidance	**Mentions**
Level 2: Guidance	4
Level 2: Phase support	2
Level 1: Representation	**Mentions**
Level 2: Structure	4
Level 2: Visualization	2
Level 1: Educational Benefit	**Mentions**
Level 2: Educational Benefit	1

Consisting of three codes, the first level of the strengths section focused mainly on highlighting the guidance, the presentation of the TAS framework itself and the educational benefits. Within guidance, the self-guiding structure was appreciated as well as the support given at each stage. The structure and visualization were also highlighted in the presentation, with approval of the new design and layout, which also correlates with approval of the guidance. Furthermore, one participant highlighted the pedagogical value of the TAS framework, which the participant felt was very supportive for people with no previous entrepreneurial experience.

Weaknesses

Table 125: Code System of Weaknesses (Scale 4 - Version Three)

Main Code: Weaknesses	
Level 1: Application issues	**Mentions**
Level 2: Time issues	2
Level 1: Redundancy of steps	**Mentions**
Level 2: Redundancy of idea creation process	1
Level 2: Redundancy of technology understanding	1
Level 1: Complexity of Framework	**Mentions**
Level 2: Unclear differentiation	3
Level 2: Lack of expertise	6

Within the main weakness code, participants highlighted application issues, which focused on the time constraints they had in the field trial, as the seminar set time frames for each task. The redundancy of the steps, especially the idea generation process, and the understanding of the technology were also mentioned without further explanation. Thus, the complexity of the framework was highlighted as a weakness, as participants argued that the lack of expertise made it difficult to work through the framework. They also pointed out that the distinction between the different steps was not clear.

Compilation and Comparison

Whilst the guidance, design and pedagogical value of the framework were recognized as strengths, the application of the framework itself was highlighted as a weakness. Participants struggled with the complexity of the framework and also with framing it within the workshop setting, which caused time problems. While both areas focus on the same area, highlighting it as both a weakness and a strength, it is not clear what the participants' initial thoughts were behind this. Furthermore, as it was framed in a workshop setting, the initial motivation of the researchers was not clear. Furthermore, the facilitators also play an important role in this process, which can also influence the positive or negative experiences of the participants.

6.5.4.2 Focus Group Workshop

Five focus groups were conducted to evaluate the TAS framework. A total of 13 participants were involved, each assigned to a specific focus group according to their professional roles and fields of research. These roles were specifically categorized into researcher (2), students (3), academic spin-offs (2), entrepreneurship educators (3), and innovation managers (3). The focus group methodology was previously introduced in Subchapter 6.5.2.3.1. The duration of each focus group lasted between one and two hours, depending on the number of participants in each group. The sessions included a 10-minute introduction to the goal and motivation of the workshop, followed by a 15-minute presentation of the TAS framework and an open question and answer session. This was then followed by a SWOT analysis, with 15-minutes allocated for each phase to ensure explicit feedback. Before commencing the SWOT analysis, participants were instructed to read the newly created one-pager in preparation. The sessions concluded with final remarks on the entire TAS framework. After the workshops, the participants were asked to fill out a short survey, which asked about fulfilment of the requirements, having a 5-point Likert scale, equivalent to the survey of the field experiments.

The SWOT analysis was chosen as it is a reliable method that enables the strengths, weaknesses, opportunities, and threats to be strategically identified (Helms & Nixon, 2010). By integrating qualitative data collected during the focus group workshops, the SWOT analysis provides a comprehensive understanding of the current situation of the TAS framework (Leigh, 2010).

All five focus group workshops were conducted online via the video conferencing tool Zoom. In addition to the participants, the focus group workshops were facilitated by a moderator, who guided the participants through the agenda and SWOT analysis, and an observer who took notes. The results of the feedback from the SWOT analysis were coded by two researchers using the Gioia method (Gioia et al., 2013), to analyze qualitative data. Further, the participants were asked afterwards to indicate their assessment of the fulfilment of the underlying requirements. Thus, the quantitative and the qualitative results will be elaborated below.

6.5.4.2.1 Quantitative Analysis of the Focus Group Workshop

While the focus group workshop was mainly analyzed qualitatively, the quantitative assessment was carried out through the post-survey sent to the participants. Sending the survey after the workshop ensured that participants had a thorough understanding of the final version of the TAS framework, as well as how to apply it. In addition, the online format allowed participants to respond anonymously, reducing potential bias. The survey contained the requirements that had been set for the artifact, no adaptation of the wording was made, and they were asked to rate on the basis of their perceived fulfilment of the requirements. Table 126 therefore shows the final assessment.

Table 126: Fulfilment of Requirements based on Quantitative Analysis of Focus Group Workshops

Code	Requirement	Focus Group	
ER	**Environmental Requirements**		
ER_1	Usability	4.40	+
ER_2	Comprehensibility	4.70	+
ER_3	Completeness	4.60	+
ER_4	Adequate complexity	4.50	+
ER_5	Efficiency	4.80	+
ER_6	Suitability	4.70	+
ER_7	Customizability	4.40	+
FR	**Functional Requirements**		
FR_1	Enhance market knowledge	4.70	+
FR_2	Enhance knowledge about technology	4.10	+
FR_3	Improve utilization of social capital	3.80	-
FR_4	Provide ideation guidance	4.50	+
FR_5	Evaluate applications	4.90	+
FR_6	Enable structured process	4.70	+
FR_7	Consider customers	4.50	+
SR	**Structural Requirements**		
SR_1	Coherence		
SR_2	Conciseness		
UR	**User Requirements**		
UR_1	Comprehensive process and method description	4.60	+
UR_2	Guiding poster (Canvas-like structure)	4.80	+
UR_3	Include supporting methods for each component	4.60	+
UR_4	Prioritization of components possible	4.00	+
UR_5	Usable without external expert guidance	4.00	+

As a requirement will be considered fulfilled if the corresponding mean value exceeds M = 4,0, the participants overall rated the requirements as fulfilled. Only exception is FR_3 relating to the improvement of social capital utilization, Still, it can be assumed that the participants are satisfied with the current version of the TAS Framework for its intended purpose.

6.5.4.2.2 Qualitative Analysis of the Focus Group Workshop

As previously stated, the analysis of the qualitative data of the focus group workshop adheres to the methodology outlined by Gioia et al. (2013) and used simultaneously like in the previous design cycles. Reducing subjectivity and ensuring consistent coding, the data was evaluated involving two researchers. In total, 38 codes sublevel 2, 13 codes sublevel 1, and four main codes were identified. However, the four main codes correspond to the four areas from the SWOT analysis. Given the extensive number of codes sublevel 2, Table 127 only provides an overview of the detected main codes and their corresponding codes sublevel 1. In the following, the findings are presented for each main code.

Table 127: Main Codes and Corresponding Codes Sublevel 1 from the Evaluation

Codes Sublevel 1	Main Code
Design Information presentation Overall framework	Strengths
Design Framework limitations Information presentation	Weaknesses
Design Information presentation Overall framework	Opportunities
Challenges Design Framework limitations Information presentation	Threads

Strengths

The main code “Strengths” consists of the codes sublevel 1 “Design”, “Information presentation”, and “Overall framework” encompassing nine first order concepts (see Table 128). In general, the tables have been condensed into a compressed presentation due to the extensive content collected in the focus groups. The total number of mentions made by all participants in the focus group workshop across all phases is also indicated.

Table 128: Identified Strengths from the Focus Groups

Main Code: Strengths	
Level 1: Design	**Mentions**
Level 2: Graphical visualization	28
Level 2: Structure	56
Level 2: Timeboxing	1
Level 1: Information presentation	**Mentions**
Level 2: Content	127
Level 2: Terminology	3
Level 2: Examples	9
Level 1: Overall framework	**Mentions**
Level 2: Manual	3
Level 2: Desirable application	3
Level 2: Overall experience	12

Beyond the individual phases, several aspects of the new design of the TAS framework were acknowledged as strengths. Specific emphasis was drawn to the graphic visualization, highlighting attributes such as the clarity and visual appeal of the overall design, as well as the provision of space for content input. The visualization as a whole was complemented, with positive feedback on the use of iconography, color selection, and the aesthetically pleasing presentation of content. The layout was also commended for supporting usability by facilitating easy completion. Furthermore, the structure of the framework was praised across all phases. The simple and clear organization of content, combined with effective guidance beyond the individual phases, was highlighted. The structure was described as self-explanatory and systematic so that no external help is required (which was particularly emphasized in phase two) and users can work autonomously with the canvas. The framework was praised for its general lucidity and the logical sequence of content. Moreover, the integration of timeboxing was also acknowledged as a strength.

Another strength lies in the presentation of the content within the framework. Here, the specific content of the individual phases was commended. In phase one the overall content was praised encompassing the understanding of the technology, the self-summarization in step two, and the technology properties with the Idea Open Space & Concept Box. In particular, the questions within the Idea Open Space & Concept Box were highlighted due to their thought-provoking nature and their ability to trigger deep thinking. In phase two, the content particularly in relation to the ideation anchors was perceived as a strength, along with the categorization of ideas in the How-Wow-Now-Ciao matrix. Phase three was positive in terms of the existing criteria, gathering expert feedback, and the ability to record “Notable Insights”. The quantitative assessment of ideas, in addition to the qualitative measures, was highlighted. In addition, the questions in step three were seen as helpful and crucial in deciding which idea to pursue. In phase four, the customer segments focusing on B2B, using the Jobs-to-be-Done method, and working with hypotheses were seen as strengths. In phase five, the methods used were also praised, emphasizing the focus on the competitor's analysis, and considering the market landscape from various perspectives. VRIO, the value profile, and the conclusion with the value proposition statement were highly appreciated. Overall, the supporting features in the tags were positively emphasized, especially the guidance for additional interviews in certain steps. Furthermore, the use of familiar research terminologies in phase one was praised. The examples displayed on the canvases, particularly those illustrating how to complete certain methods in phases four and five, were seen as a significant strength.

Regarding the overall framework, another strength lies in the acknowledgment of the manual and its existence. In terms of desirable application, participants were positive about the integration and use of the TAS framework, affirming it as a valuable tool for thinking "outside the box". Concerning the overall experience, specific mention was made about the framework fulfilling its purpose, providing support, and being enjoyable to use. Participants highlighted the versatility of the framework, referring to its potential interest for different target groups and its applicability to different needs.

Weaknesses

The main code "Weaknesses" consists of the codes sublevel 1 "Design", "Framework limitations", and "Information presentation" encompassing nine codes sublevel 2 (see Table 129).

Table 129: Identified Weaknesses from the Focus Groups

Main Code: Weaknesses	
Level 1: Design	**Mentions**
Level 2: Graphical visualization	1
Level 2: Structure	7
Level 2: Placement	4
Level 1: Framework limitations	**Mentions**
Level 2: Lack of information	32
Level 2: Missing element	2
Level 2: Possible misperception	9
Level 2: Too extensive	13
Level 1: Information presentation	**Mentions**
Level 2: Content	15
Level 2: Terminology	9

Weaknesses in the design were noted. In terms of graphic visualization, concerns were raised about the presentation of the tag, as the recommended interviews in the first phase appear crowded in the first step. In terms of structure, the first step in phase one was criticized due to inconsistencies with the content to start with. During the second phase, participants found the shift from basic brainstorming to idea generation challenging. Additionally, limiting the number of ideas to ten in this phase was considered inadequate. In the third phase, the scale for rating was criticized, as otherwise too many zeros could be entered. Issues with placement were identified, encompassing criticism of the space allocated for the brainstorming box in phase two and for the third step in phase five, which was felt to be too small for adequate processing.

Concerning the limitations of the framework, a lack of information within the framework was identified. In the first phase, the absence of intellectual property rights was noted. In phase two, the lack of creativity techniques for brainstorming was highlighted. The step regarding the ideation anchors was also flagged as a weakness due to unclear task instructions and an expectation of a manual icon, which is currently absent. In phase three, limitations were perceived in terms of limited space for qualitative thoughts, the absence of criteria for expert interviews, and a lack of clarity in the transition from step two to step three. Phase four exhibited uncertainties regarding the understanding that only one idea should be pursued on the canvas. In addition, the transition to phase five was not clearly formulated. Phase five included missing elements, such as the impact, identification of people responsible for implementation, and a business aspect. There was also a missing of additional examples. A general theme of uncertainty persisted across all phases, particularly regarding the level of abstraction at which to fill in the fields. In the concept of missing elements, the desire for an additional section addressing the state of the industry was expressed. Possible misconceptions in phase one included underestimating the categorization of novelty, performance, and cost as well as possible misinterpretation of the wording. In phase two, a possible misconception was identified, suggesting that the initial brainstorming round might disengage users. In phase four, uncertainties were identified regarding the final step of the task-solution-technology fit task. Certain elements of the framework were perceived as too extensive, with phases two and three being noted as time-consuming, especially when talking to experts. Phases four and five were generally described as initially overwhelming, with phase five mentioning that Porter's Five Forces analysis could be daunting.

In the context of information presentation, the specific content of the framework was also mentioned as a weakness. In the first phase, concerns were raised about the recommendation of interviews only for the "State of the Art". Participants suggested that interviews could also be valuable for other steps within this phase. In the Idea Open Space & Concept Box, the proposed questions were considered too many. In phase two the usefulness of PESTLE as an ideation anchor was questioned. Phase three encountered criticism for its content dependency on the quality of the experts. Phase four raised concerns about filling out the persona canvas and the lack of clarity of the remaining steps related to the technology. In phase five, weaknesses were identified such as uncertainty about how to research competitors in the competitive analysis and potential difficulties in understanding the VRIO concepts. Moreover, a few terminologies were highlighted as weaknesses in phase one, including the term "Promise". In phase four, it was suggested to revise the term "Recommended interviews". Considerations were also given to whether "customer segment" was the right term for the roles.

Opportunities

The main code "Opportunities" consists of the codes sublevel 1 "Design", "Information presentation", and "Overall framework" encompassing ten codes sublevel 2 (see Table 130).

Table 130: Identified Opportunities from the Focus Groups

Main Code: Opportunities	
Level 1: Design	**Mentions**
Level 2: Further development	3
Level 2: Guidance	12
Level 2: Framework utilization	9
Level 2: Structure	17
Level 2: External feedback	3
Level 1: Information presentation	**Mentions**
Level 2: Content	50
Level 2: Terminology	1
Level 2: Learning experience	6
Level 1: Overall framework	**Mentions**
Level 2: Manual	1
Level 2: Naming	1

Within the TAS framework, several design opportunities have been detected. In terms of further development, the participants suggested a gamification approach to encourage frequent usage. During the fifth phase, the opportunity to expand the content to include further support options for technology transfer was recognized. Under guidance, participants acknowledged in phase two that the different approaches for idea anchors provide useful guidance for ideation. However, it was recognized that additional guidance could further enhance efficiency. In phase four, the Jobs-to-be-Done content was specifically identified as delivering good guidance, and the suggestion was made to take deliberate breaks. Other general opportunities included allowing more flexibility and providing a global example of the beginning and end of the TAS framework to provide more guidance. Moreover, the design of the framework utilization was praised as it is designed so that a workshop format is not required, but it could still be incorporated. It was noted that the framework can also be used independently of the overall process as a standalone process, which gives it potential for utilization. In addition, the framework offers the opportunity to establish connections with technology experts through the recommended interviews. Regarding its structure, it was noted that it facilitates organized and systematic thinking. A recommendation was offered to readjust the content order in step one in the first phase. During phase two, it was observed that with more time planning for the ideas, more ideas could emerge. In phase four, the iterative approach at the end was recognized as a potential of this process to reconsider the idea with the task-solution-technology fit. With external feedback, the possibility was recognized that the completed content could generally be challenged by external experts to improve the solutions. Furthermore, phase five should include additional external feedback, which could add further value.

Regarding the information presentation, some opportunities were identified in terms of content. In the first phase, for example, it was suggested to incorporate interviews into the novelty, performance, and cost aspects. Additionally, alternative phrasing was proposed for task descriptions to provide a more detailed explanation in both phases one and two. A personal interest in ideation is also considered. During phase three, it was recommended that the evaluation of ideas should also be based on a good gut feeling, and it was suggested that only pre-filtered ideas should be discussed with experts. Numbering the ideas as a reference was also considered positive. In phase four, the suggestion was made to involve external tools to further develop the ideas. Phase five highlighted Porter's Five Forces and other methods as significant opportunities. In terms of terminology, an alternative wording for profitability was suggested in phase four. Regarding the learning experience, particular attention was paid to phases four and five, as it was observed that the methods used are highly effective for self-learning.

Regarding the overall framework, it was suggested that integrating interview guidelines into the manual could improve the structure of interviews. As for the naming, it was recommended that a clearer label than "Systematic Technology Application Selection" be selected.

Threats

The main code "Threats" consists of codes sublevel 1 "Challenges", "Design", "Framework limitations", and "Information presentation" encompassing ten codes sublevel 2 (see Table 131).

Table 131: Identified Threats from the Focus Groups

Main Code: Threats	
Level 1: Challenges	**Mentions**
Level 2: Clarification	41
Level 2: Cognitive bias	17
Level 2: Individual dependence	6
Level 2: Timeboxing	22
Level 1: Design	**Mentions**
Level 2: Structure	3
Level 2: Overproduction	4
Level 1: Framework limitations	**Mentions**
Level 2: Possible misperception	10
Level 2: Too extensive	1
Level 1: Information presentation	**Mentions**
Level 2: Content	16
Level 2: Lost opportunity	3

Several challenges have emerged within the TAS framework that can be seen as potential threats for the framework. It has been observed that certain content requires clarification to prevent misunderstanding or misinterpretations. For instance, during phase one, it was highlighted that a lack of information within the steps can lead to certain parts being skipped. During phase two, there was confusion about certain instructions and the lack of a clear link to the first phase. In phase three, concerns were raised about potential misunderstandings arising from the wording of the evaluation criteria. Additionally, confusion was expressed regarding the scoring system for each idea. In connection with the expert interviews, it was pointed out that the selection of experts can be limiting, especially if there is no access to qualified experts. In this context, the desire was expressed to receive assistance in identifying suitable experts and to critically evaluate the results. It was emphasized that comprehensive evaluations of experts are not given for all ideas, potentially leading to the loss of valuable ones. During phase four, it was recommended that the order define the persona first and then apply the Jobs-to-be-Done method to allow better development. Furthermore, the last step six could benefit from a clearer presentation highlighting the possibility to go back to this step for a new idea. In phase five, integrating expert interviews would minimize the risk of inadequate market assessment and provide detailed information for further actions. Overall, it was pointed out that users should be aware that completing the whole process is time-consuming. In terms of cognitive bias, it was highlighted that individuals in the first phase think about applications too early and may evaluate the technology subjectively and too positively. Additionally, during phase two, it was observed that individuals fall back too strongly into a market-driven thought pattern and neglect the anchors. For phase three, a potential bias in the selection of experts was mentioned, which could lead to overlooking valuable ideas. In terms of individual dependency, it was observed that the effectiveness of the framework depends heavily on the individual's ability to complete it. Regarding the time management, participants often expressed that the allocated time for the individual steps across the phases might be considered as too short.

In terms of the design, observations in phase five noted a consistent shift from external to internal considerations. A suggestion was made to initiate the process with external aspects before transitioning to internal components. In terms of overproduction, it was found that the canvas can generate too many ideas in phase three, which can lead to a loss of overview. Moreover, filling out the canvas in phase four can be perceived as exhausting. Framework limitations may lead to possible misperception in phase one due to subjectivity and uncertainty, as well as in phase four when applying the Jobs-to-be-Done method. In terms of being too extensive, phase five appears to pose more challenges than other phases. Further, the information presentation provides some challenges in terms of content, such as the possibility that some steps could be too demanding in terms of content. During phase three, it was highlighted that the evaluation based on the summary could lead to choosing a middle ground rather than the best idea. Phase four was rated as too extensive in terms of content, and in phase five the competitive landscape was presented as too late. In the context of lost opportunity, it was noted in phase four that due to the extensive content, there is a threat that users could get lost, which in turn could lead to them only completing the framework superficially instead of using it properly.

6.5.4.3 Final Refinements and Design of the TAS Framework

Building upon these aspects, several refinements are identified to improve the comprehension of the TAS framework. These refinements align with the iterative loops of the DSR and HCD processes and provide an opportunity to integrate feedback into the development of the artifact. The determination of which items, prioritized after the evaluation, should be integrated into the final version of the TAS framework was reached through the collaborative decision of two researchers. Involving two researchers enabled careful coordination, minimizing subjective influences, and ensuring a well-founded selection of the final refinements. The refined adaptations for each phase are presented in the following. The ultimate iteration of the TAS framework represents the culmination of efforts to translate insights into concrete measures.

Phase 1

In the first phase, several refinements were made to enhance the overall usability and clarity of the framework. Firstly, the title of the framework was changed to the more manageable "Technology Application Selection Framework". To discourage premature focus on potential applications, the term "application" was entirely removed from the canvas. The wording in the objectives was aligned with the phrase "Reflect on the Characteristics". The technology characterization in the first step was restructured for a better order of the individual characteristics. Moreover, the allocated time for this step was extended and the term "Interviews recommended" was streamlined to "Interviews" to simplify language. The task description in step three was revised, to allow for the integration of completing the Idea Open Space & Concept Box. For the parameters of novelty, performance, and cost, an additional interview tag was introduced. Within the Idea Open Space & Concept Box, a question was divided into two parts, and the application-related questions were removed. Overall, the planned time for step three was also extended. Figure 36 provides the final version of the phase with all adjustments for the TAS framework.

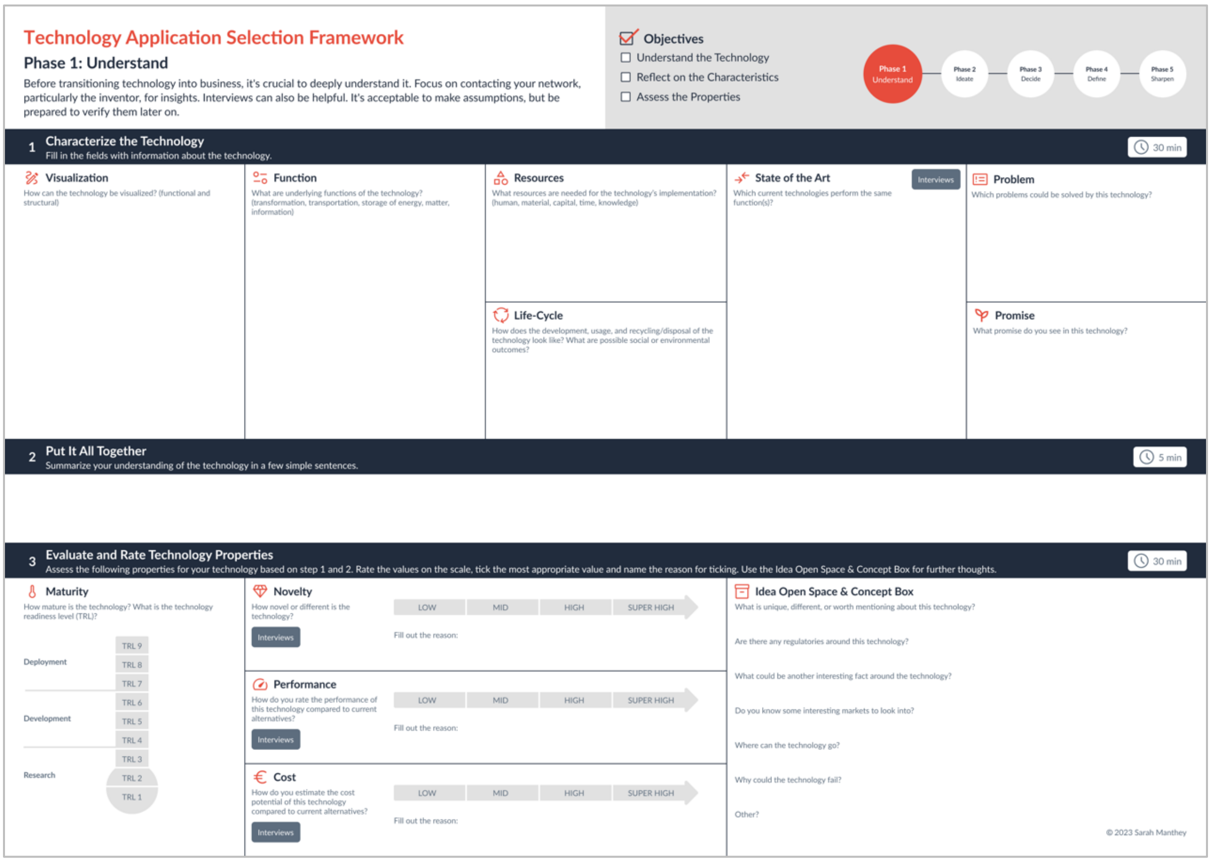

Figure 36: Final Version of Phase 1 of the TAS Framework (Own Illustration)

Phase 2

In the second phase, the task description for the initial step was modified to explicitly indicate that it involved the initial intuitive brainstorming session. Consequently, the objective was also renamed to better align with this clarification. In the second step, the task description was further adapted and the intention behind ideation anchors was emphasized. Additionally, the manual icon has been integrated, and the allocated time for the step was extended. In step three, the task description was modified to clarify the purpose of collecting all emerging ideas from the previous steps. Here, users were instructed to consider personal factors, such as individual interests during idea generation. To avoid limiting users, the numbering of ideas up to ten was removed, with only the numbering for the first three ideas indicated. Step four has been more clearly articulated in the task description, emphasizing that ideas from the "Ciao" area should not be pursued in subsequent phases, and instead focus on the other "How-Wow-Now" areas. An overview of the final version with all adjustments can be seen in Figure 37.

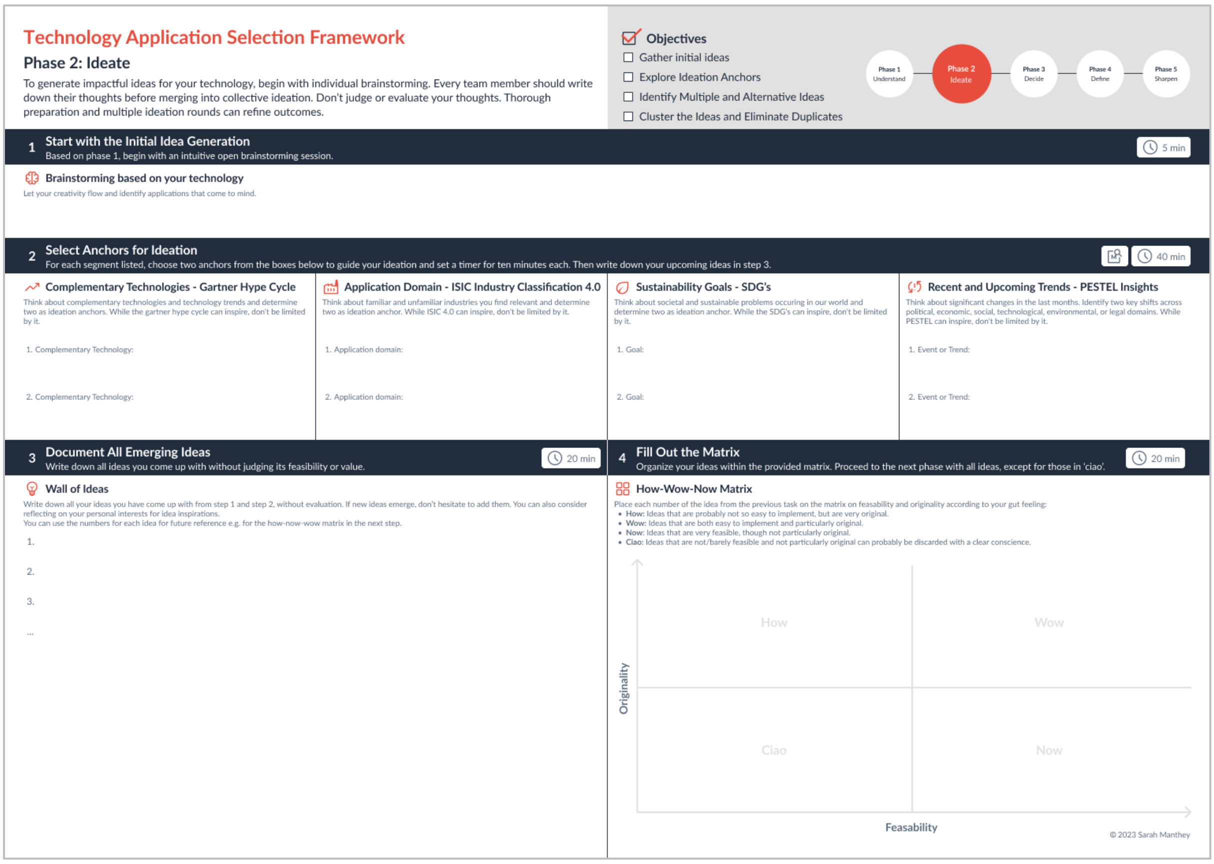

Figure 37: Final Version of Phase 2 of the TAS Framework (Own Illustration)

Phase 3

In this third phase, the introductory text was refined to explicitly communicate to users that the intention of this phase is to streamline the idea selection process. Users are encouraged to be aware of not only criteria and expert insights but also personal preferences. The task description in step one was modified to specify that, at the end of the evaluation, users should circle their favorite ideas, disregarding the resulting sum in the criteria evaluation. Moreover, the allocated time for this step was extended. Step two has been revised in both the task description and evaluation process. Only ideas with a positive sum from the first step should be discussed with experts. The evaluation now involves providing a sentiment, indicated by "+, -, 0" with an overall sentiment. This modification aims to capture not only the expert's assessment but also the overall feeling associated with the ideas. In step three, the wording was adjusted to focus on "favorite" ideas. The task description was further refined to communicate those criteria assessments, expert evaluations, and personal preferences should contribute to the evaluation, but not solely depend on criteria and experts. The sum boxes were removed, providing a clearer direction. Furthermore, the task emphasized that users should continue to the next phase with their first favorite idea and, if it does not work out, they can revisit and proceed with the other two ideas. Figure 38 shows the final version of phase three of the TAS framework with all modifications.

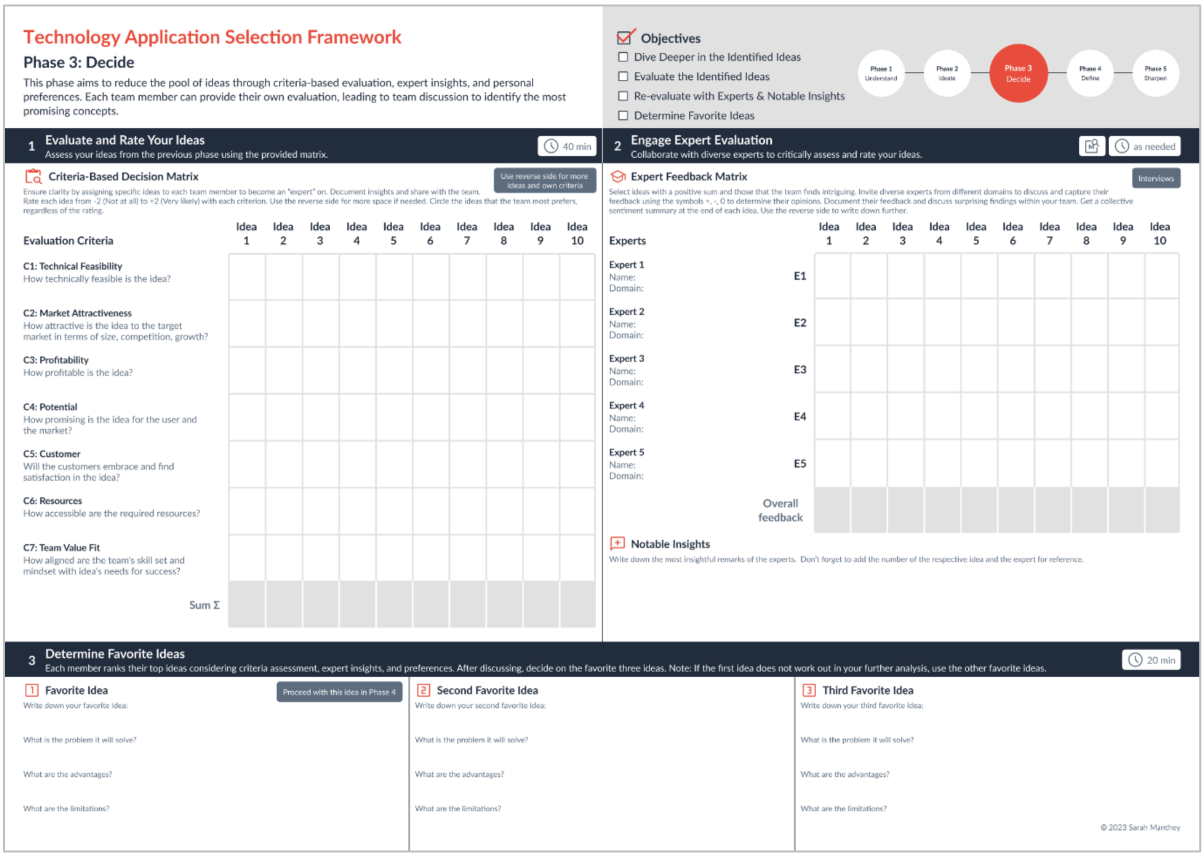

Figure 38: Final Version of Phase 3 of the TAS Framework (Own Illustration)

Phase 4

In the introduction text of this phase, emphasis was placed on shifting the focus to business analysis to make users aware of the new perspective. In step one, regarding customer segments, it was clarified that this step refers to the Buying Center, and the word "segments" was replaced with "roles". Additionally, the allocated time for this step was increased. The sequence was adjusted, placing the Persona task after the customer segments to ensure a logical structure. The term "buyer" was removed from the persona title to avoid confusion with the buyer from step one, and the time allocated for this step was extended. The following step involved the Jobs-to-be-Done method, combining the previous steps two (core jobs) and three (desired outcomes). Consequently, the overall time for the entire task was increased. In step five, the tag "use reverse side" was added to indicate that the reverse side should be utilized to maximize space for noting all underlying hypotheses. The time for this step was also extended. The previous step six, now step five, involving the task-solution-technology fit was further adjusted. The questions were removed, and checkboxes were introduced. Users are now instructed to tick the box if the corresponding statement is true. Only when both boxes are ticked it makes sense to proceed to the next phase. Therefore, a visual pause section was incorporated, encouraging users to reflect on whether the solution is indeed the best fit for the task and technology or if it might be worthwhile to go back to phase three and try a different idea. All customized modifications for the final version of phase four can be seen in Figure 39.

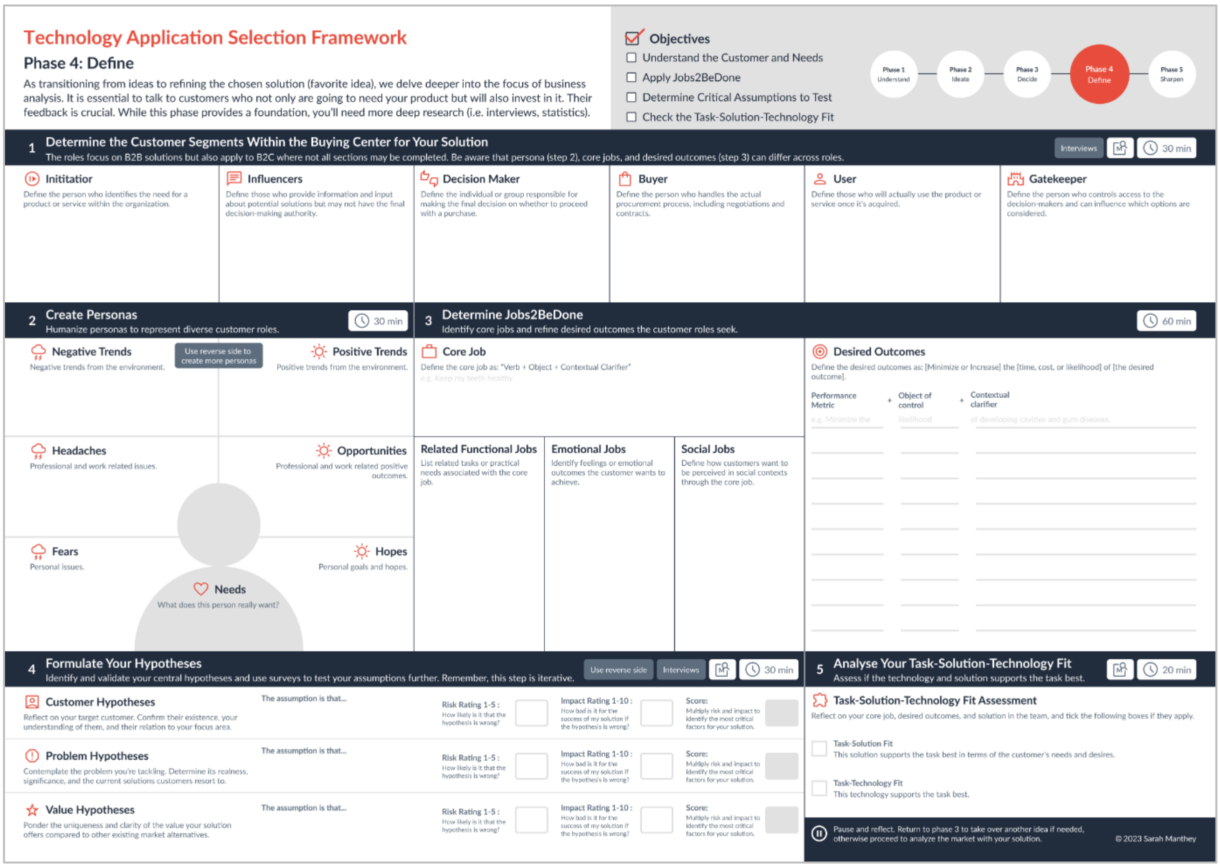

Figure 39: Final Version of Phase 4 of the TAS Framework (Own Illustration)

Phase 5

In step one, the task description was revised by incorporating core jobs as support in the positioning against competitors. The allocated time for this step was increased. Similarly, the time for steps two, three, and four was extended. In step three, the “Interviews” tag was added to include suggestions for external perspectives. To further assist with the value profile in step four, the manual icon was integrated in this step. Finally, in the last step, outlining the outlook for the next steps, it was emphasized that users should also initiate the prototyping process. Figure 40 provides the final version of phase five of the TAS framework.

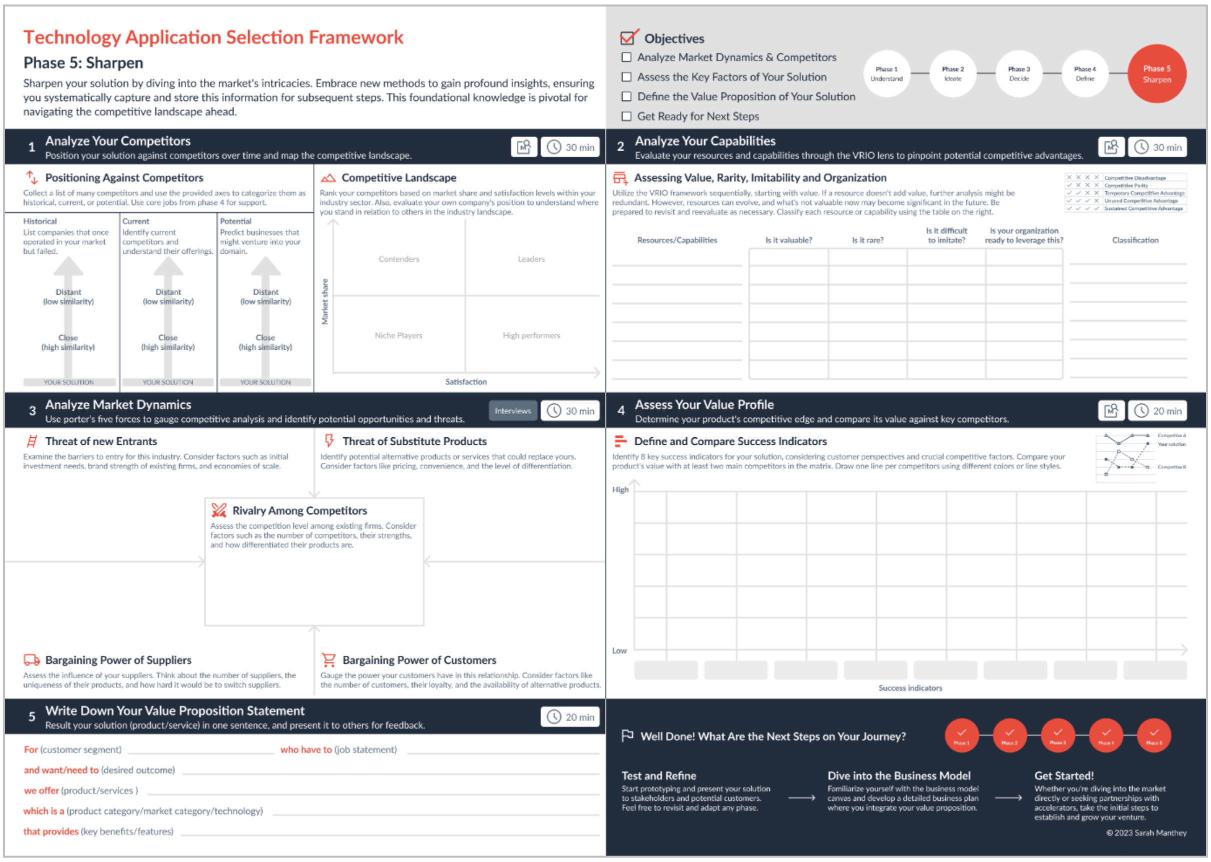

Figure 40: Final Version of Phase 5 of the TAS Framework (Own Illustration)

6.5.4.4 Fulfilment of Requirements

Two data points allow a quantitative assessment of the overall artifact in order to evaluate the fulfilment of the requirements. On the one hand, the survey used in the field experiments and, on the other hand, the data obtained through the ranking in the focus groups. While the field experiment survey allowed to assess the environmental and functional requirements, the focus group survey also highlighted the user requirements, which together enable a complete picture of the fulfilment of the requirements. Table 132 shows the quantitative assessment with the respective data collection methods.

Table 132: Fulfilment of Requirements - Quantitative Assessment

Code	Requirement	Focus Group		Field Experiments		Logical	Overall
ER	**Environmental Requirements**						
ER_1	Usability	4.40	+	4.41	+		+
ER_2	Comprehensibility	4.70	+	4.35	+		+
ER_3	Completeness	4.60	+	4.18	+		+
ER_4	Adequate complexity	4.50	+	4.35	+		+
ER_5	Efficiency	4.80	+	4.59	+		+
ER_6	Suitability	4.70	+	4.29	+		+
ER_7	Customizability	4.40	+	4.47	+		+
FR	**Functional Requirements**						
FR_1	Enhance market knowledge	4.70	+	4.29	+		+
FR_2	Enhance knowledge about technology	4.10	+	4.47	+		+
FR_3	Improve utilization of social capital	3.80	-	4.41	+		+
FR_4	Provide ideation guidance	4.50	+	4.29	+		+
FR_5	Evaluate applications	4.90	+	4.35	+		+
FR_6	Enable structured process	4.70	+	4.18	+		+
FR_7	Consider customers	4.50	+	4.32	+		+
SR	**Structural Requirements**						
SR_1	Coherence					+	+
SR_2	Conciseness					+	+
UR	**User Requirements**						
UR_1	Comprehensive process and method description	4.60	+				+
UR_2	Guiding poster (Canvas-like structure)	4.80	+				+
UR_3	Include supporting methods for each component	4.60	+				+
UR_4	Prioritization of components possible	4.00	+				+
UR_5	Usable without external expert guidance	4.00	+				+

It can therefore be seen that the main objective of achieving a score of at least 4.0 as a requirement has been met. The results of the focus group workshop are mostly rated higher than the field experiences, except for ER_1 Usability, ER_7 Customizability, FR_2 Improve knowledge about technology and FR_3 Improve use of social capital. Furthermore, the largest differences can be observed in FR_3, FR_5 and FR_6, with a difference of around 0.5 - 0.6. Requirement FR_3 is still rated as not fulfilled by the focus group workshops with a mean value of 3.8. Based on the mean of the field experiments, which is 4.41, the overall mean of these would be 4.11, so it is also rated as fulfilled in the overall rating.

While also qualitative data was obtained by both data collection methods, they were not transformed into requirements to assess the fulfilment. In the context of the field experiments based on the relatively low number of mentions (26 mentions in total, 13 for strengths and 13 for weaknesses) a calculation was not done, but rather were the insights used for the final refinements represented in chapter 6.5.4.3. Further, regarding the focus group the qualitative data was used to improve the current version of the TAS Framework, in order to adapt necessary aspects, to enable a final and refined design of the final TAS Framework. Thus, both data points were used to enhance the TAS Framework, but not transferred into requirements.

6.5.5 Conclusion

The third cycle began with a review and discussion of the evaluation analysis of EE2, focusing specifically on the results of the expert interviews, following an analysis of the evaluation results of Design Cycle 2. The purpose of this reflection was to derive action items to be incorporated into the third version of the TAS. In addition, as the EE2 revealed the need to specifically improve the UX in order to make the TAS framework appealing and tangible for the target group, the researchers, special attention was given to this aspect, resulting in further research activities to gain more insight into the requirements for an improved UX of the TAS framework. Thus, the aim was to enhance the TAS framework in terms of UX by improving its usability through a comprehensive redesign of the canvas elements. This involved situating the framework's design within the HCD process in addition to the DSR approach. This integrative approach facilitated the redesign of the framework by actively involving and centering on user needs within the HCD process, while simultaneously ensuring a scientifically grounded development of a new artifact within the DSR approach. The development of the revised version of the TAS framework was based on the above highlighted expert interviews, where both the content and design were evaluated by professionals. Additionally, a specific focus group workshop was conducted to gather targeted feedback on the visual design of the framework. The insights gained from these evaluations were incorporated into the redesign and further assessed in five additional focus group workshops using a SWOT analysis, resulting in a final refinement of the design. Finally, a field experiment with the intended target group and a survey of the focus group workshop participants were conducted to assess the overall fulfilment of the artifact's requirements,

The outcomes of expert interviews provided various insights into improvement factors concerning both the content and design of the TAS framework. Negative aspects of the visual design, such as perceived overloading and potential overwhelming effects, were particularly identified in the conducted focus group. Additionally, occasional unclear guidance in individual phases was noted. Simultaneously, strengths such as the integration of phase goals and the use of visual highlights and iconography were recognized. Based on these qualitative data, suggestions were derived and integrated into the new framework design. Content-wise, adjustments were made to the tasks, and further tasks were added. Task descriptions were refined and clarified for better comprehension. Visual changes, guided by the developed style guide, were implemented in the color palette, typography, and visual elements. Elements on the canvases were reorganized into a consistent sequence across all phases to ensure continuous orientation. Hence, a pre-final version of the TAS Framework was designed, which was used for further evaluation.

The evaluation took place in two formats: a field experiment with the intended target group, similar to previous settings, and focus group workshops with representatives of the technology transfer nexus. The field experiments were evaluated quantitatively and qualitatively, using the same survey as in EE2 to ensure comparability. The focus group workshops were also analyzed through a qualitative content analysis using the SWOT framework and a short survey, which was analyzed quantitatively. Thus, the quantitative evaluation was used to check the requirements, while the qualitative evaluation was used to further refine the TAS framework, resulting in the final version of the TAS framework.

Focusing on the final refinement, the focus groups portrayed in general a positive picture of the TAS framework evaluation, with praise for the new design in particular. The participants praised the structure and color selection, noting that the streamlined appearance facilitates the framework's use. Another highlighted aspect was the content, which was seen as coherent in its structure, serving the purpose of transforming valuable technologies into applications effectively. The introduction of new methods such as VRIO and Porter’s Five Forces was generally well received. Participants also recognized the comprehensive nature of phases four and five but still considered them valuable additions to the TAS process. However, some potential challenges were identified, including possible comprehension issues in completing the framework alone. Participants suggested revising the task descriptions to provide more clarity and supplementing the associated handbook with additional information and deeper insights into the content of the canvases. The existence of a manual was also found to be explicitly helpful in this regard. Participants acknowledged individual dependency and the subjectivity that comes with completing the framework, as individuals may seek out experts to positively evaluate their ideas. The framework itself cannot prevent such subjectivity as they themselves are responsible for the content produced. Awareness raising among users may be needed here to take responsibility for creating effective content. Another notable point for the TAS framework was the perceived short duration of the timeboxing for individual tasks. Here, it was sometimes misunderstood what was covered by the timeframe, necessitating better communication and revised scheduling. In summary, areas for improvement appear to be minor and focused on improving user understanding. There were no major discrepancies, and the TAS framework was well-received, effectively serving its purpose.

Overall, the results indicate, that the requirements are fully met, and the users are satisfied with the presented version of the TAS Framework. Further, the discussions within the focus group workshops also revealed, that the researchers, as well as entrepreneurship educators and researchers are interested in using the final version. The academic spin-offs acknowledged the usefulness of the Framework, but in regard to their progress, they do not rely on the content anymore, but would recommend it to people who are about to start. Additionally, the results of the survey show that the target group acknowledges the TAS Framework in terms of content and design, which is also represented by a throughout positive evaluation.

Shifting the focus on the design knowledge, the adaptation of such an artifact to the target group and the improvement of its UX in order to facilitate its use and to minimize demotivation is an important activity within a DSR project. From the results of the cycles, particular drawing from the third design cycle, design principles (DPs) can be derived. DPs encompass generic functions and capabilities of designed artifacts (Baskerville & Pries-Heje, 2010), and can guide designers in the design process. Although several DSR projects have contributed to developing systematic approaches to technology exploitation or entrepreneurship practices, little is known about the design principles when technology-based innovation is fostered through the use of a systematic process.

The relevant principles have been developed based on the identified design guidelines derived within the proposal and evaluation phase. Based on the CAMO or CIMO logic, the design principle framework of Gregor et al. (2020) is applied, which suggests to formulate DPs consisting of the "aim, context, mechanism and (if applicable) rationale, and to consider the roles of stakeholders in the relationships between these elements" (p. 28). The DPs are listed in Table 133. DP1 and DP2 focus mainly on the design of such an artifact, guided by the HCD described in Design Cycle 3 (6.5.2.2), whereas DP4 and DP5 focus on the application of such an artifact, guided by the theory of goal setting (see also 6.3.2.1). In addition, DP3 represents the interface between design and application.

Table 133: Overview of Design Principles based on the DSR Project

Building block	DP 1	DP 2	DP 3	DP 4	DP 5
Aim	To achieve acceptance for the artifact	To facilitate a positive user experience	To facilitate goal focused application by ensuring comprehensiveness while reducing complexity	To achieve validated results	To facilitate an efficient and correct use of the artifact
Context	…in the context of technology-based innovation	…in the context of technology-based innovation	…in the context of technology-based innovation	…in the context of technology-based innovation	…in the context of technology-based innovation
Mechanism	…ensure that the target group is involved in the design process	…by considering specific design elements to guide users seemlessly through the artifact	…consider streamlining the layout while retaining essential information	...ensure that external sources and networks are used and exploited	…ensure that supporting material is provided
Rationale	…because gathering feedback on the design prior to implementation is a critical factor in approaching the design process strategically.	…because of the interdependency of content and design.	…to address the complexity of the process and the need to keep it as simple and sufficient as possible at the same time.	…to address the lack of resources of the user(s) and the need to involve external experts.	…to minimize the potential for misunderstanding, frustration and demotivation.

DP1 can be summarized as follows: "The adoption of the artifact should ensure the incorporation of the target group to increase acceptance." The target group of researchers in the TAS framework is a technology savvy audience, most of whom have little business experience - which is reflected not only in a mostly different way of working compared to business, but also in what they are used to working with. Although canvasses are an accepted tool in entrepreneurship (i.e. Osterwalder & Pigneur, 2010), they are not commonly used by researchers. It is therefore important to ensure that the design of the tool does not discourage researchers and that the layout is appealing to them in order to reduce the likelihood of them refusing to use it.

DP2 can be translated as follows: "The interdependency of design and content should be considered when designing the artifact." The third design cycle highlighted the importance of a comprehensive understanding of the TAS process for the integration of appropriate design elements and design decisions, particularly with the incorporation of the HCM method. The evaluation of the expert interviews and focus groups revealed that participants questioned design decisions that did not align with the content, which was a critical aspect of the redesign. It also became increasingly evident from a design perspective that aligning content and design was crucial. This was highlighted through the involvement of additional researchers in the design process. A solid overall understanding was a prerequisite for making the final design decisions.

DP3 can be translated into: “To ensure goal-focused application, it is important to maintain comprehensiveness.” The Goal-Setting Theory (Locke, 2013) which was already incorporated into the first design cycle, suggests that the complexity of the artifact must be appropriately designed to enable the user to work through it in a targeted manner. This was also supported by the recurring qualitative evaluations, which described the artifact as complex and occasionally overwhelming. The TAS process is complex with multiple facets, streamlined in Design Cycle 3 to ensure simple and sufficient layout.

DP4 can be summarized as follows: “External input should be gathered to address the lack of resources and increase data quality.” The TAS Framework guides users through each phase of the process, however, the outcome is only as good as the user's validation of the data collected. Hence, the decisions made within the process must be validated to ensure accuracy. Assumptions are necessary, but the risk of unvalidated decisions must be mitigated. Thus, to effectively apply the artifact, the designer must integrate a prompt to encourage the user to utilize external sources and networks in order to ensure that users obtain validated results.

DP5 can be translated as follows: “Supporting material should be provided to minimize potential misunderstanding.” Frameworks should be accompanied by guiding material to ensure a thorough understanding and efficient utilization. As users differ in their experience and knowledge, as well as their necessity for guidance, they require different kinds of support. Still, the artifact should be kept lean to be consistent with the other DPs. Supporting material can minimize potential misunderstandings, reducing frustration and demotivation. In entrepreneurial environments, artifacts also demonstrate their practical relevance through supporting materials such as Osterwalder's handbook (Osterwalder & Pigneur, 2010), Lau's slidedeck (Lau, 2022), or Hatzijordanou's onepager (Hatzijordanou, 2019).

While the Design Requirements guided mostly the content-related design process of the artifact, the design principles can guide creators to design artifacts in the context of technology-based innovation, at the intersection of entrepreneurship. Still, it is assumed, that these may be applicable in a broader context within the design of artifacts related to entrepreneurship and technology transfer.

7 Conclusion and Outlook

7.1 Summary

Groundbreaking research with the potential to transform our world is hidden in universities and other institutions - this work aims to enable its rediscovery and commercialization for the benefit of society. One particular aspect of working towards this goal is the TAS process. However, this area of research has been largely overlooked and has received relatively little practical and theoretical attention. Its significance has been discussed in various studies, and some researchers even contend that the decisions taken at this stage are of utmost importance for the ultimate success or failure of a project. Researchers, particularly those who lack entrepreneurial experience or knowledge, who strive to commercialize their technology, i.e., by founding a spinoff, can benefit greatly from a comprehensive understanding and guidance of the TAS process to navigate through its complexities.

With the awareness of the challenge of supporting researchers to identify and select most promising applications for their given technologies, the main research question of this dissertation project was derived: "How to support researchers in identifying and selecting promising applications for the given technologies?"

To address this research query, first, an exploration of the TAS Nexus was undertaken, guided by three research questions. The initial question (RQ1) examined challenges and influential factors in application identification processes, while the second question (RQ2) focused on the manifestation and perception of the TAS process in practice. The third question (RQ3) analyzed current TAS processes and their potential for conceptualization of an ideal TAS process. The results of RQ1-3 served as the basis for RQ4, by providing a set of issues of researchers facing when trying to work through the TAS process. Building upon the findings of the previous RQs, RQ4 concentrated on developing a systematic TAS process for researchers, utilizing a design science research method. The artifact, which is called the TAS Framework, has been developed and improved in an iterative manner over three design iterations and has been finalized in its fourth version.

To address the first research question (RQ1), an in-depth systematic review of the factors and challenges involved in the identification of technologies for specific applications was conducted. The investigation of influential factors found several general factors, which are not specifically related to technology applications, but rather to idea generation in general. However, factors such as the search process, customer involvement, clear technological advantage, carefully considered alternatives, information transformation, contact with industry, and contact with the scientific community are particularly relevant, although they have only been highlighted in a few studies (Bishop & Magleby, 2004; Holzleitner, 2015; Rasmussen & Wright, 2015). Nine key challenges were identified concerning the process of identifying technology applications, highlighting the evolving and uncertain nature of linking technologies with potential applications. Overall, within the process, one is confronted with cognitive challenges (Grégoire & Shepherd, 2012), the fuzziness of the process due to a lack of standardization (Lim & Lee, 2019), and insufficient market knowledge (Gruber et al., 2008; Holzleitner, 2015; Vohora et al., 2004). Thus, the findings of the study provide valuable insights into significant factors and difficulties in identifying applications for technologies. This laid the foundation and the necessity for further research in the TAS nexus.

With the second research question (RQ2), the TAS process was investigated concerning its manifestation in practice, together with accompanying challenges and support mechanism. This was accomplished by conducting 45 semi-structured interviews with diverse stakeholders engaged in technology transfer. Two perspectives were considered in this study, one from the support side represented by entrepreneurship educators and technology transfer managers, and the other from the executive side represented by spin-offs and researchers with a potential interest in spin-off ventures.

The study centers on the initial phases of nascent spin-offs and uncovers diverse observations regarding the manifestation of the TAS process in practicality. First of all, it is clear that the practical application of TAS has been somewhat neglected, while focus was set on the occurring challenges and the provided and desired support within the process. This was demonstrated by the relatively low frequency of mentioning how TAS operates in practice, whereas challenges and support for the TAS process were mentioned much more frequently. The results indicate that in current TAS practice customer involvement, continuous improvement, rapid assessment and adaptability is highly relevant. Further, in regard to the challenges perceived, effective communication, compromising the customer perspective, and initial validation are encountered as difficult in the practical implementation of the TAS process. Additionally, addressing knowledge gaps, aligning with the market, and balancing innovative proposals with commercial viability are crucial elements to consider. Also, the transition from academia to entrepreneurship poses certain challenges that require adapting to a business-oriented mindset.

The support mechanisms mentioned vary between coaching, training, and financial support, as well as entrepreneurial ecosystems, networking, methodological support, and awareness-raising. All seem equally covered and desired. Thus, it becomes evident, that overall, a more customized, systematic, and need-tailored support is desired, which is partly available, but the communication lacks effectiveness between the supporting and executing side. The effective implementation of the TAS process necessitates addressing challenges, employing support, and incorporating customer-centric methods, early feedback mechanisms, and iterative refinement throughout the process. The results strengthen previous research, which suggests that the TAS process is an overlooked area in both academic research and professional practice (Finner & Manthey, 2023; Manthey et al., 2022a; Manthey et al., 2022b; Manthey, 2023). To expand on the insights gained from RQ2, deeper theoretical examination of TAS processes was required, representing the focus of RQ3.

The third research question (RQ3) aimed to identify and evaluate existing approaches to TAS in order to develop a conceptual model of an optimal TAS process. This model formed the basis for the design of a TAS framework. By conducting an SLR, eighteen TAS approaches could be identified and extensively explored to differentiate their structure and functionality. Based on this characterization, nine fundamental building blocks for the development of the conceptual TAS model were derived. The analytical approach allowed the construction of a conceptual model based on the identified building blocks and the observed functions and arrangements within the processes. Given the significant similarities in the design and operation of the processes, the nine exclusive building blocks are grouped into three sections: Technology Characterization, Application Identification, and Application Selection. While the Technology Characterization itself can be assigned to one building block, the Application Identification and Application Selection phases are intervened. Two of the building blocks, the product conception and prototyping stages, can be considered optional, leading to a total of seven building blocks integrated in the conceptual model of the ideal TAS process, of which six are within the phases Application Identification and Application Selection. By providing new insights into the structural composition and foundational basis of the TAS process landscape, which has not been explored previously, this study enhances the understanding of the TAS process landscape. It highlights the importance of the foundational design of a model in developing a valid and theoretically sound TAS framework, thereby also providing the basis for RQ4.

The development and design of a systematic Technology Application Selection Framework was addressed by the fourth research question (RQ4). Its intention is, by the means of a TAS Framework, to support, in particular, researchers in identifying and selecting the most promising technology application, guiding them throughout the process and providing necessary steps and methods to encounter their potential lack of entrepreneurial knowledge and experience. Following the DSR approach to tackle the fourth RQ, this thesis derived and evaluated seven functional design requirements, six environmental design requirements, two structural design requirements and five user design requirements (Johannesson & Perjons, 2021) and five design principles (Gregor et al., 2020), contributing to a deeper design knowledge base that can support researchers and practitioners in developing new methodological tools in technology transfer and technology entrepreneurship in the future.

The main target group of the framework are experts from the research field who are familiar with technical terms and the specific context but may not have a conventional understanding of entrepreneurship. This reinforces the need for the framework to be comprehensible and simple in its approach to entrepreneurship principles and practices. Since there has been no equivalent to the TAS framework in the past (Manthey et al., 2022), it is critical to set clear expectations and ensure that it is effectively tailored to the target audience. It is important to recall that the TAS framework is specifically designed for transforming scientific technologies into successful ventures. Therefore, a certain level of expertise is required. Further, the framework is suitable for both individual and group work, supporting both use cases equally.

The initial two renditions of the TAS framework were designed for workshops guided by a TAS framework moderator, concentrating on content review of the framework itself rather than artifact design. Accordingly, EE1 and EE2 were formulated through field trials in a simulated environment, where students advanced through the TAS procedure, utilizing the TAS Framework and predetermined technology presented as university patent explanations. While this adds a practical yet simulated dimension to the evaluation, it is essential for bridging the gap between theoretical understanding and practical implementation. The evaluation episodes were designed with the researchers in mind. But according to the research aligned to question 2, researchers lack initial awareness of the TAS processes and are therefore unaware of the promising applications that can arise from the TAS framework. As a result, they are reluctant to test the purely theoretical framework for fear of wasting resources. Therefore, to address the content improvement first, the evaluation design was a simulated setting within educational workshops. However, to enhance the level of usability for researchers and increase but also test the acceptance towards such a tool, researchers were invited to collaborate in the simulated settings through the provision of their technology to the student teams. The collaborative approach comprised of presenting the technology, procuring all relevant data for a comprehensive understanding, and being readily available as technical consultants throughout the application of the TAS framework. While the researchers were involved in the process, they did not actively follow the TAS process steps themselves. The collaborative sessions' primary aim was to identify potential commercial applications that could benefit the researchers, so they could further pursue the commercialization of the technology. The teams received positive feedback regarding the final application selection, however it is not clear yet if the identified applications will be the final application of the researchers in their commercialization process. To improve the content of the TAS Framework, EE2 further involved interviews with 15 technology innovation managers, aiming to identify improvement factors and areas in the TAS framework, adding insights into the TAS framework's real-world implications and potential applications.

The third version aimed to depart from its previous format. Its focus shifted towards the design of the framework to maintain flexibility for independent editing and use, with the ultimate objective of the framework application in mind. Additionally, the third design cycle primarily focuses on enhancing the UX of the TAS Framework. Numerous challenges arose while designing the framework due to its intricate nature and abundance of content. However, this intricacy is warranted, given the framework's aim of comprehending technology and transforming it into prospective applications. This is a meticulous process requiring adequate content provision.

The preceding version of the framework was criticized for overwhelming users with an excessive amount of content per canvas, necessitating the redesign to streamline the layout while retaining essential information. Despite the challenge of preserving the richness of content while simplifying the design, the repositioning of content, summarization of elements, and elimination of redundant components led to successful outcomes. Even though this study focused primarily on the visual design of the framework, it is difficult to distinguish between content and design because they are inherently dependent. Therefore, a thorough examination of the framework's content was essential for the design process to comprehend how specific design elements could aid users in task performance. Combining the DSR and HCD methodologies in design cycle three was a valuable approach in the overall design process. This consolidation enabled the creation of an artifact that is founded in science and tailored to meet human needs. Collecting feedback on the design prior to its implementation was a critical factor in approaching the design process strategically. It provided a clear insight into the obstacles to overcome and strengths to preserve. The evaluation carried out upon completion of the design and content revisions has revealed minor areas for improvement, which have contributed to further enhancing the user experience. This iterative process of gathering feedback, designing, evaluating, and refining has played a crucial role in fine-tuning the UX, making it more responsive to evolving needs and preferences. Additionally, the positive feedback received during the evaluation served as validation, affirming the successful resolution of previously identified issues. Overall, in terms of design knowledge creation, these findings serve also for the derivation of DPs, which guide designers of such artifacts in their design process.

The artifact consists of a framework as hardcopy in DIN A3 (alternatively as DIN A4), a one-page user guideline in DIN A4 and an accompanying TAS manual delving into the details of the TAS Framework to support users. The TAS Framework provides a step-by-step guideline through five distinct steps, that are sequential and build on each other. Still, each step can be used independently and customized to each own needs and preferences.

While the TAS Framework was created for independent use, it is optimal to work through this framework as a team to enhance commitment, motivation, and creativity. Additionally, a team provides more human resources that can be utilized to maximize the outcomes. Further, the TAS Framework is also applicable in a workshop setting that requires a moderator to guide the process. This moderator is capable of gathering pertinent information from the TAS manual and assisting the team throughout the entirety of the process.

Several usage conditions were identified during the evaluation episodes which enhance the effective utilization of the TAS Framework. It is crucial to customize time management guidelines individually and plan time between phases and steps. Integrating social capital demands time and resources and necessitates appropriate preparation prior to and after integration. Having an open attitude towards entrepreneurial thinking enables ease of use. While entrepreneurial knowledge is not a prerequisite, it can be advantageous to have someone on the team or serving as a mentor to provide assistance with relevant queries or challenges. Teams that approach the TAS Framework with an open mind, willingness to challenge assumptions and a certain level of motivation are more likely to benefit. The framework has been seen as especially valuable during team discussions, making team participation an advantage. The clarity of having all information on a single sheet is also appreciated, as is the need for the framework to be complemented by other tools. Familiarization with the framework, or the use of the provided user guideline, is mandatory.

While the design provides comprehensive guidance to users, additionally, a supporting manual was created. This manual delves deeper into the TAS framework and presents users with a comprehensive understanding, eliminating the need for workshop assistance. However, the creation of this manual is outside the scope of this thesis, but one should acknowledge that one is available. It should be emphasized that the framework does not aim to accomplish the optimal idea in a short period of time. Rather, users should allow for sufficient time for thorough implementation.

In summary, this dissertation satisfactorily answers the main research question and its four supporting research questions. As a result, it effectively simplifies the complicated and uncertain nature of utilizing TAS processes, especially for researchers within technology transfer. Most importantly, it serves as a practical guide for the actual exploitation of technologies in researchers' commercialization efforts, as well as in entrepreneurship education and other activities related to the fuzzy front end.

7.2 Relevance

This research project is of both significant scientific and practical importance. Chapter 2 critically reviews the state of the art and identifies several research gaps, which this dissertation aims to address and provide valuable contributions to the field. Accordingly, this dissertation enhances the understanding of technology application selection processes, particularly for researchers, and thereby contributes new insights to the scientific community in the field of technology and innovation management. As such, the TAS framework provides direction and guidance to address the challenge of implementing a TAS process in a methodical and effective way and to work through the TAS process in a systematic manner. Therefore, the findings of this dissertation make a significant contribution to the field of innovation research, specifically in the fuzzy front end, and provide new insights for technology management research.

This dissertation's goal was to develop a framework that supports researchers in identifying and selecting the most promising applications for their technologies. The Technology Application Selection Framework is a comprehensive framework that encompasses five canvases. Its aim is to support researchers, entrepreneurs, technology enthusiasts and innovators in identifying and selecting promising applications for a given technology in a systematic manner. TAS provides clear guidelines and a user-friendly structure to follow through the necessary steps. In addition, it offers customizability to tailor the framework according to individual needs. The TAS Framework facilitates the acquisition of relevant knowledge by encouraging the collection of data from various sources, particularly consulting experts, utilizing networks, and enhancing social capital. As a result, it supports informed decision-making during the fuzzy front-end phase. Specifically, the TAS Framework can be applied for: (1) Gaining a comprehensive understanding of the technology, including its limitations and advantages, and communicating it clearly and simply. (2) Identifying various alternative ideas for potential technology applications. (3) Evaluating potential applications systematically and comprehensively, including collecting data from personal research and expert interviews, which is necessary to arrive at a final selection of three preferred ideas. (4) Evaluating the selected idea through the lens of the problem and the customer. (5) Examining the market around the preferred idea for decision-making. Overall, this leads to an informed and broad picture of the idea and its application within a broader scope, setting the foundation for further steps in commercialization.

The dissertation project makes three important contributions to theory. Firstly, the artifact designed and the knowledge about its use add significantly to the existing knowledge base, as they provide a solution to a previously unresolved problem, namely the methodological workings of the TAS process (Hevner, March, Park, & Ram, 2004b). The archival knowledge base improves the understanding of the TAS process in general, both theoretically and practically, and particularly benefits technology transfer researchers by providing a comprehensive overview of the current state of TAS practice, its perceived usefulness, support mechanisms and challenges. In addition, through the analysis of current TAS procedures and the identification of the fundamental components of an optimal TAS process, the existing theoretical knowledge on TAS processes is brought together and the foundations are laid for a conceptual model of an optimal TAS process. Thirdly, there are still concerns in and around management schools regarding the development and application of DSR methodology in the field of entrepreneurship. The successful implementation of DSR in this dissertation can thus serve as a benchmark to broaden knowledge in the field and reinforce the application of DSR (Romme & Reymen, 2018).

Further, by employing a DSR approach, a process to guide researchers through the technology application selection process was designed, materialized as a framework with canvasses. It incorporates seven functional DRs, six environmental DRs, two structural and five user DRs, as well as five DPs, making it a comprehensive concept contributing to the body of design knowledge (Gregor et al., 2020; Johannesson & Perjons, 2021). With these, the results contribute to the intersection of design science and entrepreneurship as well as technology innovation management, which is still an evolving field (Romme & Reymen, 2018).

Likewise, the artifact demonstrated its potential to enhance existing entrepreneurship education curricula through field experiments. The artifact is a valuable addition to entrepreneurship teaching and practice. It complements the suggested "adaptive toolkit" approach to business planning (Gruber et al., 2008) and aligns with recent tools utilized throughout the entrepreneurial process, including the well-known Business Model Canvas (Osterwalder, 2004; Osterwalder & Pigneur, 2010).

Moreover, technological advancements and innovative pursuits provide a positive impact beyond the interests of universities and researchers themselves. Correspondingly, technological innovations possess the potential to positively influence society. For instance, existing products and services can become more feasible, efficient, and affordable through technology innovations. Additionally, innovation activities act as a critical growth factor for entire economies. It fosters company foundation, job and knowledge generation, tax revenues, and ultimately increasing prosperity.

In summary, the dissertation holds great significance from a scientific, macroeconomic, and microeconomic standpoint. Throughout the research project, the author encountered considerable interest from innovation scholars and technology transfer representatives. This dissertation is further underpinned by the objective evidence and positive feedback highlighting the importance of technology use within universities and research institutions and its effective management.

7.3 Limitations and Outlook

In the process of addressing the research questions, this project has limitations that are common in research but require documentation. The limitations specific to the expert interviews and focus groups have been outlined in their respective chapters. Nonetheless, it is beneficial to evaluate the main limitations of the overall study design from a comprehensive standpoint, laying the groundwork for future research activities.

RQ1 and RQ3 were based on a literature review using SLRs as a suitable approach. Although there is justification for the methods, there are limitations. The process of selecting studies and extracting data required some interpretation, which may have introduced bias, although a rigorous process was followed. In addition, some relevant literature may have been overlooked due to the predefined search strings. Furthermore, as the TAS Nexus represents an underrepresented area in research, the overlooking of grey literature may have resulted in excluding relevant literature. Furthermore, the potential outcomes of non-technological idea generation challenges and influencing factors were not distinguished within RQ1. Thus, a further study would be required to clarify whether the identified factors are different from those related to non-technological idea generation. Furthermore, the potential bias due to subjectivity is evident in RQ2, although efforts were made to ensure inter-coder reliability by including a second researcher to code independently. Also, the building blocks developed in response to RQ3 were formed after a thorough review of existing practice, and a second researcher was involved in the clustering process, still there is a possibility of bias due to subjectivity. Furthermore, there was no analysis of the interaction between the identified papers, which could potentially lead to a different outcome in terms of the conceptualization of the model and the predefined building blocks.

Further limitations arise in relation to the design of the TAS Framework itself, along with its associated methods and application format. The underlying requirements were based on the findings derived from RQ1-3, as well as literature and previous work concerning the interplay of DSR and entrepreneurship.

However, no standardized approach is known for identifying and determining requirements for such an artifact.

Furthermore, the TAS Framework's intended use is for researchers. Field experiments evaluated the framework in simulated workshop settings. Although these experiments were conducted collaboratively with researchers in EE2, no testing was conducted in a real-life scenario. Furthermore, while additional data collections were included in the evaluation episodes, they remained partially artificial.

For future studies, a possible approach to enhance the usability assessment of TAS frameworks would be to carry out a more immersive evaluation. While the focus groups and field studies with predefined technologies for educational purposes offered valuable perspectives, the participants mainly commented on a brief overview of the framework, lacking in-depth interaction. A future evaluation could involve active participation from the users, where they engage with the TAS framework utilizing their own technology. This approach can reveal challenges that might not have been evident in the current evaluation, offering a more thorough understanding of user interaction and experience. A study of this kind could act as an extra layer of validation and enhancement, guaranteeing that the TAS framework aligns seamlessly with user needs in practical settings.

Further research should explore whether the novel TAS Framework is more effective than current institutional processes within universities and research institutions. This can be evaluated through an A/B test, with one group utilizing the TAS Framework while the comparison group seeks to identify and validate applications with or without existing frameworks provided by their institution. Both groups could present their validated applications to a panel of experts. Additionally, A/B tests could be performed to assess the suitability of specific methods used in the framework, especially as there may be more appropriate methods for certain tasks or target audiences. Overall, A/B tests provide valuable opportunities to compare methods under the same conditions and determine the most effective variants. In any event, because of the inherent restrictions of this study, the TAS Framework ought to be persistently interrogated and improved. In light of the significance of a carefully crafted application that yields well-informed and substantiated decision-making, for the prospects of future success of spinoffs, such an activity is worthwhile to pursue further.

7.4 Concluding Remarks

While risky, resource intensive and uncertain, technological innovations open up tremendous opportunities to bring value into society. The dissertation at hand aims to contribute to closing the existent research gap and to provide navigation in the fuzzy technology-based innovation process, to guide researchers successfully through the TAS process. Primarily, the dissertation should help to reduce the complexity and uncertainty associated with technology application selection processes. As not all steps and methods are equally relevant to all users, the application of the TAS framework must take into account the specific contextual circumstances in order to leverage the value of the technologies.

To support researchers in their forthcoming technology transfer projects with this challenge, the TAS Framework provides a hands-on tool to guide the researchers through the fuzzy front end of technological innovation, enabling them to work through the TAS process efficiently and systematically and come up with a rigor and relevant value proposition on the basis of their technology. However, the operational framework should be thoroughly questioned and continuously refined, due to the inherent limitations of this thesis. The great potential of technological innovations is worth the effort.

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Appendix

Appendix A – Declaration of Authorship

Eidesstattliche Versicherung

gemäß § 13 Abs. 2 Ziff. 3 der Promotionsordnung des Karlsruher
Instituts für Technologie für die KIT-Fakultät für Wirtschaftswissenschaften

1. Bei der eingereichten Dissertation zu dem Thema *Adopting Design Science Research to Develop a Framework for Systematic Technology Application Selection* handelt es sich um meine eigenständig erbrachte Leistung.

2. Ich habe nur die angegebenen Quellen und Hilfsmittel benutzt und mich keiner unzulässigen Hilfe Dritter bedient. Insbesondere habe ich wörtlich oder sinngemäß aus anderen Werken übernommene Inhalte als solche kenntlich gemacht.

3. Die Arbeit oder Teile davon habe ich bislang nicht an einer Hochschule des In- oder Auslands als Bestandteil einer Prüfungs- oder Qualifikationsleistung vorgelegt.

4. Die Richtigkeit der vorstehenden Erklärungen bestätige ich.

5. Die Bedeutung der eidesstattlichen Versicherung und die strafrechtlichen Folgen einer unrichtigen oder unvollständigen eidesstattlichen Versicherung sind mir bekannt.

Ich versichere an Eides statt, dass ich nach bestem Wissen die reine Wahrheit erklärt und nichts verschwiegen habe.

Sarah Manthey

Appendix B – Design of a Systematic TAS Framework

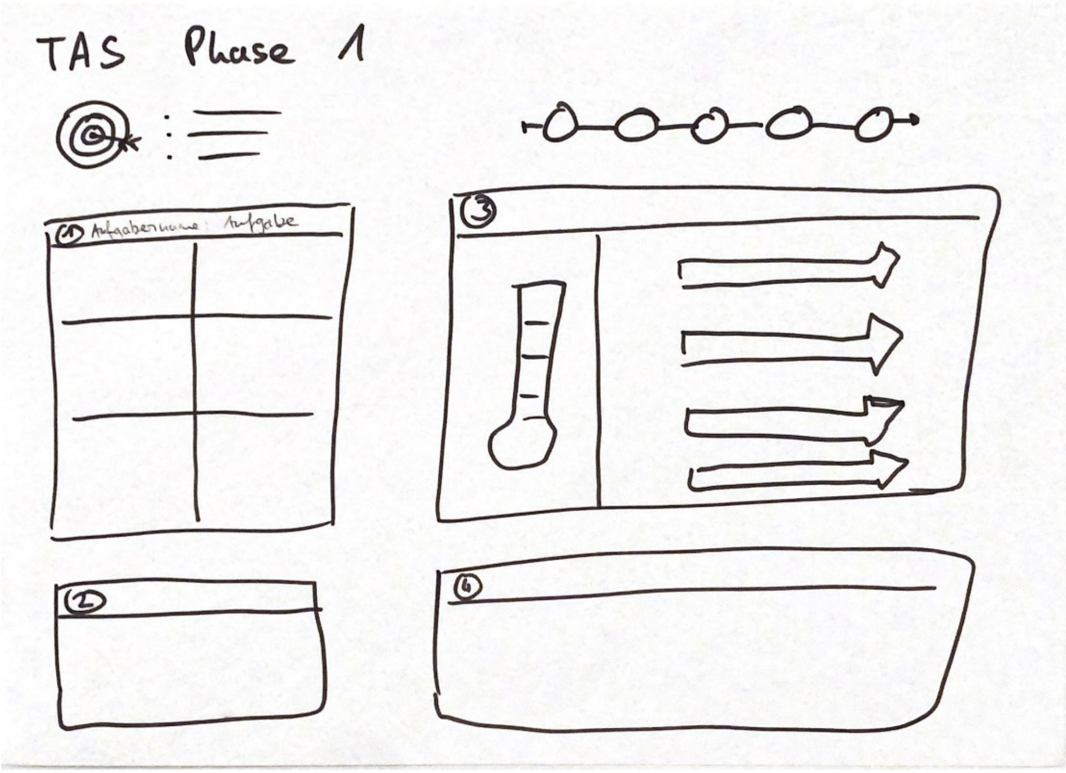
B1 – Design Cycle 2: Expert Interviews – Questionnaire

Expert Interviews - Questionnaire

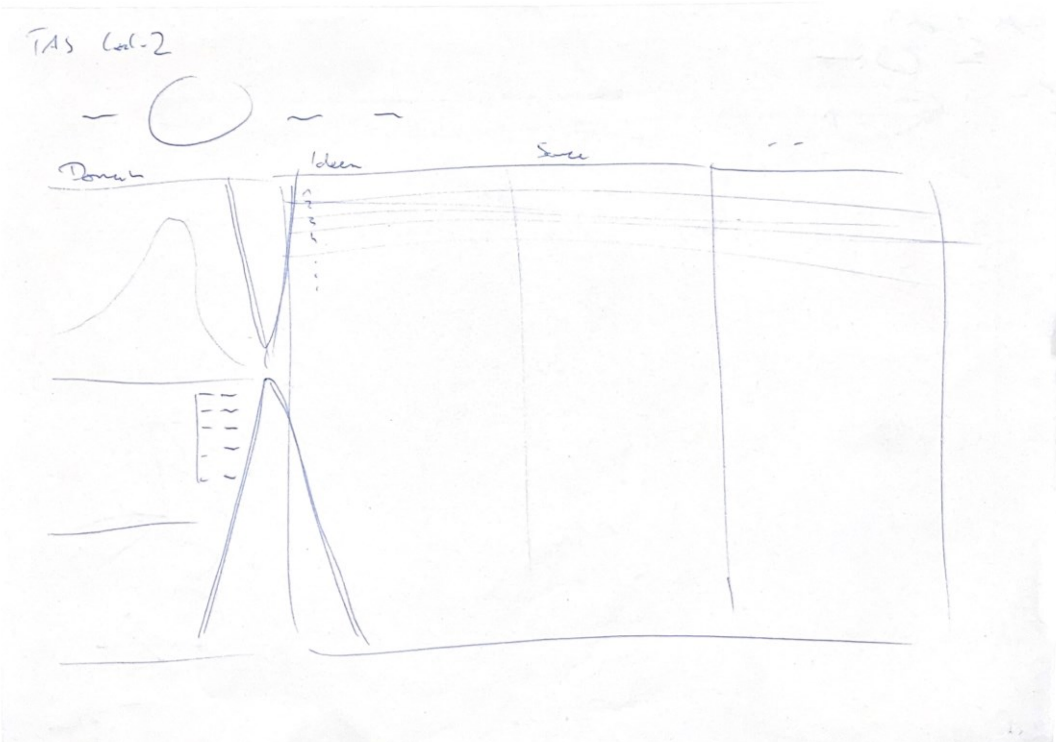
Topic	Interview question	Requirement	Question type
Part 1: Introduction and experience in technology	There are different strategies to bring an innovation to the market, like technology push and market pull innovations, and few practical applications exist for the former. Let's talk about your experience. What position do you occupy? How are you involved in technology transfer? How do you handle technology transfer or technology push innovations in your company? What challenges do you see in this process?		Introductory questions/ Experience questions
Part 2: Knowledge about technology application selection processes	As I already mentioned the TAS framework.... Which supporting artifacts for technology application selection do you know? Do you use them? (if yes in which context/ if no, why not) Who is using the artifact? How are they conceptually designed? What advantages and challenges arise in using such artifacts?		Experience questions
Part 3: The process and content of individual steps	Here is our artifact to transform the technology into a value proposition developed based on existing frameworks and tools transitioned into five phases. Let's go through the individual steps of the TAS! Questions for each step: Tell me your thoughts about this step! Is the step complete? Is something missing? Is something unclear? Does the order make sense to the previous step?	FR_1 - FR_7 ER_1 - ER_7	Open questions/ Yes,No questions
Part 4: Goal	Does the TAS cover all relevant aspects in order to exploit potential applications and select the best one for technologies/fulfill its goal? Is there something missing? For whom can the TAS be of value?	FR_1 - FR_7 ER_1 - ER_7	Open questions/ Yes,No questions
Part 4: Design and content	Do you have any recommendations in order to improve the design? Do you have any recommendations in order to improve the content?	FR_4, FR_7	Open questions
Part 5: Challenges of TAS	At the beginning of the interview, you mentioned a few challenges in using such artifacts… Which of the challenges also apply to the TAS framework? Do you see additional challenges with the TAS?	FR_7, FR_8, ER_5	Open questions
Part 6: Closing remarks /Outlook	Do you have any additional remarks concerning the TAS?	UR_1, UR_2, UR_3, UR_4, UR_5, ER_3	Open questions

B2 – Design Cycle 3: Results of Brainstorm Session (Workshop)

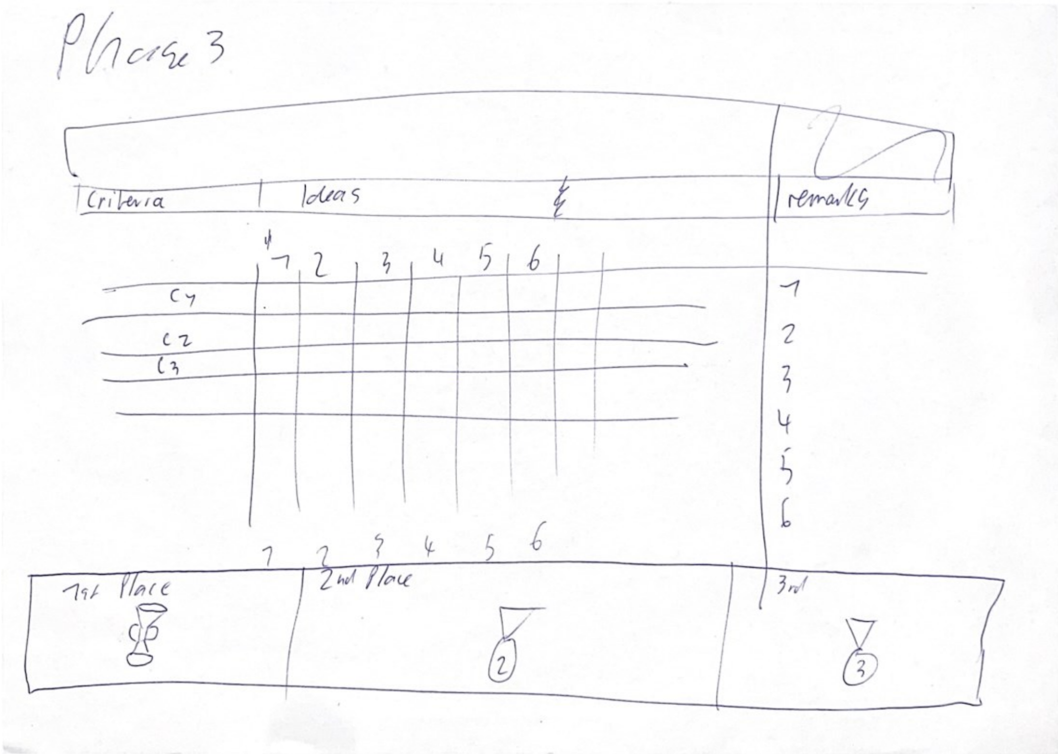
TAS Phase 1



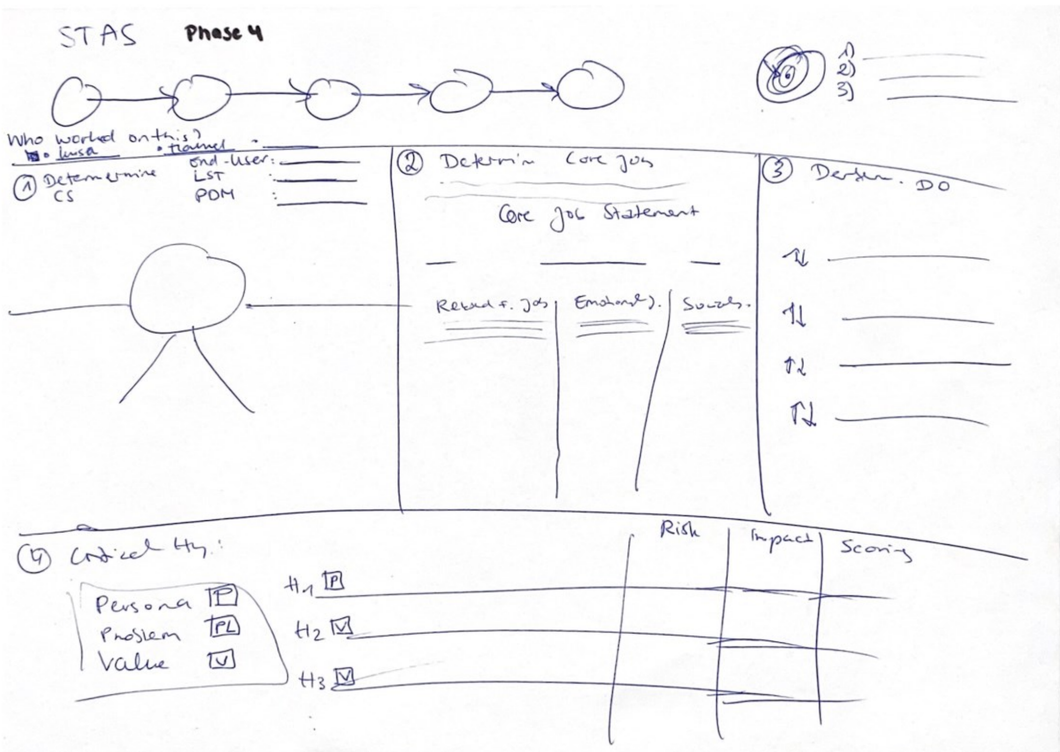
TAS Phase 2



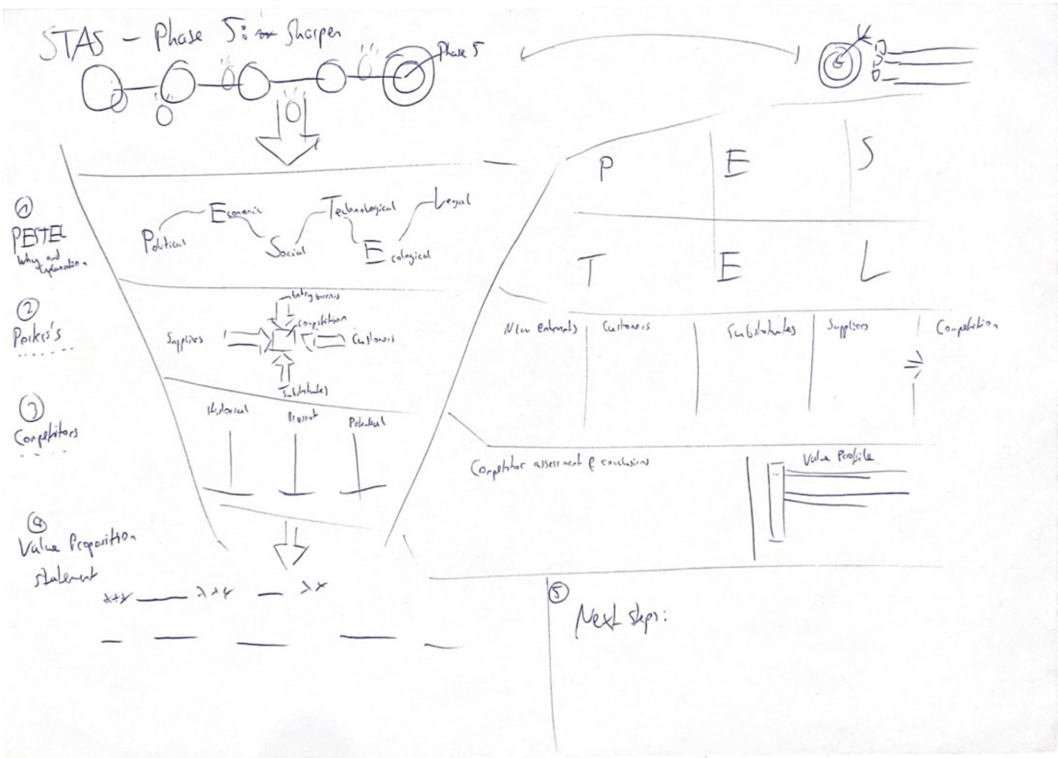
TAS Phase 3



TAS Phase 4



TAS Phase 5


STAS – Phase 5: Sharpen
Phase 5
P
E
S
T
E
L
① PESTEL
Political
Economic
Social
Technological
Ecological
Legal
② Porter's
Suppliers
Competition
Customers
Substitutes
New Entrants
Customers
Substitutes
Suppliers
Competition
③ Competitors
Historical
Present
Potential
Competitor assessment & conclusion
Value Profile
④ Value Proposition statement
⑤ Next steps:

C3 – Design Cycle 3: Illustrated One Pager (TAS Framework)

Technology Application Selection Framework

The Technology Application Selection (TAS) framework is a tool that aims to support the process of identifying and selecting applications for technologies. Use this framework to work through a structured and systematic manner.

Step-by-Step

The TAS consist of a total of 5 phases where you work through the framework in the order provided. While phases 1-3 are foundational and lead you to identify a technology idea, phases 4 and 5 provide deeper exploration and refinement of the chosen idea and serve as valuable but optional extensions. Each step builds on the previous one, enabling systematic development of your technology idea.

Phase 1 Understand — **Phase 2** Ideate — **Phase 3** Decide — **Phase 4** Define — **Phase 5** Sharpen

How to Work

Each phase has its own canvas. The canvas consists of further individual steps, which are to be worked through in the numbered sequence. If individual tasks are not understood, the manual can be consulted.

This framework is a interactive guide. Use the tools and resources provided to sketch ideas, solicit feedback, and iterate. It's okay to go back and rethink things. Technology and market conditions change, and flexibility can be the key to your success. If possible, work in a team. Different perspectives enrich the process and lead to a more mature solution. Nevertheless, the framework can also be worked on alone.

Canvas Explanation

20 min

Timeboxing
The time specification gives you an orientation of how much time you can plan for the individual task. Note that this doesn't include external activies such as interviews or research.

Help in the manual
The icon gives advice to consult further information from the manual. Here you can find more detailed explanations about each tasks.

Interviews

Special Indications
In this type of tags there are separate instructions or tips to solve a task in a more optimized way.

Be aware, that at the beginning a lot assumptions will be made. While the TAS offers structured guidance for the identification of a selected application, it's crucial to engage with the real world: consult experts and collaborate with your team for deeper insights.

Now that you're ready, start with step 1 and make your technology vision a reality! →

For feedback or further information please contact us:
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