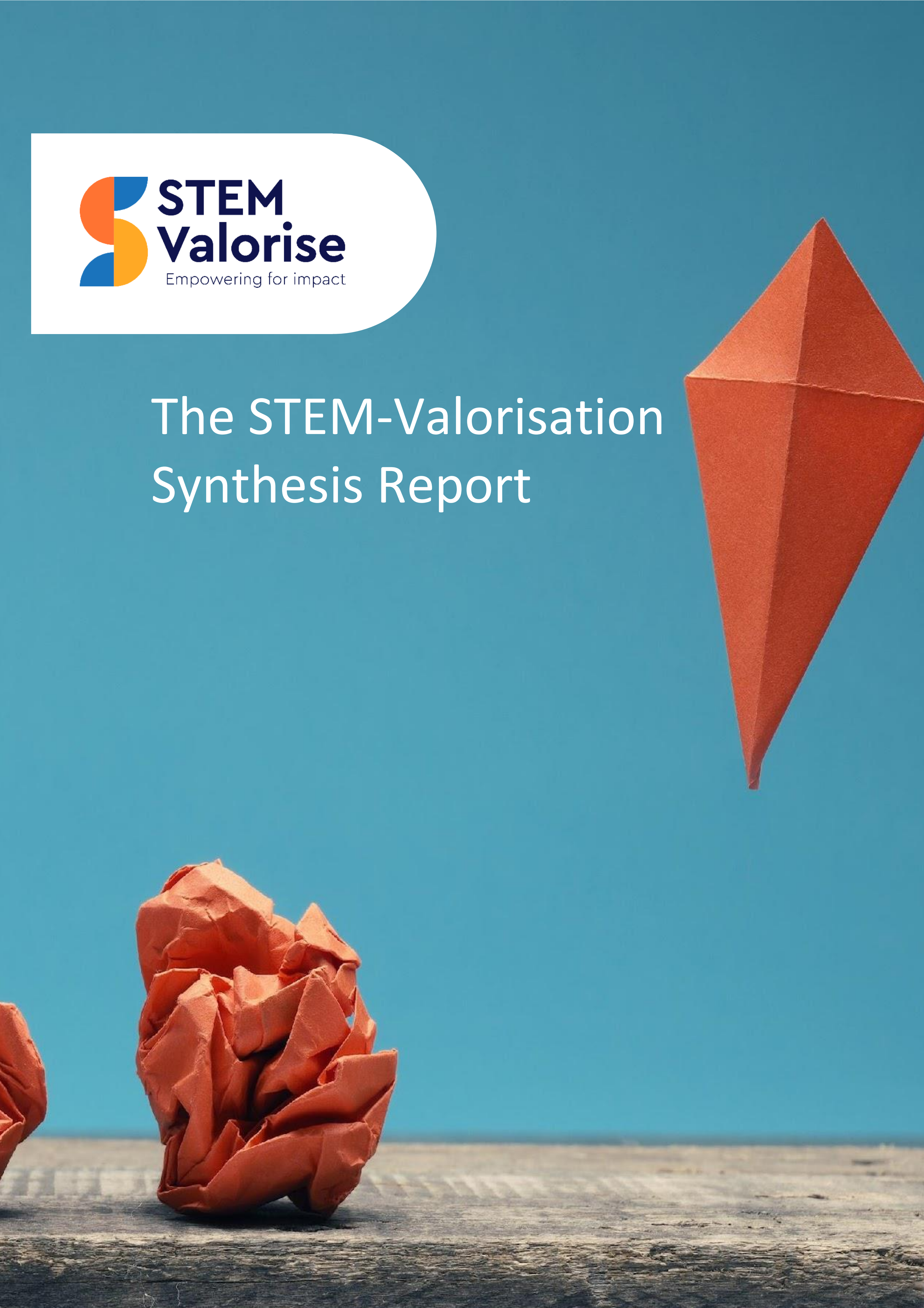

The STEM-Valorisation Synthesis Report

The Valorisation Synthesis Training Investigation Report

The Project Consortium

University Industry Innovation Network

An international leader on university-industry engagement, entrepreneurial & engaged universities and knowledge transfer. They conduct research, organise events and provide training and consultancy services to their community of 80+ organisational and 500+ individual members.

Munster Technological University

A multi-campus technological university, contributing to the region through the provision of academic programmes that support student development and opportunities, education and research. MTU has an extensive and impressive regional footprint with six campuses across the South-West region in Cork and Kerry, and a student body of 18,000.

Institut Mines-Télécom Business School

One of France's major educational and research establishments. IMTBS has a strong connection to a local network of SMEs in both research and education to support SME innovation and providing education for future employees.

Istanbul Technical University

With a historical background tracing almost 250 years, Istanbul Technical University is an institution that plays a leading role in science, technology, arts and sports. İTÜ aims to be the centre of science, which connects the past to the present by producing projects for the future.

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Executive summary

The term valorisation is becoming more utilized and coincides with an increase of requirements for universities to deliver more on their "third mission", to provide service to the community. Valorisation of Science, Technology, Engineering and Mathematics (STEM) research can be understood as a process of interaction between different actors with an aim of creating social benefits from knowledge. Valorisation starts when the research-based data are disseminated to society and practically applied to improve or to develop new products, processes, and services in order to create evident, measurable or observable impact beyond the academic context.

This Valorisation Synthesis Training Investigation Report aims at providing a comprehensive understanding of the need for valorisation and research-driven entrepreneurship training for first stage Science, Technology, Engineering and Mathematics (STEM) researchers. Specifically, the report identifies what is valorisation of research results including defining the term and distinction from similar terms, describing the valorisation process, stakeholders involved in the process, the general barriers and drivers for valorisation and the mechanisms to support valorisation. The report describes the activities that are part of STEM valorisation, and methods or pathways that are part of valorisation process. It examines STEM research valorisation processes compared to other disciplines, such as social sciences and humanities (SSH). The specific barriers and drivers for STEM valorisation and support needed for STEM research valorisation are also discussed.

Moreover, the report expands and develop understanding of valorisation, research-driven entrepreneurship skills and the knowledge needed for first stage STEM researchers to valorise their research. This includes skill deficiencies / needs of STEM researchers for research valorisation. It also illuminates the existing learning frameworks for valorisation of STEM research knowledge, including training offerings and concepts, curricula, and extracurricular programs, for valorisation and entrepreneurship. The report provides a short overview of STEM valorisation in the regional context through the partner institutions' review. These regional overviews specifically identify the unique barriers and drivers as well as other factors effecting STEM valorisation.

Finally, the report provides recommendations for the successful trainings in valorisation of research that serves as starting point for development of the learning framework and content of the modules that will be implemented as part of the STEM Valorise project.

Content

1. Introduction

Valorisation of research is becoming an important concept and has been at the core of various recent initiatives led by the EU Commission. It has been recognised that, while the EU contributes to the scientific output with 22.7 % of all high-quality scientific publications (EU Commission, 2021) the translation of the output into products, services, processes and solutions is lagging. EU member countries have increased their investment in public research systems since 2000 and overall the amount of funding and the number of people in research has increased, leading to improvements in both the quantity and the quality of their scientific outputs, however the valorisation of scientific outputs has not been proportional.

As a result, the Council of the European Union in 2018, called on the EU Commission to develop a strategy for potential uptake of research outputs – a valorisation strategy – that should go with "a multidimensional approach which goes beyond technological transfer and which recognizes the essential contribution of all players involved, including citizens and public authorities" (EU Commission, 2021). Within In recent years valorisation of research has gained considerable attention in policy and strategy development circles both at national and European levels.

The term valorisation is becoming more utilized and coincides with an increase of requirements for universities to deliver more on their "third mission", to provide service to the community. The development of this third mission becomes more prominent as the connection between the development of society and the university sector is emerging, with the "development of the university moulding to the needs of society" (Davey, 2015). As a result, academic research outputs have been widely recognized as going beyond publishing papers alone and modern universities make an impact through "the contribution that research makes to the economy, society, environment or culture, beyond the contribution to academic research" (OECD, 2009). In other words, getting more value from the mostly public investment in research be it commercial or otherwise has become an increasingly important policy goal. Through practical application of knowledge and research outcomes, universities are taking on new roles and are contributing to and promoting innovation, economic growth, and regional development (Brito, 2018; Van Drooge et al., 2013). To explain how universities transfer knowledge, research outcomes, skills and technologies beyond the institutional boundaries to a wider audience, a number of conceptual processes such as "valorisation"," knowledge transfer", "technology transfer" and "commercialisation" have been developed (Davey and Galán-Muros, 2016). While these terms share conceptual similarities, they differ in scope, and this requires further investigation.

This Valorisation Synthesis Training Investigation Report aims to provide a comprehensive understanding of the need for valorisation and research-driven entrepreneurship training for first stage Science, Technology, Engineering and Mathematics (herein STEM) researchers. Specifically, the report identifies what is the process of valorising research results including the following;

- Stakeholders involved in the process.
- General barriers and drivers for valorisation.
- Mechanisms that support valorisation.
- Activities that are part of STEM valorisation.
- Methods or pathways that are part of the valorisation process.
- Specific barriers and drivers for STEM valorisation.
- Supports needed for STEM research valorisation.

The report examines STEM research valorisation processes compared to other disciplines, such as social sciences and humanities (SSH). Moreover, the report expands and develops understanding of valorisation, research-driven entrepreneurship skills and the knowledge needed for first stage STEM researchers to valorise their research. This includes skill deficiencies / needs of STEM researchers regarding research valorisation. It also illuminates the existing learning frameworks for valorisation of STEM research knowledge, including training offerings and concepts, curricula, and extracurricular programs, for valorisation and entrepreneurship. Finally, the report provides a short overview of STEM valorisation in the regional context through the partner institutions' review. These regional overviews specifically identify the unique barriers and drivers as well as other factors effecting STEM valorisation.

1.1 Methodology

The methodology for this report applied the mixed research methods with data collected in four European countries. **The first phase in the research process included an extensive desktop review** of relevant scientific and grey literature with an aim to define **what is valorisation of research results. This desktop review describes** the process; stakeholders involved, the barriers and drivers for valorisation and mechanisms that support valorisation. The literature provided an insight into the national context in each region in relation to the process of valorisation and the supporting structures. The literature review distinguishes between STEM and Social Sciences and Humanities (herein SSH) valorisation of research with a focus on explaining the specificities of STEM disciplines. The literature review considered the existing training models and learning frameworks for STEM research valorisation and identified the knowledge, skills and attitudes required by STEM researchers for research valorisation. This literature mapping provides a **background and foundation** for understanding the skills needed for STEM research valorisation and for the development of training modules for successful STEM research valorisation.

The second phase of research included semi-structured interviews with 40 key stakeholders:

20 Experienced STEM researchers were selected as interview candidates based upon:

- Their proven expertise and experience in university-business cooperation/collaboration.
- Their experience with valorisation of their own research data (successful & unsuccessful).
- Their participation in training models and learning frameworks for valorisation of knowledge.

20 Technology transfer/Knowledge transfer professionals interview candidates were selected based upon:

- Their proven experience with leading institutions that engage with businesses and society in their region.
- Their expertise with the valorisation process.
- Their expertise with development/implementation/evaluation of training models and learning frameworks for valorisation on knowledge.

The third phase of research included the collection of 20 successful case studies on education and training in valorisation and entrepreneurship of STEM data. The case studies were divided in two groups, Traditional Case Studies and Non-traditional Case Studies:

The traditional case studies comprise examples of traditional training, concepts on valorisation and entrepreneurship offerings from various perspectives including:

- Higher Education Institutions,
- Academic Spin Off Offices,
- Technology Transfer Offices,

- Research Institutes,
- Science and Technology Parks,
- Innovation Hubs, incubators and laboratories in companies,
- Industry stakeholders and National Agencies.

Non-traditional Case Studies comprise educational activities that support valorisation of STEM research and enhance the impact of STEM research results, including:

- Start-up programs that incorporate training for valorisation and entrepreneurship education focused on STEM researchers,
- Social networking with either a dissemination or education focus for STEM research results,
- Challenge projects to solve a societal problem where STEM researchers are included and can valorise their research results.

The output of the third phase provides implications and suggestions for the development of successful STEM valorisation training /entrepreneurship training programmes to enhance STEM research valorisation and inform the next stage in the STEM Valorise project implementation.

Comprehensive analysis of the collected results was conducted using NVivo software to code summary interviews and case study data. For the purpose of the individual data protection, names of interviewees have not been disclosed. Informed consent of all interviewees was collected prior to the interviewing phase.

2. Setting the scene: defining valorisation of research data

In the scientific literature valorisation is often referred to as “knowledge valorisation” where value is a specific and important characteristic of valorisation itself. As a result, the “value” of valorisation should be taken in the broader sense as a concept that encompasses the creation of social and economic value, rather than exclusively economic value (Goorden et al., 2008; Hladchenko, 2016; Vilarinho, 2015 in Coutinho, 2020). The type of value created through knowledge utilization makes the essential difference between the terms that are usually applied as synonyms for valorisation. These terms should be acknowledged and understood to arrive at a better definition of what valorisation is.

> *“Valorisation of research data is a process of turning the knowledge we've gained through research into something demonstrably practical, obviously, but that also has a benefit either to society or to a particular industry or the wellbeing or the advancement of people as a whole, whether that is achieved through new products or processes or just through increased learning and knowledge which can be applied elsewhere.”*
>
> **Head of Research Unit at Centre for Advanced Photonics & Process Analysis (CAPPA) at Munster Technological University**

Valorisation and commercialization have been frequently used as synonyms. Both *valorisation* and commercialisation are transfer processes, creating value from knowledge and are used synonymously (see Wubben et al., 2005). Benneworth and Jongbloed (2010) describe an “active tension” between the two terms, where often valorisation is understood only in a narrow sense and is viewed to be the same as commercialization. The commercialization of research results has often been defined as a process that turns “new ideas and/or research output” (Zhao, 2004), or “scientific discoveries and inventions” (Harman, 2010), or “scientific knowledge” (Fini et al., 2018) into marketable products and services. Commercialization activities may involve commercialization of research and development (Galán-Muros et al., 2017; Gascó et al., 2020) such as patenting, licencing, and spinouts activities (Lokett and Wright, 2005; Galán-Muros and Davey 2019). Perkman and Walsh (2008) distinguish between commercialization activities and academic engagement. Commercialization activities are clearly measurable and direct contributions of universities to economic and social development. Academic engagement includes more general knowledge-based co-operations with non-academic actors and organizations.

Academic entrepreneurship may be considered as a form of commercialisation and therefore, as a valorisation of research also. It relates to "the creation of an entrepreneurial culture or start-ups by HEI students or academics" (Davey et al., 2011). Academic entrepreneurship is "the attempt to increase individual or institutional profit, influence or prestige through the development and marketing of research ideas or research-based products" (Louis et al., 1989). It involves a process where researchers, either alone or together with partners, establish companies, commercialize their technologies, and transfer intellectual property to companies by creating patents (Perkmann and Walsh, 2007).

Valorisation is a broader concept than either commercialization or academic entrepreneurship, as it envisions wider contributions to society, or enhancements of societal impact (Benneworth and Jongbloed, 2010; Ngwenya and Boshoff, 2018). Literature recognizes a clear difference in that commercialization is more focused on creating commercial or economic benefits or outcomes from scientific knowledge (Slaughter and Leslie 1997), whereas *valorisation* makes knowledge more broadly accessible for societal stakeholders (Benneworth and Jongbloed 2010). This distinction delineates between valorisation and either commercialisation or academic entrepreneurship, both of which can be considered as narrower forms of valorisation.

Compared to innovation, valorisation is considered to be the broader concept because innovation relates to successfully bringing something new and developed to the market. *Valorisation* often includes a long-lasting chain of processes that include the steps taken through various channels (Bekkers and Bodas Freitas, 2008 in Van Geenhuizen, 2013) to reach an end result and involves close collaboration with various stakeholders. It starts with a first thought (Van Geenhuizen, 2010) about use of a product outside of the academia and about steps to be taken to reach end result through various channels (Bekkers and Bodas Freitas, 2008 in Van Geenhuizen, 2013) and close collaboration between stakeholders. While innovation is focused on the moment when something new is delivered to the market, valorisation includes a more complex and interactive process between knowledge providers and non-academic stakeholders and this interactive process is crucial in all stages (Valorisation agenda, 2008 in Van Geenhuizen, 2010).

> *"Valorisation is whatever work is done in the lab but ends up either in a product that will be produced by a company, or as a new method or a process that will work in practice and society. It is not only the scientific result but includes method or process and benchmarks that can be applied in practice."*
>
> **Researcher, University of Ljubljana**

Valorisation also* differs *from knowledge transfer and technology transfer in respect to the directness and active nature of the transfer/exchange. Valorisation of research data does not always include a technology application but can provide a transfer of knowledge in the form of information and knowledge dissemination, which makes the major difference when compared to "technology transfer". The limited literature on valorisation does explain the different pathways of valorisation compared to the pathways of "knowledge transfer" and "technology transfer". Valorisation in most cases includes interactions between actors in the process of knowledge sharing. This knowledge sharing is usually without precise definition as to whether it is simply finding ways to make scientific knowledge more accessible, or whether it is a more organised form of transfer/exchange. Benneworth and Jangbloed (2010) define it as "the results of academic research available or more easily accessible to increase the chance of others, outside academia, making use of it". In this sense, valorisation is the more modern concept, and it has started to replace frameworks of "knowledge transfer' and 'technology transfer'", echoing the shift from linear production of knowledge and technology transfer models to a non-linear production of knowledge that is transdisciplinary and co-produced by heterogeneous groups (Swan et al., 2010, p. 1311 in Davey and Galán-Muros, 2016).

It is evident that valorisation is the broadest of those conceptual frameworks presented, and it "broadly refers to the multiple ways in which knowledge from universities and public research institutions can be used by firms and society to generate economic and social value and industry development" (OECD, 2013 in Munari and Toschi, 2021).

"Valorisation involves impact created out of knowledge and can be direct like technology transfer and indirect as disseminated knowledge, published in journals or research papers. Valorisation is the creation of value from knowledge."

Director of Valorisation at French Alternative Energies and Atomic Energy Commission (CEA)

Narasimhalu (2012) describes valorisation as a process that creates or enhances value, while Ala, Vilarinho and Portugal C. (2014) describe this value as being both social and economic in nature. This value can be applied and made accessible through activities such as the conversion of research to "competitive products, services, processes and new ventures" (Etzkowitz and Leydesdorff, 2000). Dutch Ministry of Education, Culture and Science described valorisation as the process of developing a value from knowledge by making knowledge appropriate and available for economic and societal use and translating that knowledge into products, services, processes and entrepreneurial activity (Nederland Ondernemend Innovatie land 2009, p. 8 in De Jong et al., 2015).

It is also a process of identifying who would aspire to be an entrepreneur, how to create a link between research and entrepreneurship, and how to create a link between research and the job market. It is a very interactive process. In summary it is important that valorisation is an interactive process and not a simple kind of linear leapfrog where such an interactive process can be perceived as knowledge utilization through interaction (Andriessen, 2005).

> *"Valorisation is the process of creating the link between research inside a university and local community. It is a process to enable and make relationships functional between university actors, society, and business actors."*
>
> **Director of Technopole Eurekatech and Head of Economics, Innovation and Education at Grand Angouleme**

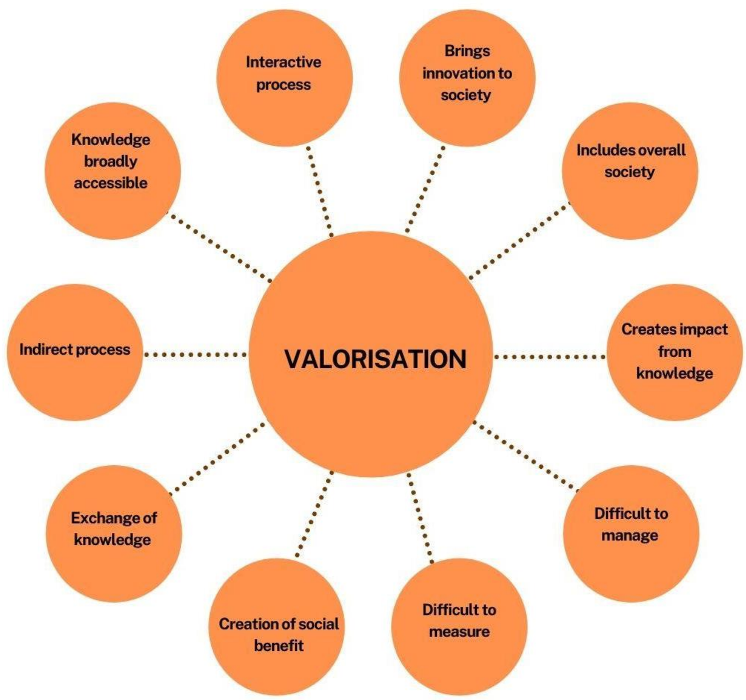
It can be concluded that valorisation has a somewhat broader meaning and can encompass all of the above mentioned terms but despite the increasing popularity of valorisation within the academic and policy circles, some aspects remain unclear e.g. to what extent is the knowledge brought to the market, what is the process for knowledge valorisation and which factors facilitate and hamper valorisation (Van Geenhuizen, 2010). Uncertainty here may be caused by the complex forms that knowledge can take, and this therefore impacts the comprehensiveness of the valorisation of such knowledge, a key objective of the valorisation activity. Van Geenhuizen (2010) highlights some important factors of valorisation "Knowledge may be tacit, it may be codified in journals, patent descriptions, etc., it may be embodied in instruments, machinery and advanced equipment, and it may be embodied in academics and graduates starting a business. At the same time, knowledge valorisation may take many modes, like licensing of a patent to a firm, university-business collaboration to elaborate an invention to bring it to market, graduates working in research departments in the business sector, and spin-off firms engaged in developing an invention towards a marketable product or service" (Van Geenhuizen, p. 2, 2010).

2.1 Main characteristics of STEM valorisation

Valorisation of Science, Technology, Engineering and Mathematics (STEM) research data shows specific characteristics. Valorisation of STEM is focused on demonstrating quantifiable, instrumental impacts of research through tangible products (Williamson, 2016), and it is supported through commercialization activities that result in economic value, such as products, licences, patents, and spin-off companies (Benneworth and Jongbloed, 2009; Olmos-Peñuela et al., 2015; Blasi et al., 2018).

STEM and SSH do not lag behind one another in terms of valorisation, but both have different valorisation characteristics. According to Lakhurst SSH's role is to tackle the social challenges that STEM cannot and then make reference to the growing value placed on interdisciplinarity in research harvesting both STEM and SSH research to address large societal issues as this compartmental approach is not really true in most universities.(Lokhorst 2016). The main characteristics of STEM valorisation are presented below in Figure 1.

Figure 1: *Main characteristics of valorisation*



Source: Adapted from Davey, T. (2015).

The biggest difference between valorising STEM and SSH is that "STEM valorisation often results in products, applications and spin-offs, which have a solid business model behind them" (Lokhorst 2016, p. 38), and STEM is often presented and perceived as more useful than SSH. In general, STEM valorisation is more tangible and concrete in comparison to SSH valorisation (Lokhorst, 2016).

In summary, valorisation of research is a process of interaction between different actors with an aim of creating economic and social benefits from knowledge. Valorisation starts when the research-based data are disseminated to society and practically applied to improve or

to develop new products, processes or services in order to create evident, measurable or observable impact beyond the academic context.

2.2 Stakeholders - who plays what role?

The interaction of actors is at the core of the process of research valorisation (Hladchenko (2016) indicates that those actors may include any individual or any organization. Where the actors are not necessarily specified, there are different typologies of stakeholders involved in research valorisation. The purpose and the role of stakeholders within the valorisation process broadly defines the stakeholder typologies and they comprise ***academia*** (incl. research and technology organisations), ***industry*** (incl. SMEs and start-ups), ***private investors*** (banks, venture capitals, business angels, etc.), ***public authorities*** (incl. public finance) and ***civil society*** (associations, NGOs, etc.) (EU Commission, 2020).

The main actors could alternatively be defined as: the knowledge providers (university, institute), the beneficiaries of the valorisation process (business, industry, government, NGO, public etc); and the intermediary organisations (science financier, knowledge transition facilitator) (Hladchenko, 2016).

Knowledge providers include various producers of higher education knowledge located within universities; academics, institutes, laboratories, etc. Knowledge transfer has become of strategic issue within universities as a source of funding for research and as a policy tool for economic development (Geuna and Muscio, 2009). Academics, institutes, laboratories, and university management serve as a bridge between universities, users of the knowledge and the intermediaries. Bridging is necessary as academics often lack the knowledge, skills and time to go through the entire process of knowledge valorisation successfully. Here the management of a university plays an important role, with the process of valorisation built on cooperative relationships between researchers and university management (Hladchenko, 2016). Other important valorisation actors include the university students and the senior researchers, especially those with entrepreneurial skills, knowledge in innovative processes, technical expertise, creativity or design capabilities to produce a valuable output, and experience in innovative projects e.g., internships (Elia, Secundo and Passiante, 2017).

One example, the French Alternative Energies and Atomic Energy Commission (CEA) from France, illustrates the importance of public institutions for research in valorisation. Here, employees of the institutions are involved in valorisation, including research and development of IP to the direction of technology transfer. According to the CEA director of valorisation, CEA itself does not directly produce innovations, rather it supports different forms of valorisation that comprise part of the mission of the public institution. Therefore, valorisation of innovation is one of the CEA's key objectives. Other CEA's aims target increasing economic competitiveness in France, supporting leading national positions at the global research and facilitating application of knowledge in society. All staff employed in CEA contribute to the process of valorisation, some staff have specific functions in supporting valorisation by other stakeholders and in contributing to the valorisation process in laboratories, helping to deposit patents, helping to detect potential for spin-outs or start-ups, and helping to create identities of innovation.

Beneficiaries in the valorisation process comprise a broad group of stakeholders and can refer to the above-mentioned groups as well as others: business, industry, national level authorities (ministries, agencies, other), regional level (regional authorities), municipalities/local authorities/community, schools or other educational institutions, hospitals, museums, civil society organizations and citizens. The organisational capacity of the municipality and the regional authority is of high importance for knowledge valorisation (Van den Berg et al., 2003 in Van Geenhuizen, 2010) and it "refers to the capability to recognize urgency for specific knowledge and to achieve sufficient commitment for policies that support this" (Van Geenhuizen, 2010). A more structural approach to defining the beneficiaries uses Davey's (2015) explanation of beneficiaries as those dependant on the gain(s) from knowledge circulation in university-industry interaction. University and business cooperation, or interaction, forms part of the valorisation process, and this approach may explain the outreach impact for different stakeholders. As explained, there are three levels of University Business Cooperation (UBC) beneficiaries: at 'Micro' level, stakeholders receive direct outcomes of valorisation (individuals: students, academics, and business staff), at 'Meso' level, stakeholders also receive direct outcomes of valorisation (institutions: universities and businesses) and at 'Macro' level, stakeholders receive indirect outcomes of valorisation (communities: society, region, science, and industry) (Davey T., 2015). The relationship between knowledge producers and the final beneficiaries is mediated by intermediary organisations that also play a significant role in valorisation.

Intermediary structures can involve knowledge transfer offices (KTOs), technology transfer offices (TTOs), business incubators and science parks, research institutes, and policy development departments. These intermediaries generate a pathway for knowledge valorisation by helping researchers and innovators practically apply their solutions, products, and services. They facilitate the whole process of valorisation as they are usually the first contact point for both the researchers and the industry searching for new opportunities. Intermediaries may well play the roles of mentors or coaches, or they may provide networking platforms and examples of best practices and thereby, they additionally boost the valorisation process. Alumni students' associations and alumni networks also play a role in valorisation, and alumni may provide a reservoir of role-models, mentors, financial supporters or partners for projects.

2.3 STEM vs. SSH actors in valorisation

While both STEM and SSH valorisation processes include most of the stakeholders involved in the valorisation of research, some of those actors are more commonly present in the STEM valorisation process than others. The academic knowledge producers lie within the same category for both STEM and SSH and consist of members of universities, such as management, academic staff, students, and internal research organizations (Siegel et al., 2007; Hülsbeck et al., 2013). The key difference is that different faculties or departments are relevant for STEM compared with SSH disciplines.

The intermediary structures in the valorisation are one of the main differences between the stakeholders in STEM and SSH disciplines. Within STEM valorisation processes the main intermediary structures include Technology Transfer Offices (Siegel et al., 2007; Hülsbeck et al., 2013), incubators, accelerators, science and research parks (Rothaermel et al, 2007; Wright et al, 2007), research centres/institutes (Bercovitz and Feldman, 2006; Bozeman, 2000;), and laboratories in companies involving academic and industrial professionals (Bozeman, 2000; Rothaermel et al, 2007; Wright et al, 2007).

The intermediary structures for SSH valorisation remain mostly within the universities. Strong university management support is crucial for supporting partners in having better communication with universities (Stier and Dobers, 2017). Universities also provide good practices and bring other collaborators into projects (Stier and Dobers, 2017). Outside of the universities, administrators, university donors and other regulators are stakeholders in the valorisation process (Benneworth and Jongbloed, 2009). With SSH disciplines the term "intermediary" can be extended to include the likes of university employees (supporting staff), suppliers (secondary education, alumni, insurance providers), competitors (post-secondary education providers, employer training

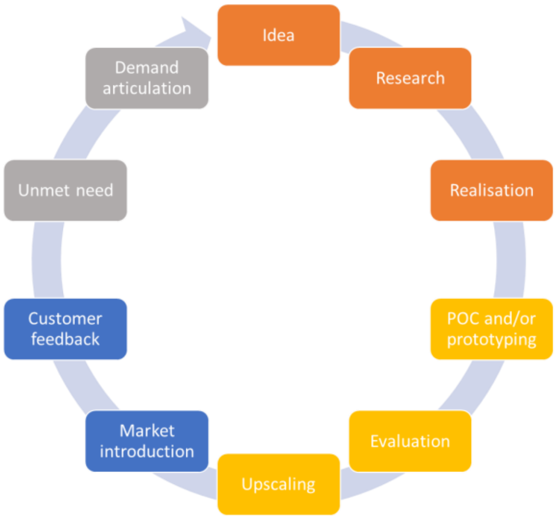
programmes) and clients (students, parents, employers), depending on the breadth of the definition of "stakeholder" (Benneworth and Jongbloed, 2009).
STEM beneficiaries are mainly external stakeholders consisting of government and industry stakeholders who typically engage in STEM valorisation activities motivated to secure innovative products, competent labour and economic growth, to improve public image via marketing, to contribute to the future development of society, and to increase interest and knowledge of STEM education and careers (Andrée and Hansson, 2020). Stakeholders in SSH groups mostly include academics, public, private, and social partner organisations, government, and industry (Uhrig, 2019). Civil society organisations and society in a broader sense also form a new level of stakeholder by combining existing categories (Uhrig, 2019). The role of governments in society is to prioritise the health and welfare of its citizens, necessitating the continued production and collection of SSH research (Stier and Dobers, 2017). Civil Society Organisations (CSOs) have recently been included as full stakeholders in valorisation, initiated primarily by the Norwegian Social Sciences Research Institute. Finally the general citizen is the main and the most important beneficiary, although often forgotten, as revealed in the interim evaluation of Horizon 2020.

2.4 The valorisation process

While it is evident that an interaction between actors is a "*sine qua non*" of valorisation activities, there is limited literature available focused on explanation of the valorisation process. The literature does not precisely explain clear paths for making scientific knowledge more accessible or for describing exact ways to transfer knowledge to beneficiaries. It seems that there are many different options for valorisation, differences for how the process of valorisation can look and different channels that can be used for interaction. No matter the form of valorisation, the key factor is that knowledge is exchanged to create benefit.
Van den Nieuwboer and De Burgwal and Claassen (2016) elaborated on the valorisation process and described the *Valorisation Cycle,* consisting of four overarching phases: Science, Business Development, Market and Society. In terms of "Science", an idea is researched and converted to a patent or publication. Thereafter, in the "Business Development" phase which includes undergoing successful proof-of-concept (POC), the idea/product is evaluated and used for industrial up scaling. This then leads to the introduction of the research product to the market and feedback from users. Finally, "the

unmet need for articulation takes place which feeds back into research" (Van den Nieuwboer and De Burgwal and Claassen (2016). This Valorisation Cycle provides a guideline that links the unmet need from society back once more to science and research.

Figure 2: *Valorisation Cycle*



Source: Van den Nieuwboer and De Burgwal and Claassen (2016).

Another approach that can be used to explain valorisation is the *Stage Gate* process that focuses on the innovation process and is patented and trademarked of Dr Robert Cooper (Cooper and Kleinschmidt, 2001). The Stage Gate uses stages that are separated by so-called "gates" and those can be used as phases in a valorisation process. At each phase or gate, a decision is made whether to continue the process or not, based on the prognosis and information available at that moment.

Phase 0: Discovery is an initial preparatory stage and within the valorisation process this would refer to the decision made by the researcher as to what research result or part/method/process of the research results should be considered for valorisation. It includes interaction with colleagues, university management and potential scientific committee to share the research.

Phase 1: Scoping is about evaluating the potential placement in the market, including (dis)advantages of the part/method/process to be valorised. In the valorisation phase this means the decision whether or not the research result can or should be utilized in the market and made by the researcher in cooperation with business stakeholders. This is the moment to take possible threats from competitors into account.

Phase 2: Research (data) utilization concept development is important for finalization of the actual product/service/method based on the research. This valorisation phase requires assessment of benefits that research results bring and identification of the conditions and functions that must be met to bring the product/process/method to the market. This requires assessment of structures and supports that will be needed to valorise the research (data).

Phase 3: Development where plans from the previous phases are implemented and tested. In this phase, the timeline for further steps is developed together with a prototype.

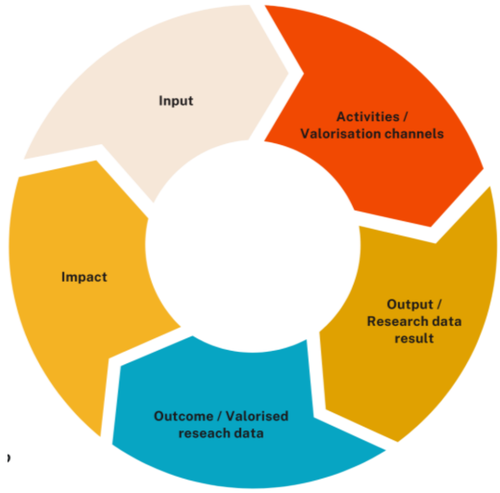
Phase 4: Testing and validation of the prototype includes establishing the manufacturing process, communicating with stakeholders and assessing if the product/method/process is accepted by beneficiaries or end-users.

Phase 5: Implementation is where the dissemination strategy and marketing strategy comes into play. The product is prepared to be launched and this phase requires time, capacities and financial resources.

The Stage Gate process has been documented in case studies analysed for this report. For example, the Stage Gate Process is utilized in the process of research data valorisation at French Alternative Energies and Atomic Energy Commission (CEA), as explained by director of valorisation at CEA. In CEA, there is a department concerning fundamental research that is used to develop key enabling technologies and then to participate in the market, providing a continuum of research, creation of innovation and development of products. In the later stages or phases, if successful, the innovation can be exploited.

Another approach that can be used to better explain the STEM research (data) valorisation process is an adapted application of the University Business Cooperation (UBC) framework (Galan-Muros and Davey, 2019). UBC uses five major elements to explain the valorisation process, and equally, these can be utilised as phases in the valorisation process of research data. UBC clarifies that there are several activities of knowledge providers, both inside and outside of academia (lectures, career services etc.) that are useful in explaining valorisation of research data. However, it is important to emphasise that in the UBC framework knowledge is arising from research itself. UBC is a more circular model than the linear model of Stage Gate (Wholey et al., 2010) and includes several elements with potential to explain the valorisation process and its phases: inputs, activities, outputs, and impact. Some modifications and additional explanations for the UBC process will be presented here to set a foundation for understanding the valorisation of research data in STEM.

Figure 3: *Framework of UBC process applied to valorisation of research data*



Source: UBC Framework process (Davey T, 2015).

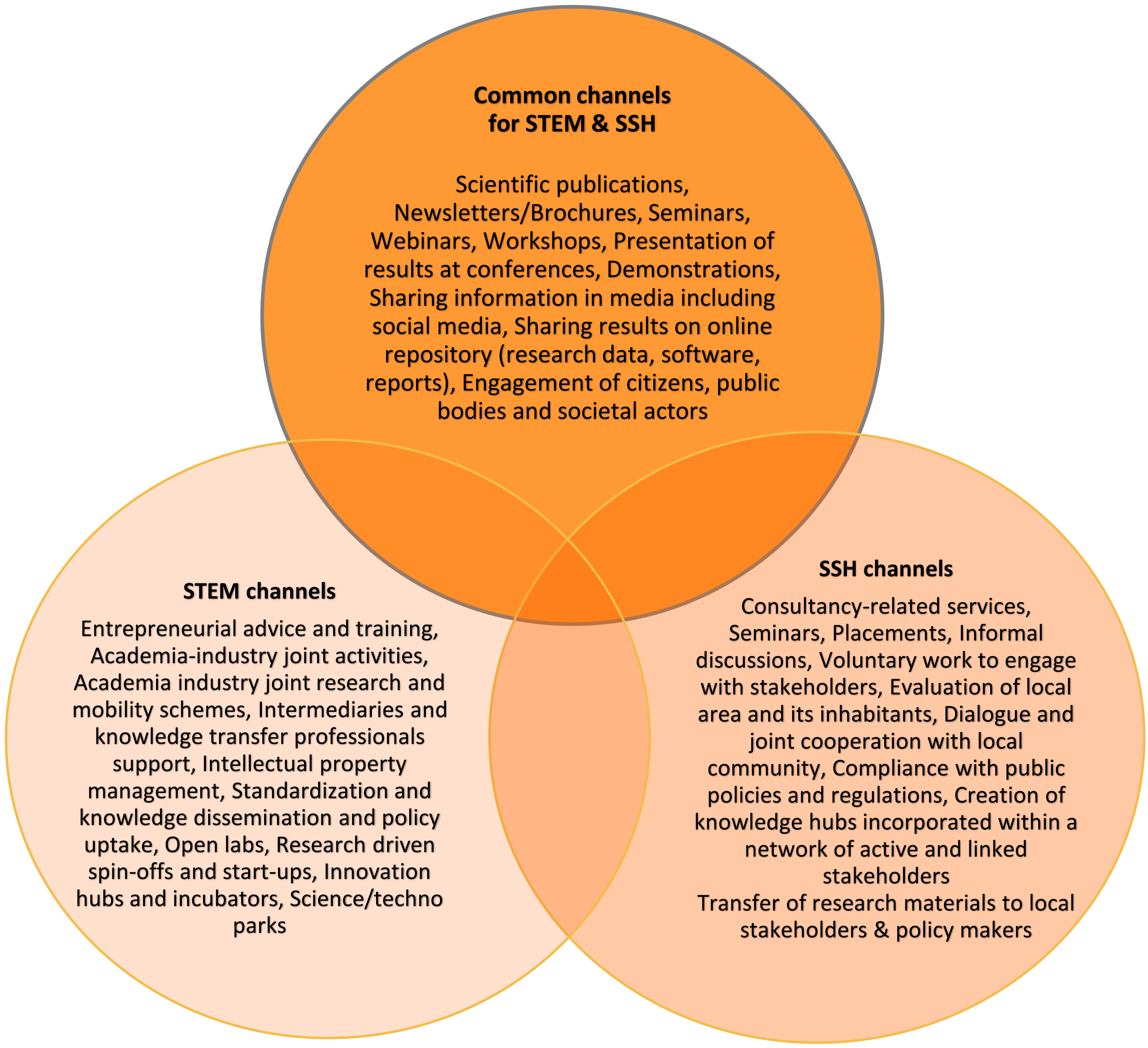
Inputs within the process of valorisation include all available resources that sometimes may be combined and used as UBC activities. These include human, financial, and physical resources (Galan-Muros and Davey, 2019) and each resource provides knowledge that can be valorised. Therefore, inputs can include: HEI staff, researchers, students, lectures, different funding mechanisms, materials, equipment, or facilities (Tartari and Breschi 2012; Carayol, 2003). The STEM valorisation process, when compared to SSH valorisation process, usually requires more financial support since STEM usually includes technology development and innovation.

Activities within the UBC framework correspond to the valorisation channels and these activities can include cooperative interactions and supportive efforts to transfer and exchange knowledge, technology, or other assets, between a HEI, an academic, a manager or a member of any public or private external organization, in both STEM and SSH (Galan-Muros and Davey, 2019).

Channels for valorisation to utilize knowledge rely on their scientific discipline and include scientific publications, newsletters/brochures, seminars, webinars, workshops, presentation of results at conferences, demonstrations, sharing information in media including social media, sharing results through online repositories (research data, software, reports), as well as engagement of citizens, public bodies and societal actors (EU Commission, 2020).

While STEM researchers use more formal approaches and are more market oriented (Olmos Peñuela et al., 2015), SSH researchers tend to use more informal channels to reach end-users, with decreased visibility in the market (Olmos Peñuela et al., 2012).

Figure 4: *STEM and SSH channels for valorisation of research data*



Source: Adapted from the European Commission (2021) and Le Dû-Blayo (2017).

STEM valorisation channels focus more on entrepreneurial advice and training; academia-industry joint research and mobility schemes; supports for intermediaries and knowledge transfer professionals; intellectual property management and standardization and knowledge dissemination and policy uptake; open labs; research driven spin-offs and start-ups; Innovation hubs and incubators; science/techno parks; as well as academia-industry joint activities and STEM consultancies (EU Commission, 2021). SSH valorisation channels focus more on SSH consultancy-related services (e.g. participation in scientific and steering committees of local projects, offering internships for students, offering courses, seminars and publications to researchers); engagement with stakeholders through seminars, placements, informal discussions, and voluntary work, evaluation of local areas and local inhabitants (e.g. considering history, culture, potential and constraints of area), dialogue and joint cooperation with local communities, compliance with public policies and regulations, creation of knowledge hubs incorporated within a network of active and linked stakeholders, other program partners beyond the realms of the research; transfer of research materials to local stakeholders and policy makers e.g. books, handbooks (Le Dû-Blayo, 2017). While there are several interaction processes between different stakeholders, channels in the valorisation process for SSH appear to be less focused on the production of the outputs.

Outputs are direct products, services or other properties that are the result of UBC activity. For the valorisation process of STEM research, outputs are mostly tangible (countable) results based on the delivered research to individuals and institutional stakeholders and the outputs are, therefore, the research results.

Outcomes include results that derive from outputs, tangible or intangible, and that can be experienced, directly or indirectly, over a long time. For STEM valorisation, these outcomes mainly include the practical application of research results (D'Este and Patel, 2007) either through product or service development (Huang and Yu, 2011). By contrast, in SSH, outcomes are more visible in the development of policy, strategy and legal frameworks, and development of different protocols, rulebooks, and various documents. For STEM valorisation an outcome is typically more tangible and development of the outcome requires extra specific considerations. As a Manager of IP intelligence at L'Oréal explains, in the process of developing the outcomes in the short-term term a researcher can easily go to the process of business consideration but researchers also must consider if it makes sense to make that particular product accessible to the market. All market segments must be assessed before the product is commercialized with consideration given to market

> *"In L'Oréal there was a case of the production of biopolymers. It took 10 years, 5 researchers, cost of 2 million euros, and additional side costs for developing biopolymers. At the end the of the process the project was not successful, and investors have been informed that the product is not successful. Instead, the team could offer a similar product to be produced and that was eventually a success."*
>
> **Manager of IP intelligence at L'Oréal**

interest for the product, competitiveness in the market, price of similar products and cost of production. For final successful outcomes, transparency in the process and good communication with business partners, particularly during the development of an outcome, is very important. A researcher must openly present business constraints to the partner, and explain what the possible transfer costs are, and estimate if, within an acceptable timeframe, the researcher can finalize the product and meet the delivery expectations.

Outcomes do not have to be and cannot always be final products. Sometimes, if the production of an outcome is too expensive, or if the process does not go in the desired direction, researchers can offer alternatives to the investor. Such alternatives need not be related to the product outcome itself but can relate to one part of the product or to a production method or some other element that also has a market value. In suggesting alternative outcomes, a researcher can explain to potential business partners the significance and potential market fit to those methods, resources, and processes. Valorisation, in this instance requires interaction in all UBC phases.

A Manager of IP intelligence at L'Oréal highlights that there must be a plan on how to come together to close the gaps. Simply saying that the initial product is the best, is not a good idea. The main goal for industry is to pay as little as possible and for researchers is to sell the best possible products. Negotiation is necessary to reconcile these conflicting aims, and this should be done from the very beginning to avoid failure and unnecessary costs. Negotiation should be a straightforward process that builds trust between the parties and closes the gap between conflicting aims as this forms a main core of the successful valorisation of research.

Outcomes from either the practical application of STEM research results or from making policy changes usually include harsh trade-offs, resulting in winners and losers, because both the business community and policymakers operate in an uncertain world of competing and conflicting interests. Developing an innovative and market-relevant product that fits to a policy relevant framework is time consuming and researchers need to adopt a "business stakeholders' perspective" or a "policymaker's perspective" and to familiarise themselves with the relevant valorisation cycles. The following important parts of the STEM and SSH valorisation cycle are intended to act as a guide for researchers.

Table 1: *SSH vs STEM insights of valorisation cycle*

STEM	SSH

What is general market interest for the STEM research results?	Who set the policy agenda?
Who are the market competitors?	Who leads the policy processes?
What are capacities of business to buy in the research result?	What is capacity of society to use the research results? What capacities should be developed?
What are the financial needs to develop a prototype/to secure IP?	How will issues be resourced?
What structures and mechanisms are needed for a market placement of the product?	What structures and mechanisms are needed to support this different approach?
How will the intellectual property rights will be governed and how to secure long term funding?	How will the project be governed and evaluated?
How to negotiate with business stakeholders?	What is an effective approach to communication with stakeholders?
What is overall utilisation of the product at the market?	How to approach cultural issues in the overall process?
How to measure impact?	What does success look like?

Impact in UBC framework is explained as results experienced indirectly by individuals, institutions, and societies (Kellogg Foundation 2004 in Galan-Muros and Davey, 2019) and in the process of research valorisation, it is a long-term result based on the practical application of the research. The actual impact cannot usually be demonstrated in a short timeframe and using uncertain evidence because large innovation processes may take 10 to 15 years to make real changes (Galleron et al., 2017).

Since valorisation is an interactive process, actors can interact through all these phases, this makes valorisation a broad and comprehensive process. The social impact of the valorisation process should be considered from the beginning in the project design and throughout the process via the establishment of a research network of diverse and relevant stakeholders and in the later stages of the research via the effective dissemination of the results. Collaboration at different stages of the project and among different agents, within and outside academia, is a necessary component of success in valorising research.

It is relevant to note that SSH are reflexive and non-cumulative sciences, contrary to the normative and cumulative structure of STEM so judgments on the value and impact of research can vary depending on the existing different schools of thoughts (Weingart and Schwechheimer, 2007; Ochner, Hug and Daniel 2016). Researchers emphasize that SSH impact cannot only always be assessed as 'return on investment' (Weingart and Scwechheimer, 2007). It follows that seeking similarities and normative solutions to assess SSH research impact is unlikely to produce reliable results because it clashes with the internal diversity of the SSH disciplines (Kuhlmann, 1998). In comparison to SSH research, STEM research data is more measurable and tangible (Galan-Muros and Davey, 2019) and includes patents, collaborations, improved technological solutions, STEM innovations, improved technology processes, and advanced business practices. Innovations in SSH often orient towards "creative", "social", and "civic" innovation rather than product innovation (Pedersen, 2020) and there is a need for improvements in methods, techniques, metrics, and methodologies to better grasp the impact of SSH research (Reale et al., 2018). Within SSH disciplines, the interests and goals of stakeholders must be included in design and review systems, and impactful results can only be achieved in interaction with stakeholders (Galleron et al., 2017). SSH research valorisation is well represented in the specialized literature on political and social impacts. This finding may be attributed to the characteristics of the epistemic communities that are included within the humanities and are traditionally less focused on demonstrating an 'impact' to external stakeholders (Ochsner et al., 2013).

Impact evaluation in STEM is challenging. While numbers alone can help prove STEM valorisation results, they are insufficient to understand all the impacts from and the quantitative data should be complemented with evidence–based case studies (European Commission, 2020).

Further differences between STEM and SSH valorisation of research lie in the areas of coverage, focus, application and measurement of the research results. Therefore, STEM researchers tend to orient their research results at a wider, global level, while SSH researchers have a much higher orientation towards users that are visible nationally and regionally (Olmos Peñuela et al., 2012, p. 5). While STEM valorisation processes produce more tangible outcomes, the valorisation model with SSH should concentrate less upon the "value for money" dimension and more upon finding the ways to stimulate the production and the dissemination of SSH knowledge, a point made by the head of department for the Western France regional branch of CEA Tech (Pays de la Loire, Bretagne). What STEM researchers perhaps could learn from SSH valorisation process is that the focus of valorisation should not be primarily on commercialising research but contributing to the society in less tangible forms.

2.5 Barriers and drivers for valorisation

Studies on drivers and barriers for valorisation of research are mostly at an early stage. However, drivers and barriers for entrepreneurship may provide a fruitful starting point for the analysis. Various barriers and drivers for entrepreneurial behaviour have been identified by Davey (Davey T., 2015) who provides a useful distinction to understand barriers and drivers for valorisation as well.

Relationship drivers had the largest impact on academic tendency to be entrepreneurial, by contrast, personal characteristics and human capital, typical indicators of entrepreneurship for the boarder population, had little influence (Davey T., 2015). Plewa and Quester (2007) identified that satisfaction, trust, commitment and "organisational compatibility" are key entrepreneurial relationship drivers, while at individual level, Barnes et al. (2002) highlighted common commitment and joint direction as a driver for collaboration. For valorisation to occur, researchers require motivation to engage in valorisation processes (Hladchenko, 2016) and the capacities to successfully develop impact from their research. Van De Burgwal, Hendrikse and Claassen (2019) describe motivations of different kinds such as financial, career-related, personal, and moral. Financial motivation comes from monetary gain and is related to the valorisation of one's research; career-related motivation relates to career progression that likely results from taking part in valorisation activities; and personal and moral motivations are intrinsic to the researcher.

Access drivers (Davey, 2015) are another important factor that can influence valorisation of data and include access to research and development facilities equipment and resources (Tartari and Breschi 2012), as well as access to knowledge applied in practise (Van der Sijde, 2012).

Research drivers (Davey, 2015) uncover gaps in knowledge and provide inspiration for research (D'Este and Perkmann 2011), often through exposure to significantly motivating and relevant "real" problems (Meng et al., 2018).

University mission drivers (Davey, 2015) are another type of driver. As previously mentioned, relationship drivers for academics in cooperation with their university, as part of the institutions' mission, increases academic entrepreneurial activities. Further key drivers have been extracted from interview summaries gathered for this report and these are outlined next.

Infrastructure and other supporting structures are important in terms of the university support to STEM research valorisation. Here infrastructure refers to the creation of science parks and valorisation centres, as well as similar organisations that support academics in the process of valorisation. These institutions provide academics with information and legislative support, while ensuring the results of their research are appropriate and accessible for uptake by external actors. Science parks and valorisation centres also provide connections between academics and other societal actors, i.e. the target groups (Hladchenko, 2016).

A clear policy of the institution or research centre is one the important factors for valorisation. Within the institutional policy context, the Head of department for the Western France CEA identifies two key questions: (a) Why the institution is doing valorisation? For example, is it for financial reasons, to take the leading role in scientific research, to create social impact, or for other specified reasons and (b) What technologies or knowledge will be valorised? Not all of an institutional business portfolio can be valorised. Some products are not mature enough or interesting enough for business stakeholders.

A benchmark that is clearly formulated provides important input to the valorisation process. Benchmarking allows a check of the products level of maturity, its competitiveness and if equipment and staff are needed to support delivery of the products. Manager of IP Intelligence at L'Oréal confirms that benchmarking is very important in the STEM valorisation process – when people propose technology they don't know if they have competition. In L'Oréal, the team must know who the competition is, what they do and if they are ahead of L'Oréal or not, "What is surprising in academia, they consider there are no competitors; they see it more as a general background" (Manager of IP Intelligence at L'Oréal) and "researchers tend to think that the process is done once research is concluded" (Entrepreneurship expert from Muster Technological University).

Support for valorisation through official recognition of valorisation efforts has been stressed by PhD students and researchers as an important area. From the experience of the co-founder and CEO of Sparkmate, students are motivated to valorise research when they get European Transfer and Credit System (ETCS) credits for it. Accreditation is best supported through projects in existing university ecosystems, where students combine learning, ideas, and outcomes and engage in co-working spaces and transfer their success to ECTS credits.

Trustful, transparent, and close cooperation with industry facilitates valorisation as it increases interest in the business side of the research and is developed through fruitful cooperation with industry. According to a manager of IP intelligence at L'Oréal, transparency in the process is very important, particularly in the communication with business partner. One strategy lecturer who is co-responsible for Seed Master at the Institute Mines Telecom identifies a main driver for valorisation in the business owner's interest in the. Research. A PhD candidate from Muster Technological University confirmed work with external stakeholders as a driver for valorisation. The availability of researchers leads to closer cooperation and greater ease of introduction when the business stakeholder wishes to commercially launch and everything is easy when business stakeholders want to formalize things. When researchers work with business stakeholders, it is easier to sell products and services, because the content is better (Strategy lecturer who is co-responsible for Seed Master at Institute Mines Telecom).

Interest level of the academic to make an impact in the society by applying scientific research results is a further driver. According to a Professor from Istanbul Technical University, the sense of responsibility of being an academic and the positive societal reputation that academics enjoy are two drivers for valorisation. An assistant professor from Istanbul Technical University lists valorisation drivers as an increased awareness surrounding valorisation, encouragement of academics to not be one dimensional, and collaboration with stakeholders. Another professor from Istanbul Technical University sees inner motivation as a key driver of the valorisation. One PhD candidate at Munster Technological University believes that STEM researchers are usually motivated by research applications and 'real-world' problems. Founder and CSO of Corion Biotech, confirms mixed motivations for valorisation including the possibility to "create your own work" and to develop something impactful for society that is profitable at the same time These were the main drivers for the valorisation process located within the qualitative data. Barriers were clearly defined also based on an analysis of interviews gathered.

Van den Nieuwboer, De Burgwal and Claassen (2016) recognised some **barriers to valorisation**: fundamental research barriers, capacity research barriers, financial barriers, regulatory barriers, collaboration barriers, marketing barriers and product barriers. The literature explains that general barriers to valorisation include shortfalls within the university itself, such as researchers lacking the capabilities to valorise their work and faculty restructuring such as the closing down or reorganising of research groups. Interviewees provided useful information to understand barriers for valorisation. **Ineffective communication between university and industry** was highlighted throughout the interviews as a main valorisation barrier. Ineffective and insufficient interaction with businesses and societal beneficiaries negatively influences the valorisation process. A PhD candidate from Munster Technological University noticed that familiarity with their own research formed a barrier from an application point of view as working at the research for so long might blind them to obvious industry applications. This underlines the importance of ties with industrial stakeholders and underscores that a lack of involvement with industry can be a barrier to application of research. Other barriers identified by a PhD researcher and lecturer on the Seed Master program at Institute Mines Telecom, comprised the differences in perspective and identities between academic and business stakeholders, a lack of mutual understanding, a lack of time and knowledge on the side of business owner, a lack of interest on the side of researcher, a lack of knowledge into university processes on the side of industry, and a lack of interest to reach out to industry by the university. Director of Technopole Eurekatech and head of Economics, Innovation and Education at Grand Angouleme identified the lack of social (inter)connectedness with other bigger areas, either regional or international, as one main barrier to research valorisation. Researchers are working on their own subjects with a link to their local region, so they are not connected with the ecosystems outside of their local campus or community. Therefore, it is important to make more efficient connections between researchers and local communities and establish effective communication. At the global community level, from the words of Manager of IP Intelligence at L'Oreal "you have to be world connected to create value."

Ineffective university procedures for valorisation. University procedures for the valorisation of knowledge can sometimes become a barrier. As the Head of Intellectual Property at Atos explained: if during contract negotiations with a university, there was no mutual understanding and the university wanted more shares than the stakeholder could agree, then the valorisation can be jeopardized. Universities should be aware of fears by investors that the universities, as shareholders, may focus more on return instead of helping the valorisation process, ultimately creating unnecessary burdens. Similarly, university procedures that regulate the establishment of business ventures by researchers could be a barrier, with licensing a common example of this. Universities should recoup some investment, contribute to the level at which the company is being launched, but should not try to build it as their own business or revenue stream He also **confirmed** that many barriers exist in the process of obtaining intellectual property rights (IP). Researchers lack basic information on IP and communications between researchers and universities are characterised by a lot of inefficiencies in IP negotiations. Excessive ‘red tape’ administrative discussions and burdens does not help any party in the valorisation process.

Financial issues and access to venture capital. Regional shortages in financing, such as difficulty accessing venture capital coupled with a lack of knowledge regarding the marketing of products, lead to inefficient valorisation. Director of valorisation at French CEA believes that more financial support is needed to further develop research, and to assist the maturation of technology, especially in the area of technology transfer strategy and support to start-up. Other interviewees have confirmed these barriers. As Co-founder and CEO of Sparkmate explained, compared with the U.S. and Silicon Valley, France, in general, does not provide enough money for valorisation of research. The U.S. government assist in accelerating the growth of existing successful companies, in funding them and growing the U.S. economy at the same time. This contrasts strongly with support practices in France (Co-founder and CEO of Sparkmate).

Long term process of valorisation. A business development manager from the University Industry Innovation Network, emphasized that barriers for STEM valorisation are located in the time-scale needed for the development of technology and for scientific research to reaches the point of valorisation and in the universities’ focus on bibliometrics, instead on taking other initiatives as valorisation. A lecturer from Munster Technological University also observed that for the creation of start-ups to become a successful form of valorisation, it is important that the start-up should be managed well. For instance, 95% of start-ups fail within less than 5 years, because start-up and scaling are difficult processes. Besides needed business management skills and other entrepreneurial skills for start-up and for scaling a business, the challenge is also in finding an idea to ensure that the company will succeed in the longer term.

Lack of time for supporting valorisation and entrepreneurship activities by academics at universities is perceived as a barrier. The barrier for those who have managed to become entrepreneurs and who find that they require more people to support the business is that they lack the time and resources to dedicate to enterprise development. Even for those researchers who consistently conduct entrepreneurship activities, other academic and teaching tasks consume their time (CEO of Tumirobotics and professor at Pontifical Catholic University of Perú).

Lack of knowledge and skills to practically apply research findings has been highlighted as one of the dominant barriers. A Co-founder and CEO of Sparkmate, considers the inability to apply in practice what is being taught in school as a general barrier for valorisation. Studying something that is not directly applicable kills the drive or motivation. Business development manager from the University Industry Innovation Network, confirmed that individual academics go often for what is interesting to them not interesting to business partners. The founder of Neurospector, also considers lack of knowledge and skills as general barriers for valorisation.

It has been documented through this analysis of the barriers and drivers for valorisation of research that the capacities of researchers play an important role. Researchers' capacities to valorise their research data comprise all the skillsets and knowledge that researchers should possess and need to learn to start valorisation of their research. This report next focuses on what knowledge and skills are essential for research valorisation and what are the characteristics of a successful learning framework for valorisation of research results. This will be elaborated in the following chapter.

3. Knowledge, skills and attitudes

Learning falls into one of the three categories: knowledge, skills, and attitudes. Knowledge, skills, and attitudes relate directly to *Bloom's Taxonomy* of Cognitive, Affective, Psychomotor (Laird, 1985, p107) consisted of three domains Cognitive – Knowledge, Affective – Attitude and Psychomotor – Skills that we found useful for adopting to this chapter of the report Cognitive domain consists of six levels, the Affective of five levels and the Psychomotor of six levels. Those levels are: remembering, understanding, applying, analysing, evaluating and creating. Knowledge is defined as the cognitive and mental abilities used to retain and process information. Skills are the abilities used to perform activities and tasks. Attitudes relate to feelings or to emotional states about something or someone. When a person learns facts and concepts that falls under the knowledge category, when they learn how to do something that falls under the skill category and when they form a new or a different viewpoint or belief that falls under the attitude category. Cantera (1999) explained that certain knowledge, skills, and attitudes as well as defined personal characteristics – may, as a set, favour success.
Typically, most training focuses on the development of knowledge and skills, as those two are easier to observe and measure. Attitudes are the least addressed by training as they are most difficult for people to develop and are hardest to measure. All three categories are very relevant for education programs targeting valorisation of research and hereafter, specifically defined as "knowledge, skills, and attitudes for valorisation". Thus far, they haven't been significantly addressed in literature. In this report, we summarise what can be discerned regarding the knowledge, skills, and attitudes that are important to increase the human capital of early-stage STEM researchers and thus to increase the rate of valorisation.

> *"I think that STEM researchers need to be the champions of their ideas, they understand the novelty and potential impact of their work most deeply and their buy in is necessary for any research translation. But they often require additional training support from either external mentors or an in-house technology transfer team."*
>
> **PhD Candidate, University College Cork**

The knowledge, skills and attitudes that are required for valorisation of research tend to be even more unclear than the meaning of the term valorisation, itself. As explained earlier, depending on the definition, valorisation in the literature is frequently related to entrepreneurship and therefore the knowledge, skills and attitudes for valorisation are usually narrowly equated to the knowledge, skills, and attitudes for entrepreneurship. In this chapter we will provide an overview on knowledge, skills, and attitudes for entrepreneurship alongside the limited available literature on valorisation knowledge, skills, and attitudes, as well. We will further present the analysis of the data derived from interviewees, which provided some important insights into the knowledge, skills and attitudes needed for valorisation of research itself.

3.1 Knowledge and skills

Knowledge can be transferred from one person to another, or it can be self-acquired through observation and study (Kightley et al., 2013). Skills are manifested in adequate implementation of a task but appear also in the design, and the overall approach to task execution (Suárez, Dusú and Sánchez, 2007). Knowledge for valorisation refers to the process of making scientific/academic research available for practical use (Behrens et al., 2021). An examination of the literature did not provide conclusive indications of what knowledge would lead to STEM researchers valorising more of their research. Similarly, there is a limited literature explaining important skills needed for valorisation of research data. Some sources derived a list of the needed skills based on important activities within the valorisation process. Datta, Reed and Jessup (2013) highlighted that collaboration, competence analysis, innovation protection, design and manufacturing, pricing and distribution are the important skills for STEM researchers to practically apply their research data. Butter and van Beesr (2017) explained an elaboration of the "FINCODA", an EU funded Framework with an Innovation Barometer Assessment Tool, that identifies five dimensions important for entrepreneurship and these are closely related to knowledge and skills that STEM researchers should develop. The five dimensions include creativity, critical thinking, initiative, teamwork, and networking (Butter and van Beesr, 2017). Effective encouragement of entrepreneurship within students and academics would entail a greater educational focus on technical skills and business management skills. Technical skills include written and oral communication, technical management and organizing skills while the business management skills refer to planning, decision-making, marketing, and accounting skills (Acharya and Chandra, 2019).

> *"Discovering needs of society and finding out relevant solutions and opportunities to meet those needs through the research is at the heart of the STEM research valorisation process."*
>
> **Rector at Istanbul Technical University**

As limited studies were found showing the benefits of specific knowledge and skills for valorisation, we now examine a closely related field with at least some robust evidence coming from analysis of available literature and conducted interviews.

Visionary approach is needed for valorisation of data and scientists who are thinking of starting a company or making an impact based on their research and clearly identify the problem they are aiming to solve (Snellman and Suominen, 2021). The co-founder of Sparrho elaborated that the visionary approach in academia is still skewed towards novel innovations that are publishable, but the entrepreneur's realm is about commercial applications and impact where the range of impact is slightly wider and requires a broader visionary approach (Snellman and Suominen, 2021).

Understanding of Impact that STEM research data can achieve in practice has been recognised as key knowledge that most researchers are lacking. The Rector of Istanbul Technical University highlighted that STEM researchers mainly lack capacities in relating their ideas and research data to real needs. They may lack market awareness and knowledge of income generation models. The Rector of Istanbul Technical University pointed out that STEM researchers are always inspired by new ideas and solutions, so they are knowledgeable about the emerging technologies, and are innovative and analytical. They must improve their societal or market need analysis abilities to be more capable of valorisation of their research ideas. This lack of knowledge on how to valorise their research data at some university environments may be linked to a lack of an interdisciplinary approach provided for STEM researchers. STEM researchers are provided with few opportunities to think about the potential application of their data in other disciplines. According to researchers at ITUNOVA, a technology transfer office at Istanbul Technical University, STEM researchers sometimes have insufficient skills and knowledge in the following areas: environmental impacts, safety, general impact and ethics. They explained that STEM researchers need some cross-disciplinary training in social sciences and humanities to better understand those areas. Moreover, researchers are usually not fully aware of the impact and benefits for society that research can make if valorised. There is a need for training related to research impact to clarify for researchers how a specific project/invention may help be used by people and by society.

As a lecturer from Munster Technological University explained, STEM researchers need to see the potential application of their research. They need to question why they would put so much effort into a specific research question if they have not previously thought about how it will help people in practice. Another lecturer, from the same university, pointed out that STEM researchers are usually motivated by research applications and "real-world" problems, and this is a benefit when it comes to research valorisation. Major knowledge and skills that would improve STEM researcher's valorisation, according to the Rector of Istanbul Technical University, include communication, personal relationships, negotiation and business skills. A summary of the most important skills and knowledge for valorisation of STEM research is presented in the following paragraphs.

***Development of a business model* and skills for its application** in practice have been defined by Åstebro and Hoos (2021) as important to improve entrepreneurial outcomes. Lean start-up and design thinking identified as important learning methods (Åstebro and Hoos, 2021). Entrepreneurs' skills include effective judgment abilities that link profit and the firm to uncertainty (Klein and Bullock, 206). From the opinion of one senior lecturer from the University of Huddersfield, most academics lack entrepreneurial and business planning skills, which makes valorisation a one-way street, often sparked from entrepreneurs or someone from industry who has very specific needs. As a lecturer from Munster Technological University explained, STEM researchers need to acquire skills in development of a business plan related to their area of interest. One Program Director at LifeSciences@Work believes that they must increase their knowledge in developing business strategies and business tools that can help them explore whether their idea is feasible and desirable. Founder and CEO of Corion Biotech S.r.l., an academic spin-off at University of Torino, stated that both business and scientific backgrounds need to be present in his team, and that it is important for scientists to gather an understanding of how a business works. Some training programs recognise these needs and aim to help young entrepreneurs raise their business model development skills to help them develop their business ideas and to get financial support. One example of this is the BIGG training program from Bilkent University.

A senior lecturer from University of Huddersfield believes that the ability to read a research paper and draw a connection between that research and a commercial solution is essential to enable STEM researchers to apply research to real world challenges.

Practical skills on how to work with different stakeholders, including industry, government and society has been marked as important by many interviewees. A senior lecturer from University of Huddersfield considers that practical experience with industry is essential. He explains that having worked with industry and knowing people who still work in industry, enables you to understand their thinking and gives you more perspective on what kind of research and solutions will find more acceptance within industry.

Decision-making skills, and in particular, entrepreneurial decision-making skill has been identified as influential by Camuffo et al. (2020). In a randomised controlled trial, they taught entrepreneurs to use "a scientific approach" to data collection and decision making under uncertainty. Camuffo et al. (2020) found greater revenue and survival among the treatment group using scientific approaches in the months after the intervention compared to those randomly assigned to the control group who received a typical incubator experience.

> *"The business mind of the academicians participating in the training is a challenge. Academicians may be impractical at the decision-making stage and difficulties may be experienced in researchers communicating with business."*
>
> **Manager at Sabancı Inovent Entrepreneurship Project**

Problem-solving skills are important skills recognised both in literature and by interviewees. When selecting individuals to join their team, a co-founder and CEO should first look for people who are good at problem solving, it is an important and practical valorisation skill crucial to getting things done (Snellman and Suominen, 2021). A former PhD researcher and a co-founder of Sparrho, confirmed the essential nature of problem-solving skills for entrepreneurship and valorisation. At the same time, a former PhD researcher and now a co-founder of the IQM Quantum Computers, explained a key difference in that although a good scientist needs strong analytical skills, being a good decision maker is vital for an entrepreneur as they sometimes needs to act very quickly, without asking detailed questions because there's no time for it (Snellman and Suominen, 2021).

Communication knowledge and skills to communicate to different audiences are also required, as entrepreneurs they must precisely articulate a plan or idea, have an ability to develop a broader vision and to get 'buy in' from others. One researcher at ITUNOVA TTO, explains that STEM researchers are especially strong in their technical areas, and they need assistance in terms of expressing themselves to the general public. The prosperous entrepreneur is proficient in communicating these models to others, who then come to share the entrepreneur's vision (Klein and Bullock, 2006). A former PhD student and a Co-founder of Sparrho, stressed that the biggest learning curve for a researcher involves mastering communication to different audiences. In academia, researchers usually talk to scientists and people with a similar background. Entrepreneurs talk to a wider audience, from investors to politicians, who may not be scientifically minded. As a lecturer from Munster Technical University explained, STEM researchers need the deep theoretical skills, but they also need the soft skills, which is a complementary skill set. There is a specific language of business that scientists won't have developed so that needs to be learned. Further necessary skills include business sensitivity and scientific writing ability. A head of research programs within Science Foundation Ireland confirmed that most STEM researchers can describe their work very well in terms of the technology and the science, but they will struggle to explain who they are going to serve or for whom their work will create value. Communication skills and the ability to articulate what you are doing and whom you are doing it for are important requirements. "In our programme we use a book called 'Talking to Humans' where STEM researchers exactly learn about these skills", head of research program within the Science Foundation Ireland emphasized. This is confirmed again by the Founder and CEO of Sparkmate, and he considers that besides the skill of communicating with different audiences, networking skills are equally important, especially in terms of networking with supporting clients. This can become a decisive skill if the STEM researcher is interested in valorisation of their research.

Negotiation with business requires an advanced level of communication skills and it has been recognised by interviewees as an important skill for researchers in the valorisation process. The founder of Neurospector, explained that the Amsterdam-based ACE Incubation Programme allowed researchers to get insights into how entrepreneurship works and was particularly useful for her research. However, she needed additional support in the process of establishing the company and in negotiation with industry. A senior research fellow at University of Huddersfield explained that even though a gap exists in understanding between academia and university due to the different mindsets in industry and academia, it can, of course, always be reduced. The key is communication between the two parties. Establishing of a channel to discuss and meet on a regular basis is the most effective way to bridge this mindset gap and to share perspectives on how a specific technology, developed by academics, can be useful for that company. STEM researchers needed more training on how long the negotiation phase with university/TTO may be expected to take, and what needs to be organised to accomplish this. The Manager of IP Intelligence at L'Oréal considers a negotiation with industry as the main skill that STEM researchers should master. Without that specific skill a researcher can get lost in the different procedures and requirements from the specific industry,

> *"The main purpose for an industry is to pay as less as possible and researchers to sell the best possible products. This is mindset necessary for valorisation of research data and the core in negotiation with industry."*
>
> **Manager of IP Intelligence at L'Oréal**

negatively impacting on the effectiveness of the negotiation process and resulting in an unsuccessful end.

Knowledge on intellectual property rights has been recognised as important for STEM researchers. Founder and CEO of Corion Biotech S.r.l, explained that in STEM research valorisation, the resulting patents are the main assets of a biotech company. Sometimes it can be challenging to deposit a patent. This point has often reoccurred and been emphasised by many other interviewees. A head of department for Western France of CEA, highlighted that if a researcher wants to set up a start-up and work for that company, then it is good to have basic knowledge of IP. There will always be experts in an organization who can help a researcher solve problems that are not in their own field of their expertise (e.g., IP, entrepreneurship, management etc.) but some basic knowledge is desirable. It is extremely important for STEM researchers to understand how IP works and how research results can be protected. The manager of IP Intelligence at L'Oréal highlighted that not every STEM research result is adequate for the declaration of an IP patenting process. IP is a very expensive and comprehensive process and knowing the right moment is sometimes crucial and that, he said, is the knowledge and skill that STEM researchers need.

Based on the limited but emerging literature review and information coming from interviewees, it can be concluded that some major knowledge and skills important for valorisation of research data include a visionary approach, an understanding what impact STEM research valorisation can achieve in practice, the development of a business model and skills required for its application, decision making skills together with problem solving skills, communication knowledge as well as skills to communicate to different audiences (closely linked to successful negotiation with business), and knowledge about intellectual property rights. As the President at Bioproperty, a strategy group summarised: "In addition to business understanding, critical skills STEM researchers need to be exposed to are inventiveness and to identify the attributes that lead to uniqueness, market relevance, and, sequentially, to investment. Another key point, and perhaps even more important, is the mindset: helping them understand that life is not a linear process. This is the real secret to success, to acquire real attitude and spirit, how to think about it and how to react to challenges, for example, given the high probability that inventions are not pursued, researchers would need to understand why and find the pathways to overcome it, make it work and find the place the inventions can fit in."

In the following chapter some additional information will be presented on desirable attitudes of STEM researchers in their approach to valorisation of research data.

3.2 Attitudes

Attitudes, sometimes called abilities (Manzanera-Román and Brändle, 2016), are elements of an individual's personality that enable the execution of tasks and determine the successful development of such a task or activity. Olaz (2011, p. 610), defined them as "the potential associated with the natural characteristics of the individual to manage certain situations". Some literature on attitudes important for entrepreneurial education can help understand the attitudes for valorisation as well. In assessing different approaches in development of the entrepreneurial attitudes or valorising researchers, the usual question has been raised by practitioners and scholars: can an entrepreneurial spirit be achieved and enhanced through education and training, or are entrepreneurs just born to be entrepreneurs or born with traits that allow them to act entrepreneurially (Klein and Bullock, 2006). An interviewee for this report, an entrepreneur from Incubator HEC Paris, stressed that there is no particular entrepreneurial attitude or "an entrepreneurial spirit" but every human is an entrepreneur, and that attitude only needs to be encouraged.

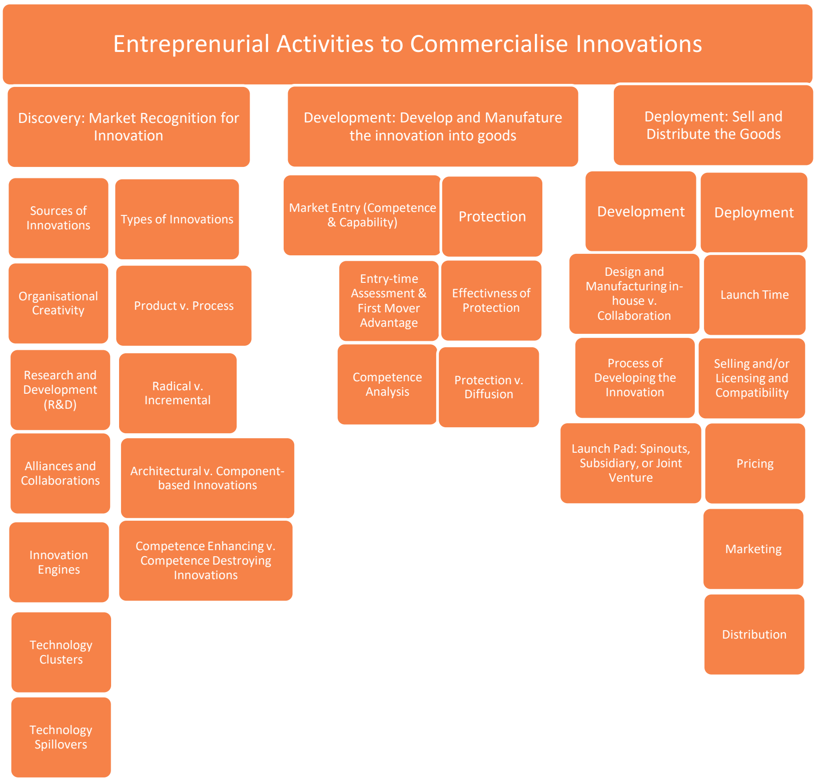
Again, while the attitude toward valorisation hasn't been specifically addressed within the literature, the academic management literature associate's attitudes toward entrepreneurship with characteristics such as boldness, daring, imagination, or creativity (Lumpkin and Dess, 1996). Moreover, the literature points out that when it comes to attitude, education should encourage development of personal entrepreneurial skills, including inner control, innovation, risk taking, persistence and being change oriented.

Persistence and devotion to the long-term objectives are also generally important. The successful entrepreneur can expect to experience failure a lot before they become successful and therefore the emotional ups and downs are similarly condensed and they should develop a skill to cope with those (Snellman and Suominen, 2021). In terms of education, some sort of psychological support is also beneficial.

4. Learning frameworks and training for valorisation

A complete instructional design model and learning framework for improving researchers' ability to valorise their research was not precisely defined in the literature reviewed. The literature that has been reviewed was focused more on activities that have been defined as part of valorisation and not on the learning framework per se. For example, Datta et al. (2013) proposed a map of "Entrepreneurial Activities to Commercialise Innovations" from research in general, as illustrated in Figure 5.

Figure 5: *A map "Entrepreneurial Activities to Commercialise Innovation""*



Source: reproduced from (Datta, Reed and Jessup, 2013).

Several frameworks have been proposed to organise and conceptualise the knowledge likely to be relevant for entrepreneurship and innovation. Entrepreneurship education at universities is usually focused on developing and increasing awareness of positive aspects and benefits of entrepreneurship as a career path and increasing the knowledge on creating a new business venture. (Acharya and Chandra, 2019). Bearing in mind that valorisation of research data is a broader concept while including entrepreneurship under its remit, it is possible to say that an education program on valorisation of research should include increasing the knowledge, skills, and attitudes of STEM researchers to make an impact by applying research for the benefit of society.

There is a main EU framework for entrepreneurial education, EntreComp, which has increasingly emphasised the importance of preparing students for their future working lives, whether self-employed or as employees, with innovation and change increasingly prevalent and necessary (Gibb, 2005). The EntreComp framework (Bacigalupo et al., 2016) proposes a shared definition of entrepreneurship as a competence in a broad sense. EntreComp consists of three interrelated areas; "Ideas and opportunities", "Resources" and "Into action", each area includes five sub competencies which combined contribute to the overarching entrepreneurship competence. EntreComp is increasingly a default reference for initiatives supporting the development of entrepreneurial capacity in Europe. It is useful in that it increases common understanding and supports consensus building among stakeholders. The efficacy of EntreComp as measured by impact on entrepreneurial outcomes relative to other approaches has not yet been established based on a search of the literature (Bacigalupo et al., 2016). The recommendation for the training in this report will be slightly different from the EntreComp framework, and further paragraphs will explain the difference.

4.1 Overview of the existing programs and trainings for valorisation

In the previous sections we discussed the skills, knowledge, and attitudes associated with valorisation of research and entrepreneurship. In this section we discuss the practicalities of supporting education of STEM researchers to improve the valorisation of their research. The type of the program delivery can be defined by the mode of training delivery with formal learning, non-formal learning, face-to-face and online delivery. Formal learning is always organised and structured, has learning objectives and is part of the formal education cycle (OECD, 2021). Typical examples are learning that takes place within the initial education and training system or workplace training arranged by the employer. Non-formal learning is also organised and has learning objectives. The advantage of the non-formal learning lies in the fact that it may occur at the initiative of the individual and also happens as a by-product of other organised activities, whether the activities themselves have learning objectives or not. In some countries, the entire sector of adult learning falls under non-formal learning; in others, most adult learning is formal. There is a third concept, defined as informal learning with no set objective in terms of learning outcomes and it is never intentional from the learner's standpoint. Often it is referred to as learning by experience or just as experience (OECD, 2021). As the Rector at Istanbul Technical University (İTU) explained, encouraging students to participate in national (e.g., Teknofest) or international competitions to promote their new models and solutions could be considered as informal training.

While programs on valorisation of research have recently emerged, several studies have already emphasised the benefits of entrepreneurship education (Clark et al., 1994). Moreover, Mcmullan and Long (1987) observed that students from a Canadian university who participated in more than three entrepreneurship related training events had increased their willingness and rates to start a business (Mcmullan and Long, 1987). Many educational programs in entrepreneurship are focused on encouraging students to start their own business (Clark et al., 1994) and with clear outcomes from these programs. The number of educational programs in entrepreneurship is increasing. In US universities there is a continuous increase of programs on entrepreneurial education and in 2003 there were more than 2,200 entrepreneurship programs at over 1,600 higher education institutions, supported by 277 awarded faculty positions, numerous academic journals and more than 100 funded centres for entrepreneurship (Kuratko, 2003).

In Europe, higher education institutions offer several STEM learning programs and opportunities, alongside formal education programs, collaborative research projects, public-private partnerships, inter-sectoral mobility programmes, and shared training programmes, that are all based on developing entrepreneurial skills and capacity building and shared training programs (Van der Sijde et al., 2013). The Framework Programmes for Research and Innovation foster collaborative research between industry and academia through formalised collaboration and training. These collaborations, which include public-private partnerships, address some of society's most pressing socioeconomic and/or technical concerns, with the goal of increasing competitiveness, creating high-quality employment, and stimulating more private investment in research and innovation.

Informal types of learning have been elaborated by many scholars and in many different studies as beneficial for valorisation. Inter-sectoral mobility programs that bring together business

> *"Hackathons are events in which community members cooperate to resolve problems. They may take different forms. They bring together innovators and researchers with different qualifications to generate solutions to problems of common interest. The hackathon will provide lessons on how to use this approach to engage with citizens and provide research-based solutions that respond to societal needs"*
>
> **European Union,** 'Description of the planned negotiated procedure for a middle value contract for testing an innovative approach to citizens' engagement for knowledge valorisation through a Hackathon'

and academics are critical for knowledge valorisation. Informal valorisation training is increasingly acknowledged as effective in improving relationships and exchanging of understanding between academy and business. Based on an assumption that valorisation commonly relies on both informal and formal social connections (Davey et al., 2018), these informal trainings may include: attendance at industry sponsored meetings, attendance at conferences, personal informal contacts, other informal contacts, talks and meetings, ad-hoc advice, networking with practitioners, career talks, interviews and career fairs. Other important non-formal learning programs related to STEM valorisation training can include the following formats: TED platform types of training on STEM research valorisation and entrepreneurship, start-up programs that include training for valorisation and entrepreneurship focused on STEM researchers, social networking with a focus on dissemination and education on STEM research results, challenge projects to solve societal problems where STEM researchers are included and through which they can valorise their research results, and hackathons focused on STEM research valorisation. Those formats are visible in the learning framework we have analysed through case study interviews, as presented in detail below.

At higher educational institutions (HEIs), there are courses and modules in entrepreneurship and work placement offered to students, aimed at developing their entrepreneurship skills and at transforming their research capabilities and innovative ideas into applicable solutions. Interviews confirmed that there is currently a lack of valorisation training programs in STEM, but interest in valorisation training is increasing among students, and academics, within some countries - as confirmed through analysis of case studies where the number of trainings offered by HEIs, TTOs, KTOs and other scientific-based institutions is increasing. As part of empirical research underpinning this report, 60 interviews have been conducted and analysed and 20 case studies on training for research data valorisation have been produced. The results of these efforts are presented below.

Some universities already offer programmes or learning opportunities that can facilitate valorisation of research. For example, **University of Technology of Troyes** offers ***MIND (Mastering, Innovating, Developing) program*** (France), deigned to allow students develop their spirit of initiative and their capacity for innovation, by gaining experience in leading projects or by becoming involved in associations. The MIND program has its own toolbox that : links projects to lectures; enables students to validate skills and get ECTS credits through projects; motivates students to use co-working spaces (MIND Lab) so that students can work and organize events together; provides equipment to test and carry out projects (3D printers, printed circuit engravers, CharlyRobot, etc.); events, conferences, TEDx talks, debates, and round tables – all created and organized within the student projects; and a social platform to connect all the actors of the project - students, teachers, companies, and alumni together. The program is available to engineering students, and it is linked to their existing curricula.

Munster Technological University (MTU) offers a ***Module on Innovation and Entrepreneurship*** (Ireland), elective program as a part of its postgraduate programs, targeting researchers at masters and PhD level across all disciplines in MTU. This module is tailored to the distinctive needs of the research student, in particular the need to equip researchers with innovation and entrepreneurship skills. It covers the concept of entrepreneurship, the culture and workings of an entrepreneurial environmental, and the personal and environmental factors that support entrepreneurial behaviour. The module gives students a grasp of the principles underlying creative thinking, problem solving and innovation, and provides scope to appraise the entrepreneurial and commercialization potential of their own field of research. The program includes lectures, workshops, independent learning, and the assessment methodologies include group exercises and development of a business plan related to students' particular area of interest. The specific skills articulated in the learning outcomes cover: assessment of the economic and social benefits and supports for successful entrepreneurship for individuals, society and the economy; evaluation of the relationship between creativity, invention and innovation in research; description of the entrepreneurial processes; description and discussion of the range of skills, abilities, experiences and personal qualities that successful entrepreneurs have and bring to their work in both the public and private sectors; and evaluation of entrepreneurship as a career path.

Another attractive module offered at **Munster Technological University** is ***Module on Research Postgraduate Placement*** (Ireland) designed for researchers at masters and PhD level across the university. The module is offered as an elective option and it involves tailoring of student's personal development plan and the work placement as a three-way partnership between the student, Munster Technological University and the employer. Together the three should develop a learning agreement for the student with concrete objectives on the work to be done and how the work will contribute to the learning outcomes of the degree. The assessment methodologies consider written and oral communication through a developed planning process and a written report or portfolio as well as a formal presentation process, to allow the researcher to present the research findings in the appropriate context.

Institute Mines Telecom (IMT) offers ***SEED (Strategic Entrepreneurship in the Era of Digitalisation) Entrepreneurship Majeur Program*** (France). It is an innovative 12-month entrepreneurship program as part of the *Grand Ecole* program and is designed for students with the attitude of change-makers and problems-solvers. Students from three different schools, either with an engineering, IT or business background, spend 3 weeks within their own office within the IMT Starter incubator developing their own company, 1 week in class seminars, workshops and bootcamps constructed to follow an entrepreneurship process. They receive mentoring from accomplished entrepreneurs, the opportunity to attend ecosystem events and site visits, and participate in hack-a-thons and urban challenges. Lectures are primarily entrepreneurs and involve a learning by doing approach, self- and team-learning, networking and ecosystem building opportunities, and combine the latest practices, tools, methods, and theory.

University of Huddersfield (England) offers ***3M Buckley Innovation Centre Fellowship*** program aimed at early-stage academics at the university to advance their research, with access to technologies at the 3M BIC. Through the fellowship, the researchers also gain access to: technical support for 2 years, training, networking opportunities, and meeting spaces within the Centre. The 3M BIC Fellowship will promote relevant research in Huddersfield that will be of significance to regional industries and will encourage grant applications that include the 3M BIC as a key partner and collaborator in follow-up studies. The fellowship also fosters a long-term commitment between the University of Huddersfield and 3M BIC to submit joint research grant bids.

Australian Academy of Technology and Engineering (Australia) offers ***IMNIS - Industry Mentoring Network in STEM***, a training program that is pairing early-stage PhD students (mentees) with senior level industry leaders (mentors), so that mentees can learn about the sector beyond academia. One of the core objectives of the program is to facilitate the researchers' career transitioning into industry. The focus of the program is on connections, networking and understanding the broader picture of the STEM ecosystem. Mentees and mentors must meet at least once a month, and mentees commit to attending events and to engaging with external stakeholders. The program has workshops with modules that layer onto the national program and consist of events led by industry leaders who are experts in the area. Through the workshops, the program aims to: increase the researchers' influence both in and out of the workplace/industry, develop a strategy to career transition, an understand the innovation pipeline (ideas through to market).

Some successful programmes described below are offered by universities and some are overall structures for the research which does have credit attached.

For example, the **University of Melbourne** (Australia) offers **internal trainings in pitch delivery**, understanding the basics of how to manage industry partnerships, understanding of IP, ability to partner with professionals to form a team (with the full set of skills required), commercial expertise and funding sources, researchers' need to be curious and what services are available in their university. Those training are available to students and employees, and some outsourced partners at University of Melbourne.

Innovation Exchange Amsterdam, the Knowledge Transfer Office of the Amsterdam universities (Netherlands) offers access to a ***Demonstrator Lab***, the entrepreneurship laboratory where students, staff and academics from Amsterdam-based universities can transform their ideas into a tangible product or service. Its goal is to foster an entrepreneurial culture in the higher education ecosystem of the city and to boost research driven innovation by giving its members the opportunity to test their ideas, without taking risks. Through the Lab, students can get access to: advice on all aspects of the idea-to-market process; lab facilities, lab space, and office space; access to mechanical and electronic workshops; seed grants (no-strings-attached, minimal bureaucracy) of up to €15,000; flagship grants of up to €40,000 for a small, selected number of projects; connection to the Demonstrator Lab network, which consists of mentors, coaches, a variety of experts, business strategists, venture capitalists, market analysts, and consumers. The Lab helps students and researchers throughout the entire idea-to-market process from composing the team, to developing a prototype. From working out the most efficient marketing strategy to finding the resources needed to deploy that strategy. Supported by their vast network, the lab provides students and researchers with the business tools that help them explore whether their idea can make it. The program aims to develop entrepreneurial skills, such as market analysis, product strategy, testing, pitching, networking, leading a team., financing, etc.

Another positive approach from Australia is the ***Australian eChallenge,*** an entrepreneurship program offered by **University of Adelaide**, where students create, develop, assess and start-up their ideas. Throughout this program students benefit from tools, interaction opportunities and the mentorship needed to begin their entrepreneurial story, but also from funding, needed to translate idea into start-up.

Irish Research Council (Ireland) offers ***IRC Enterprise Partnership Scheme, a*** training program aimed at helping early stage researchers cultivate agile independent mindsets, get access to a range of opportunities which support diverse career paths, enrich the pool of knowledge and expertise available for addressing Ireland's current and future needs (societal, cultural or economic) and to bring higher education and enterprise together to develop and foster great research ideas, thereby ensuring that researchers get the benefit of both academic and applications domain experience while developing their research. The researcher is supported through appropriate learning opportunities and modules in the university, as well as industry specific training opportunities appropriate to their research question. The project and research question are co-designed by all three partners in the process. The candidate benefits from the supervision scheme of the university, as well as a nominated enterprise mentor, who provides continued interaction and guidance from the perspective of enterprise for the duration of the awardee's (scholarship) studies.

Similarly, **University of California** (United States) offers a ***Cycloton Road*** fellowship program aimed at supporting leading entrepreneurial scientists with technology projects and helping to transform the energy and resource intensive industries on the planet. Fellows, fully or jointly, own all intellectual property developed during their two-year fellowship term, get access to funding, employment opportunities, and joint R&D.

KU Leuven Technology Transfer Office (Belgium) offers a ***Doctoral School Training*** program, targeted at researchers reaching the end phase of their PhD or who have already obtained it. This training program introduces researchers to the possibilities for valorising their research along three main pathways: collaborating with industry, patenting and licencing, or creating a spin-off company. The program includes the presentation of good practice case studies, testimonies, and mentorship opportunities. The main activities include doctoral and post-doctoral researchers developing an exploitation plan in small teams, based on the research results of one of the team members or one of their research groups. To close the program, participants present their exploitation plans to a jury of industry experts and investors.

CURIE Networks (France) offers ***Valorisation of research: A Marketing of technologies*** training program aimed at appreciation of the valuation potential of a technology, and to propose a method and operational tools to optimize chances of developing it. The program is available for researchers and business stakeholders interested in TT processes. Training consists of 2 parts of valorisation: the first part of training is intended for CEOs of start-ups and companies in need for technology transfer; and the second part of training offers basic knowledge for start-ups about IP, team management, contracting with other companies, industrialization, and funding. Training is based on practical case studies and experiments. The same organization, **CURIE Networks** (France) offers ***MOOC Innovating with public research*** training that is reserved for staff of the CURIE Network and its partners who are researchers, doctoral students, developers, or staff supporting research. Training is focused on raising awareness on innovation with research and helping research stakeholders to get involved more easily in collaborative projects and in the creation of innovative activities from public research. The program entails training in innovation through technology transfer and innovation through partnerships with companies (e.g., how to protect an innovation, how to make the innovation ready for the market, how to market it, and then it explains license negotiations).

Bilkent CYBERPARK at Bilken University (Turkey) offers senior undergraduate and graduate students a ***BIGG* training program** in entrepreneurship and valorisation of research, aimed to help young entrepreneurs develop their business ideas and get financial support. The program is focused on field-work, doing customer discovery, and a mentoring module, with large companies involved to help students develop projects and to find the right product-market fit. The skills developed are organizational abilities, communication, understanding of technology, and coordination. This program showed that students who receive mentorship perform better than those who do not. Identical programs are available at ITUNOVA and ODTU TEKNOKENT, technology transfer offices (Turkey) where students and researchers with entrepreneurship affiliations are offered *BIGG ITU* at INUNOVA and *METU BIGG* at ODTÜ TEKNOKENT training programs.

KWORKS, an incubation centre at Koc University (Turkey), also offers *BIGG* training in entrepreneurship but aimed at helping both students and academics learn communication skills and become familiarized with technology transfer processes. Specifically, the program aims to encourage professors to go into the real world and try to assess the market and see if there's interest in the product they made. This training program supports two methods of valorisation. First, if professors commercialize research through licensing, TTO can then take over their project. Second, if the focus is entirely on digital marketing, then the focus of future activities is on entrepreneurship. Both academics and students get the same core training from BIGG regarding the basic business knowledge (writing a business plan, financial planning, etc.). Mentorship is a strong asset of this training model as well.

Inovent, technology commercialization/accelerator at Sabanci University (Turkey), offers ***BIGG4TECH*** training in entrepreneurship for valorisation of research results. This program is aimed at graduate and undergraduate students, and a project proposal is the part of application for training. BiGG4tech includes mentoring, an introduction to customers, collaboration development and a pilot project implementation with companies, pre-prototype/MVP manufacturing, and usage of laboratory infrastructure. Participants are given assignments, and they must participate in experience sharing conversations with business stakeholders that take place during training. After the training, there is elimination according to the assignments given. Based on assignment points, those who score above the average pass to the next stage, and those who fall below the average are eliminated. Training and assignments are provided on subjects such as business plans, financial statements, market analyses, customer interviews, and surveys, to reinforce the subjects. After the 4-week trainings and once assignments are completed, mentoring is provided. At the end of the first phase of the program, a 5-minute pitch is made to the panel and the best projects are selected to continue. The program's key successful factors are process management and increased motivation among students.

Another example ***ADVANCE CRT*** a **Science Foundation Ireland Centre for Research Training** (Ireland) focused on future networks and the Internet of Things. The centre will train 120 PhD students across five partner HEIs.. At the core of the model is a student cohort approach, and within each year's cohort and across annual cohorts, students have the opportunity to learn and work together, network, learn from each other, support each other and develop friendships. Each student's personal development plan includes student and supervisor responsibilities and expectations, support resources, principles of research integrity, and career planning. Students get the opportunity to develop research skills, transferable skills, knowledge of human and societal impact of their research and preparation for work placement. In addition to the development of skills, students also take part in industry or partner university placements between 3 and 6 months where they work on projects commonly developed with input from industry partners. The work placement and the associated learning outcomes will be integrated into each candidate's personal development plan. Every student is supported by their designated supervisory team, and support includes regular contact, regular meetings and scheduled progress reports in line with the quality assurance measures and postgraduate regulations of each university.

Science Foundation Ireland (SFI) and the US National Science Foundation (NSF) (Ireland) offer ***NSF I-Corps Teams***, a joint structured, curriculum-based, seven-week training program designed to educate academic researchers, and technology transfer/research translation/commercialisation professionals based at academic institutions. The curriculum is developed around an accelerated version of Stanford's Lean LaunchPad course. There is a blend of workshops, online lectures, and independent learning. Training aims to develop participants innovation and entrepreneurship skills, to encourage collaboration between academia and industry, and to stimulate the translation of fundamental research to the marketplace. But it also seeks to strengthen a national innovation ecosystem that helps foster innovation among faculty and students, promotes regional coordination and linkages, and develops networks to address pressing societal challenges and economic opportunities. The acquired entrepreneurial mindset of evidence-based business decision making, targeting the question of commercial viability and start-up launch opportunity, are primary outcomes of the training program. Through a train-the-trainer approach the programme is cascading out more broadly to researchers.

District 3 Innovation Hub (Canada) offers ***Quebec Scientific Entrepreneurship program (QcSE)***, an online lab-to-market program that helps PhDs, post-docs and researchers build world-changing tech companies derived from their academic research. Within the program, participants learn the fundamentals of entrepreneurship and how to evaluate the market potential of their idea before taking the leap. It is composed of curated readings, interactive webinars, methodologies to identify market opportunities, networking with renowned experts and start-ups, with a required time commitment of a minimum of 3 hours per week. The program also incorporates practical experience encouraging the participants to work on their individual valorisation project, peer-to-peer learning, and close support of the participants by the organizers.

Based on the available literature and presented knowledge frameworks and trainings for increasing knowledge, skills, and attitudes of STEM researchers to valorise their research data the following summary has been developed to help understand the major important aspects required for training for valorisation of the research in STEM disciplines.

4.2 Content of the analysed trainings

The content of the training for valorisation of scientific research varies depending on focus of the training and type of participants that should attend. The focus of the training can relate more to the commercialisation of the research data and therefore be more entrepreneurial oriented or it may be oriented towards general valorisation of research in society, and therefore oriented more towards dissemination of research results and direct application of the knowledge generated in ways other than what we usually mean by commercialisation. Participants can come from academia, from business or from both and can have various levels of knowledge in valorisation of research. A lecturer from Munster Technological University pointed out that STEM researchers require further training and frameworks to learn about patenting, financing, and marketing their research.

Creating a new business, based on our research data, this is included in most education programs on valorisation or entrepreneurship. The majority of education programs on entrepreneurship at most higher education institutions in the U.S and in the EU include the development of a new business, business management, organizational management, relationships with venture capitalist, acquiring external financial support, and development of products with marketing (Lackéus, 2015). In a review, Nabi et al., (2017) highlighted a few studies showing competency-based pedagogies were associated with start-up performance. This competency-based pedagogy focuses on real life problem solving, communication, discussion and production.

Development of a business plan usually forms part of the training for valorisation of research. Business competitions will support venture growth by allowing founding teams to build a business plan and a strategic roadmap while also gaining a reputation as a competitor (Boh et al., 2012). While the business plan is usually unavoidable part of the training and it refers to more commercialisation process of the research data, the development of a valorisation plan, as a broader concept of research valorisation is believed to be even more important. The study of Behrens et al. (2021) confirmed that most researchers reported having a valorisation plan before the start of their project, where 95 per cent of the researchers indicate that their research resulted in a new product, service or process that can be utilized for future research/projects (Behrens et al, 2021). For example, the development of business plans has been recognised by training the Module on Innovation and Entrepreneurship (Ireland) and the Demonstrator Lab offered by "Innovation Exchange Amsterdam" and CURIE Networks from France.

Understanding and mastering the decision-making process can help researchers to make better decisions in the start-up process (Acharya and Chandra, 2019). Within entrepreneurial education, decision-making has been defined as important. This means formalising a decision-making strategy as regards to whether start-ups should proceed/ pivot or abandon an idea. To make these decisions, in one program a "scientific approach" was taught (Camuffo et al., 2020) where participants were taught to set falsifiable hypotheses and pre-defined thresholds for their decisions and then run trials/data collection exercises to see if the threshold is met or not and thereby mitigating bias in their decision making. They found that the comparison control (taught standard accelerator training) groups (randomly assigned) performed worse showing a causal link between teaching the "scientific approach" and improved start up survival and revenue. This could potentially be readily applied to valorisation efforts as STEM researchers are already familiar with many of the concepts (Camuffo et al., 2020). Decision making as a skill has been recognised and delivered in some trainings. The NSF I-Corps Teams program, offered by Science Foundation Ireland (SFI) and the US National Science Foundation (NSF) aims for evidence-based business decision making as a final outcome.

Developing networks is another learning prerequisite to support valorisation of research data and its management. After all, whether a specific research result will have a value in the marketplace is determined by how it fulfils a (latent) need. The scouting and creating of opportunities by technology transfer officers and researchers means that they must remain in contact with external actors (e.g., participate in industrial networks) and education support can be provided to encourage this. Educational programs and activities to support networking could include the hiring of an "entrepreneur in residence" or the personnel mobility of the actors involved (Van der Sijde et al., 2013). Executive director of research, innovation and commercialisation at University of Melbourne, gave an example from the University of Melbourne, where the university manages training on valorisation and developing networks internally. With the addition of some outsourced partners, the university also has an in-house accelerator program and heavily invests in precincts as they strongly believe that if you put like-minded people together (academics, business ventures, venture capital forms), they will work out the common problems and relationships will form. Moreover, the District 3 Innovation Hub from Canada, offers networking with renowned experts and start-ups.

Negotiation and successful collaboration with various stakeholders have also proven to be beneficial for valorisation of research. As research for this study showed, collaboration in the form of a partnership between a public research organisation and a private company is essential for successful commercialisation of research. Cummings and Teng (2003) identified that public private partnerships are more successful when knowledge valorisation is targeted at social utilisation instead of economic benefits only. In the latter case, commercial stakes may prevent open collaboration from taking place. A study on valorisation of research in different projects on wind energy production underlines public-private collaboration's importance to achieve knowledge valorisation in innovative (applied) research at mid-range Technology Readiness Levels (TRLs). The study confirmed that a public-private collaboration would increase the chance on a successful knowledge valorisation (Behrens et al., 2021) and therefore should be part of the training program.

From the experience of the group head of intellectual property at Atos, the parties, researchers, and businesses, are usually not realistic in what they demand. There are examples, where some ask for company shares at unrealistic and unsustainable levels. The training on proper negotiation with industry should educate a researcher and potential entrepreneur that 'at the end of day, they don't make money from IP but from selling products. IP is there to protect someone who is selling business.'

An Intellectual Property Rights training that is fit-for-purpose warrants that the creators of research outputs have a competitive advantage. Good IP education should include content on organizing innovation, creativity and knowledge sharing, and should increase the opportunities of knowledge touching the market and advancing society (RRING, 2020). It should also include training on contract negotiations with business and how to achieve mutual understanding between stakeholders. Faculty and the Office of Technology Commercialization should collaborate to classify university inventions with innovation disclosures, provisional patents, or finalized patents that could be included in the class (Boh et al., 2012).

Training for acquiring finance and funding support is important as well. As Head of intellectual property at Atos, France explained, there are the usual issues with the inventor's rewards system as they haven't had training on how to deal with those issues. Focusing only on cash is not a good incentive, "It is not about cash, but time to do your own things. Intellectual freedom and self-autonomy are very important."

4.3 Skills attendees should acquire through training

Through the analysis of 20 case studies, we identified the following skills as significant to the training, where after completion of the training attendees acquired:

- entrepreneurship skills (needed to innovate with the research)
- collaboration skills (needed to get access to industry stakeholders, resources, infrastructure, joint-research, funds etc.)
- negotiation skills (needed to negotiate length of project, resources, and other favourable conditions for the project)
- communication skills (needed for successful conversation with stakeholders and project partners)
- presentation skills (needed for successful presentation of project and/or business ideas to stakeholders),
- business skills (needed to develop business plan, develop pitch to talk with parties, get funding for business, etc.)
- networking skills (needed for identifying opportunities)
- IP skills/knowledge (necessary to prevent leakage of knowledge and provide researchers with commercial benefits of their research)

4.4 Number of participants

While number of participants varies in different programs, most programs typically recruit around 20 participants, however, some programs include more participants. Within the BIGG program, as explained by Manager from Bilkent CYBERPARK the program takes between 50-60 people.

4.5 Teaching methods

By teaching methods, we include diverse types of support that can help researchers acquire skills to valorise their research data. There are many methods or processes that have been proposed to aid innovation, commercialisation and entrepreneurship that are related to the current discussion.

"Practical cases were part of learning methods. We tried to use as many cases as possible we could, because personally I consider it the best. When you have been working in TT for many years, you really realize that there is gap between the technical consideration and practical consideration."

Manager Competitive of IP Intelligence at L'Oréal

A Practical approach is one proven to be successful through the results of the literature review on programs on entrepreneurial education with one of the successful methods identified as practical learning or "learning by doing and reflection as a development of holistic individuals" (Heinonen and Poikkijoki, 2006). It is important that a researcher who would like to be an entrepreneur, and where entrepreneur is the one of the outcomes of the valorisation process, does not spend all their time researching before they try to valorise. In the US, some universities use methods focusing on intensifying practical utilization of "technology", developing a real "business plan", and collaboration semesters with "entrepreneurs and class participation rather than traditional lecture system" (Solomon, 2007). These methods provided better results in developing entrepreneurial skills than simply passing on information to students (Acharya and Chandra, 2019). Practical experience is crucial and it is a good way to try things out and learn as you go and if the hypothesis changes, let it change" (co-founder of Sparrho, in Snellman and Suominen, 2021).

Interviewees for this report confirmed the same. The manager from Bilkent CYBERPARK explained that the program that provided most success in Turkey is BIGG and it is application based, where most of the learning is practical. Within the program, the participants bring their own ideas and projects into the program. As a result, the program participants develop skills including organizational abilities, communication, understanding of technology and coordination. While the program has a theoretical part, the participants are using Cyberpark infrastructure and are cooperating with outside organizations for prototyping facilities and mentoring.

Exposure to the entrepreneurial world is an additional method, whereby a researcher participates in the shared training programs and entrepreneurs teach and share their experience. This is a major starting point for academics to obtain the essential technical competencies, human capital, and technology transfer capabilities from the real world (see Kaloudis, Aspelund, Koch et al., 2019).

Since it has been recognised that mastering communication is an important aspect of the education programs for development of entrepreneurial and valorisation skills some methods have been proven to be better than others.

A lecturer from Munster Technological University explained that highlighting past examples of research valorisation within a country or institution would allow STEM researchers to start visualising ways of commercializing their own findings. Moreover, the engagement between a variety of disciplines within an institution would facilitate more business strategy thinking.

"In Technopole Eurekatech, we try to create links with universities, we select researchers and support them to see how the world is outside of university and explore what is an innovation ecosystem. We try to present to them how their specialisations could have local impact. This method of reaching out and persuading researchers through active conversation with stakeholders to create an impact is one of the methods that supports STEM research valorisation," said the Director of Technopole Eurekatech and Head of economics, innovation and education at GrandAngouleme.

A former PhD student and a Co-founder of Sparrho stressed that the learning approach should include courses to raise communication skills with PhD researchers by exposing them to different audiences so that they talk with people from a variety of backgrounds about their business idea. A researcher should be exposed to the entrepreneurial world and should participate at events where various start-up incubators are presented and that can help them practice communication skills (Snellman and Suominen, 2021). Moreover, when it comes to the participation in the various competitions, innovation awards, and hackathons, related to valorisation of research data or valorisation of an idea, it has been found to have a positive impact and it help students generate better ideas (Acharya and Chandra, 2019). Hallen et al. (2014) compared similar start-ups that qualify and those that almost qualify to participate in accelerators, and they find that those that did participate tended to do better providing weak evidence the elite accelerators increase the success of the seed companies.

Mentoring and coaching have been defined as a valuable part of entrepreneurial training. Within the BIGG program from Turkey, as explained by its Manager from Bilkent CYBERPARK, most people who receive mentorship perform better than those who do not. It has been confirmed by some studies where, for example, the business development manager at University Industry Innovation Network confirmed that PhD STEM students with mentors at, or outside of, campus are better positioned and supported to valorise their research.

Boh et al. (2012) identified that access to founders, business experts, licensees, and potential investors has been increased through mentoring programs (Boh et al., 2012).

The findings of Åstebro and Hoos (2021) indicate that structured active mentorship is more effective than passive informal 'role model' orientated mentorship. Mentors should become actively involved in helping the participant succeed, as opposed to 'acting as a role model' and in a passive manner. Instead of informal lunches over 6 months, 5 structured weekends over 10 months were implemented including concepts such as design thinking to develop products.

The role of coaching and advice from peers has also been shown to increase start up survival and growth in India (Chatterji et al., 2019). In that study, entrepreneurs were randomly paired with other entrepreneurs and encouraged to advise each other regarding staff management. It was found that those paired with entrepreneurs with a formal approach to staff management performed better compared to those paired with entrepreneurs with an informal approach to staff management on the metrics of survival and growth. The effect was not observed if the entrepreneur had an MBA or similar qualification. From these studies we can infer with reasonable confidence that active structured/formal coaching from 'experts' or even other entrepreneurial STEM researchers (peer coaching) is likely to increase research valorisation success rates.

4.6 Learning methods

Through the analysis of 20 case studies, we identified the following learning methods as a significant element of the training:

- getting basic knowledge in valorisation and combining this process with concrete examples (case studies)
- getting exposure to role models and mentors (hearing successful stories and getting insight into challenges and opportunities successful people faced together with adequate mentoring program)
- networking (attending events, workshops, seminars)
- making practical experiments or sharing firsthand experiences with the different stakeholders

4.7 Length of the training

Based on the analysed case studies on training, it can be concluded that programs that involve mentoring, coaching and incubation of projects usually last between ***6 months or 1-2 years***. Those programs are focused on strengthening participants' entrepreneurship abilities, innovation, business, management and networking skills. The format of those training programs is face-to-face or blended, and it requires working at laboratories, working and advisory sessions, coaching and participating in events, trainings etc. Also, these programs can be attached to students' ECTS credits, can be offered to the academic staff of HEIs, employees of different institutions, partner institutions or open internationally (mostly in form of fellowship).

Programs that offer participants the general introduction to topics, such as IP, TT, creation of start-ups, obtaining funding and similar, usually last ***between 2-3 days***. These programs are focused on broadening participants' existing knowledge on particular topics and offer them a set of complementary skills (toolbox) that can be used in their everyday business activities.

4.8 Organisational preconditions for delivery of training

The human and infrastructural capacities and capabilities of the personnel involved in the implementation of the program play a crucial role. The business development manager at the University Industry Innovation Network confirmed that they have an institutional framework in place and sufficient resources to support valorisation. The head of programme support within Science Foundation Ireland highlighted that valorisation of STEM research is also achieved through training for the academic and non-academic staff around the researchers within the university, thereby building the infrastructure to support generations of researchers. It is important to encourage academics towards valorisation and to eliminate the language barriers between academics and corporate workers and bridging between the two is necessary.

Besides the higher education institutions, an intermediary organization – such as knowledge transfer offices (KTOs), technology transfer offices (TTOs), business incubators and science parks – create a channel for knowledge valorisation by helping researchers and innovators transfer their solutions, products, and services (EU, 2020). They also promote other instruments and services to enhance research the innovation potential via networking, mentoring, coaching, and best practice sharing, which are proven to be skills for valorisation. The size, mission, business, ownership, and financing structure of intermediary organizations are diverse, nonetheless they play a significant role in enhancing STEM learning by offering opportunities for promoting knowledge transfer and innovation in general (Kaloudis et al., 2019).

This is particularly relevant when it is considered that those involved in the training should have entrepreneurial skills themselves. Within the BIGG program, as explained by the manager from Bilkent CYBERPARK, personnel should be well equipped with entrepreneurship knowledge but they are also skilled in communications, as it is essential for both program participants and for the outside organizations. They follow the teams closely and help identify their needs and then find matching mentors to help them.

Moreover, infrastructure and supporting mechanisms prove to be important for delivering successful training for valorisation of research data. Accelerator and incubator services offer comprehensive support to start-ups over time, including mentoring, financing, office space, and, in some cases, oversight and management (Boh et al., 2012).

4.9 Indicators of success

Behrens et al. (2021) reported that monitoring of the research projects near and straight after valorisation completion is important. Moreover, monitoring and following research from a certain research group, consortium or network, over a longer time (including over different research projects) improves valorisation success. Some indicators extracted from the analysed programs include:

- to what extend is the knowledge gained through the program practically applicable?
- how many successful valorisation cases are created after the program?
- how many patents are declared and achieved?
- to what extent are sponsorship and funds obtained for valorisation of a research idea after the program?
- to what extent are the programs supportive of participants in their daily work?
- how many job opportunities are created?
- To what extent is the level of awareness of the researchers raised about content and importance of application of the research?
- to what extent has the awareness of the importance of transferring researchers' data for societal benefits been increased within the target groups?

Within the BIGG program, as explained by the Manager from Bilkent CYBERPARK, the key challenge is to keep the participants in the program when they face challenges in their own projects. Some factors for encouragement for participation include: competition, ECTS credits, funding, co-publishing, joint R&D, cultural exchange, exposure to different mindsets (mobility at EU level), and the credibility of organization organizing training (e.g. having famous names as sponsors, co-partners and trainers). At the same time mentoring has been a key factor for successful outcomes.

4.10 Challenges and key issues for successful training

It is important to encourage aspiring tech entrepreneurs to try to develop business ideas or valorise their research right after finishing their PhD. That is the point of peak opportunity since they have cutting-edge and unique research to bring to the table which will lose its value if they wait (Snellman and Suominen, 2021). The rector at Istanbul Technical University (İTU) highlighted the importance of supporting students to approach industry at even earlier stage of their studies. An entrepreneurship expert from MTU agreed that the ongoing training, ongoing awareness, workshops and seminars should be embedded into all training for STEM students from an early stage, even from their first year in STEM. It is additionally stressed that all graduate researchers and PhD students, within their first 6 months should receive mandatory training on research valorisation/commercialisation, as part of early career development, according to the executive director of research, innovation and commercialisation at University of Melbourne.

The COVID influence has raised important challenges recently due to pandemic issues. As some of interviewees explained, due to the pandemic the efforts of the projects have not been able to produce long-term impact. The Covid pandemic has had an influence on this project as well by making it more difficult to access interviewees in person.

5. Summary of research

The importance of valorisation as a term is increasing, and it is becoming more used in practice as the requirement for universities to deliver more research applicable results to society or fulfil their “third mission” is increasing.

From the research conducted we can conclude that **valorisation is the broadest of conceptual frameworks** compared to “commercialisation”, “knowledge transfer” and “innovation”. It mostly includes different ways in which knowledge from universities and public research institutions can be used by stakeholders outside of academia to produce economic and social value. Valorisation of Science, Technology, Engineering and Mathematics (STEM) research is a process of interaction between different stakeholders with an aim of creating social benefits from knowledge. STEM valorisation starts when the research-based data are disseminated to society and practically applied to improve or to develop new products, processes, and services in order to create evident, measurable or observable impact beyond the academic context.

The **STEM valorisation process includes different stakeholders** from knowledge providers, beneficiaries of the valorisation process to the intermediary organisations. While both STEM and SSH valorisation processes involve similar stakeholders, some of them are more commonly present in the STEM valorisation process than SSH. The academic knowledge producers, as valorisation stakeholders, are common category for both STEM and SSH disciplines while the intermediary structures in the valorisation are one of the main differences between the stakeholders in STEM and SSH disciplines. Intermediary stakeholders in STEM valorisation include Technology Transfer Offices (TTOs), incubators, accelerators, science and research parks, research centres/institutes, and laboratories in companies involving academic and industrial professionals. STEM beneficiaries are mainly external stakeholders consisting of government and industry stakeholders who typically engage in STEM valorisation activities motivated to secure innovative products, competent labour and economic growth, to improve public image via marketing, to contribute to the future development of society, and to increase interest and knowledge of STEM education and careers.

An interaction between stakeholders in valorisation process is a “sine qua non” and the valorisation process includes different phases - discovery, scoping, research data utilization concept development, development, testing and implementation. Based on the Stage Gate framework that we used to explain STEM valorisation process, it is important that in each phase of valorisation, based on the prognosis and information available at that moment, a decision is made whether to continue the process or not. Another framework that can explain valorisation process relies on UBC framework process and includes:

- *inputs* that includes all available resources and knowledge,
- *channels* for valorisation to utilize knowledge dependent on their scientific discipline,
- *outputs* are research results,
- outcomes that include practical application of research results and
- *impact* is a long-term result based on the practical application of the research.

Our research on drivers for valorisation of research have identified a number of drivers:

- *Relationship drivers* include satisfaction, trust, organisational compatibility, common commitment and joint vision
- *Motivational* drivers: financial, career-related, personal, and moral,
- *Access drivers*: access to research and development facilities and access to equipment and resources and networking as well as infrastructure and equipment and
- *Research drivers* are related to gaps in knowledge and provide inspiration for research.

Additionally, the research has clearly shown that:

- Trustful, transparent, and close cooperation with industry facilitates valorisation.
- Support from intermediary organisations,
- A clear policy of the institution or research centre,
- Official recognition in job evaluations and incentivisation of valorisation efforts and
- interest level of the academic to make an impact in the society by applying research results all play a role.

At the same time barriers for valorisation include:

- *Cultural barriers:* including ineffective communication as well as differing ambitions, expectations and time-horizons between university and industry,
- *Bureaucratic barriers:* ineffective university procedures for valorisation,
- *Financial barriers:* financial issues and access to venture capital,
- *Lack of incentives:* lack of time for supporting valorisation by academics at universities and
- *Lack of knowledge and skills*: of academics and others involved to practically apply research findings has been highlighted as one of the dominant barriers.

Furthermore, this report recognised the following knowledge and skills as beneficial when it comes to valorisation of research in STEM:

- A *visionary approach* is needed for valorisation of data and scientists who are thinking of starting a company or making an impact based on their research.
- *Knowledge of the valorisation process* has been recognised as lacking in most researchers and this could support further valorisation.
- *Entrepreneurial skills* including the development of business models and skills for its application are recognised to be important to improve entrepreneurial outcomes, and lean start-up and design thinking identified as important learning methods.
- *Business/partner understanding* including having practical skills on how to work with different stakeholders, including industry, business, government, and society has been marked as important for valorisation to understand different stakeholders thinking and provide more perspective on what kind of research and solutions will find more acceptance within industry.
- *Problem-solving skills*, and in particular, decision-making skills are crucial to getting things done in all phases of the valorisation process.
- *Communication knowledge and skills* to communicate to different audiences' skills are also required, as entrepreneurs they must precisely articulate a plan or idea, have an ability to develop a broader vision and to get 'buy in' from others.
- *Negotiation skills* with business requires an advanced level of communication skills important in all phases of the valorisation process.
- *Knowledge of intellectual property rights* is highlighted as important for STEM researchers at least at a basic level.

While knowledge and skills are crucial for effective valorisation, attitudes are found to be important and are defined as the characteristics of the individual to manage certain situations including having a positive attitude toward valorisation would mean that education should encourage development of personal entrepreneurial skills, including inner control, innovation, risk taking, persistence and being change oriented. Persistence and devotion to the long-term objectives are also generally important and therefore some sort of psychological support is also beneficial to be part of education.

In terms of education programs for valorisation, research shows that different approaches to the valorisation of research exist depending on the content and structure of the training. The main mode of training delivery includes formal learning, non-formal learning, face-to-face and online delivery while there is also an inverted or flipped classroom approach where participants undertake background reading and experience-based practice (stakeholder engagement) outside the classroom while contact time with instructors is used to present and discuss the findings of the stakeholder engagement process. The content of the training for valorisation of scientific research varies depending on focus of the training and type of participants that should attend.

When it comes to **content**, as a basic principle, participants should understand the essentials of:

- *Valorisation process* - how to valorise their research through creating a new business or positioning their research in the society.
- *Entrepreneurial / business thinking and approaches* - Development of a market-oriented business approach is a next important module of the training for valorisation of research accompanied with understanding and mastering the decision-making process that can help researchers to make better decisions during the whole valorisation process.
- *Networking development* - The ability to develop networks is another learning requisite to support valorisation of research data and its management and it has been part of different training examples discovered in the research.
- *Marketing and communication* – The ability to communicate your research idea, outputs, outcomes and impact with different stakeholders
- *Negotiation processes* - This is closely linked with modules on developing collaboration with key stakeholders and mastering the negotiation process.

- *IP rights* - One of the modules that has been highlighted in most of the training frameworks includes understanding of Intellectual Property Rights.
- *Resource acquisition* - followed by training for acquiring finance and funding support which can be decisive in applying research results in practice.

Teaching methods also vary but the dominant method is learning by doing and exposure to the entrepreneurial world. A straightforward approach for participants to apply their research proved to be beneficial and many educational programs in entrepreneurship are focused on encouraging students to start their own business. Training that includes collaboration between industry and academia have been beneficial where industry are included in the education process as guest lecturers, case study providers or mentors. When it comes to **length**, trainings can last from 1-2 days to 6 months or even two years. In terms of **number of participants**, more generalised training has included up to 60 participants with more specialised areas having groups of up to 20 participants (like IP or development of business plan).

The capacities and capabilities of the personnel involved in the implementation of the program play a crucial role. Personnel should be well equipped with entrepreneurship and research valorisation knowledge, but they also must be skilled in communication and soft skills. Education providers should follow attendees closely and help identify their needs (for example matching mentors to help them). Moreover, infrastructure and supporting mechanisms are important for delivering successful training for valorisation of research data. Developing a monitoring and evaluation process is an important part of the education programs in valorisation as it helps measuring success and improving further education attempts. Moreover, collaborations between education providers and industry are also beneficial as they help smoother valorisation and application of research that the most beneficial to the society. They can include public-private partnerships and address some of society's most pressing socioeconomic and/or technical concerns, with the goal of increasing competitiveness and stimulating more private investment in research and innovation.

When all these different aspects of valorisation are considered, it can be concluded that valorisation of research is a broad concept whose importance is increasing. While it would take time to define precise steps, detail conditions, and positive activities to facilitate successful valorisation of STEM research, this report has provided a platform for further discussion on this important topic.

6. Recommendations for the training for valorisation of research

In this final part of the report, the recommendations for the creation of training in valorisation of research have been summarised. These will be used as a starting point for developing the learning framework and content of the modules that will be implemented as part of the STEM Valorise project.

6.1 Proposed content of the training

Training should address the following topics within modules:

1 **Introduction to valorisation**, where participants will be introducedto the potential to valorise research data, including the socio-economic assessment of research results, selection on what research should be valorised, forms of valorisation outcomes, understanding the whole valorisation process (ecosystem) so participants can develop an interest to engage in valorisation and to effectively lead it, understanding the persistence and devotion to the long-term objectives, and understanding that failure of the research valorisation is possible? expected as part of the process.

2 **Technology/knowledge transfer and exchange processes,** where participant will be introduced into the technology transfer process, the most effective use of TTOs for research valorisation, how to work on the transfer of technologies and to connect with companies, how to make an effective bridge between TTOs, companies and labs, and how to position technology in the market.

3 **Importance of the research impact** is probably one of the most important topics that training shall cover, as many researchers lack awareness and knowledge on the impact their research has for them individually, their affiliated institutions and society at large. This awareness is particularly important at the early stages of research because valorisation starts from there. Training shall specifically address topics on what are the potential benefits of research, what are potential research application domains and end users, what is the output and impact research will produce, and what does it mean to work with stakeholders and to work for society.

4 **Business development and marketing related skills** is a topic that shall provide participant with the knowledge of necessary steps for founding/launching an academic spin-off/start-up company and undertaking other forms of

commercialisation activities to introduce research to the market, how to develop business plans, what is risk taking and how to make an effective decision, what is design thinking, market need analysis, market validation, product strategy, testing, pitching, what are successful team management and growth strategies, how to lead a team, how to organise management and financing, how to make the research ready for the market and how to market research, how to use different channels and social networks for marketing and dissemination of research.

5 **Communication skills**, where participants will acquire some knowledge on skills needed for communication with stakeholders, for example how to make research understandable outside of academia, and how to communicate research results to different stakeholders (e.g., investors, potential business partners, industry, government, general society).

6 **Networking, collaboration, and negotiation with stakeholders**, where participants will acquire some knowledge on skills needed for successful ***networking***, like how to find a right partner for the project and how to use different networks to disseminate and position research results. Successful ***collaboration*** with stakeholders should cover topics on how to understand the position of industry when it comes to valorisation, learn to pitch a project to a business audience, what are public-private collaborations, how to develop a partnership with industry, how to build trust in collaboration, how to manage relationships with stakeholders and ensure that collaborations can be established and maintained successfully. Successful ***negotiation*** with stakeholders should cover topics on how to present the valuable impact to different stakeholders while being open and transparent about the outcomes, how to negotiate with a university, how to negotiate with investors and other stakeholders to get support, how to negotiate IP, and how to negotiate agreements with companies.

7 **Understanding the basics of intellectual property rights (IPRs)**, where participants will get familiar with the forms of intellectual property rights, what can be protected under IP, what are the IP application and follow-up procedures, how to fill in for the patent protection, how to license IP, how to decide if there is a need for intellectual property rights claim, and understanding the legal issues related to Standard Essential Patent and Fair, Reasonable and Non-Discriminatory (FRAND) Licensing.

8 **Obtaining funding and resources**, is a final topic we recommend for the training module, and it should provide participants with resources, skills and knowledge

necessary to identify funding opportunities, to understand what resources are available at the level of European Union, regional and national level and how to secure resources.

6.2 Proposed teaching methods

The following teaching methods can be used for training delivery:

- **Face to face approach**, where depending on the content and structure of training, participants will be provided with a co-working space that allows them to work and organize events, participate in a collaborative workshop, seminars and other events that provide them access to tools.
- **Online approach,** where lectures are organised through online tools, organisers use social platforms to connect all the actors of the project(s): students, teachers, companies, alumni, etc.
- **Inverted or flipped classroom approach**, where participants undertake background reading and experience-based practice through engagement with stakeholders. Time inside the classroom is used for instructions, presentations and discussion of findings with stakeholders.
- **Case studies approach**, where presentation of successful and less successful case studies is the main learning method.
- **Practitioner's approach**, where business representatives are included to provide lectures and practical concrete examples, case studies and testimonies, exposing researchers to industry experts.
- **Learning by doing approach**, where participants will acquire experiences and work on concrete projects with application in practice. Trainers will provide an exercise as a case study where participants should find solution to given problems, and participants will develop an innovative project proposal from current or past research, engage in other student projects, alumni, partner companies or the university related projects.
- **Mentoring approach** is a suitable method where trainings have tangible and measurable outcomes e.g., TT, KT, incubation of start-up, patents, joint R&D, etc. Within this approach, a fellow mentor in the team is someone who has a technical-innovation background and enough experience to mentor fellows, while external mentors are experts, and advisory boards members from companies to help mentees. Mentors and mentees should meet up for a minimum of an hour

once a month and mentees must commit to attend events and engage with external stakeholders, follow provision of joint supervision scheme of the university and nominated enterprise mentor if training is offered in cooperation between HEI and industry.

6.3 Support as part of the training

Through the investigation we undertook for this report, we noticed that for successful valorisation to occur support is needed. Therefore, if there are enough resources, within the training participants could get some of the following support:

- **Funding support** that could be seed grant or flagship grant for the best projects or ideas, and help to find the first funding for product or prototype.
- **Personal development support** that could be a paid training to use equipment or any other training that is needed for participant to successfully implement the project and work within the team (e.g., soft skills).
- **Expertise support** that offers an access and exposure to the expert's community, where participant can present their research potential, get mentorship and industry stakeholder's support to develop the project, find the right product-market fit, R&D and facilities (especially those that are looking to scale-up their businesses) and bring an innovation to the market and society.
- **Networking support** that offers an opportunity to attend and organise pitching and hackathon events, other events that are led by industry leaders who are experts in the area, events where researchers are required to apply what they have learned and are expected to interview potential stakeholders to discover opportunities for their research, and similar.

6.4 Proposed format and length of the training

Through in-depth analysis of 20 case studies, we noticed that due to Covid19 the majority of trainings were in an ***online*** format, while curricula bounded trainings and trainings that have a mentorship element are mostly in ***blended*** and ***face to face*** format. Specifically, short training programs that offer participants the general introduction into topics as IP, TT, creation of start-ups and similar, are mostly online. Training programs that involve mentorship and have tangible outcomes are mostly in face to face and blended format.

When it comes to the length of training, we can divide training into ***long term*** (between6 months and up to 1-2 years), and ***short term*** (between 2-4 weeks and 1-3 days).

Long term programs are mainly aimed to strengthen participants' entrepreneurship, business, management and networking skills. Format of those trainings is face to face or blended. Learning methods include mentoring, coaching, incubation of projects, work at laboratories, working and advisory sessions, and participations in different events (e.g., workshops and seminars). Those programs can be curricula-bounded and recognised through students' ECTS credits. Participants range from academic stuff, students, employees of different institutions, partner institutions, or open for international audience (mostly in form of fellowship).

Short term programs are mainly aimed to provide the general introduction into topics as intellectual property, technology transfer, creation of start-ups, obtaining funding etc, and broaden participants' existing knowledge on topics and offer them a set of complementary skills (toolbox) they can use in their everyday business activities. Format of those trainings is online or face to face, and participant gather either in the co-working space in or at online platform.

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Annex

A Status Quo Review of STEM research valorisation at national and institutional level

A Status Quo Review of STEM research valorisation in Turkey

National Background

Turkey has the world's 19th largest economy, with an average annual GDP growth rate of 5.5 percent from 2003 to 2019. Turkey is a "Moderate Innovator" according to the European Innovation Scoreboard 2019. In terms of non-R&D research investments and SMEs innovating in-house, Turkey grows comparatively well. Annual GDP growth, new business creation, and total entrepreneurial activity are all significantly higher than the EU average.[1]

According to the PwC analysis, in 2023, approximately 3.5 million of Turkey's total 34 million employees will be based on STEM employment[2]. Moreover, it is also argued that STEM employment requirements between 2016-2023 will be around 1 million.

[1] https://www.invest.gov.tr/en/library/publications/lists/investpublications/the-state-of-turkish-startup-ecosystem.pdf

[2] https://www.pwc.com.tr/tr/assets/image/pwc-tusiad-2023-e-dogru-turkiye-de-stem-gereksinimi-raporu.pdf

According to 2016 data, Turkey has the 6th largest workforce population of OECD, with more than 30 million employees. Below, some figures about STEM graduates in Turkey, and the Turkish labour pool are given.

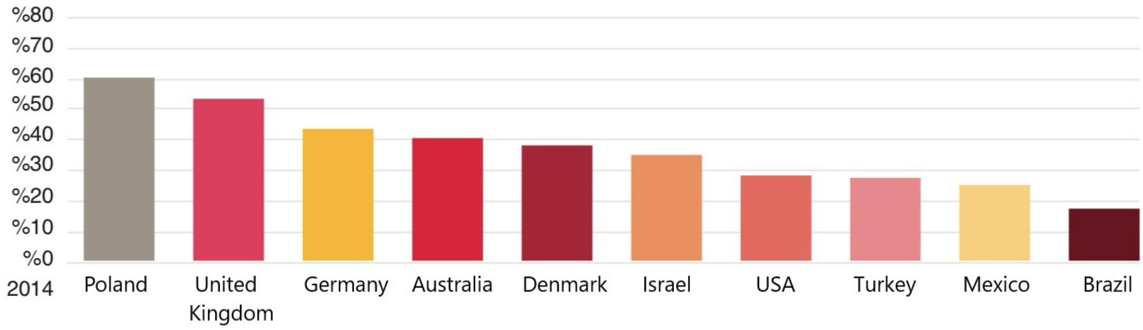

Figure 1. Ratio of STEM Undergraduates and Postgraduates to total Graduates[3]

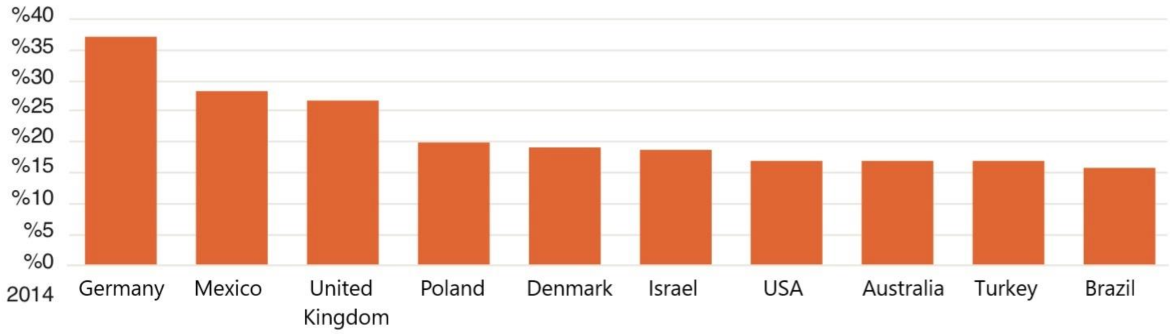

Figure 2. Ratio of STEM Undergraduates and Postgraduates in Total Employment[4]

Background of the Istanbul Technical University (ITU)

Istanbul Technical University, one of the world's oldest technical universities, and first technical u university in Turkey was established in 1773 and is approaching its 250th anniversary.

ITU has a TTO and Technopark ARI as intermediary institutions with valorisation capacities. In January 2014, the ITUNOVA Technology Transfer Office was also established with the aid of the TÜBİTAK 1513 TTO Support Program. The aim of ITUNOVA TTO is to decrease the workload of academics in project commercialization, relieve the burden of bureaucracy, and provide business model development support for valorisation and commercialization of projects[5].

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[3] http://stats.oecd.org/Index.aspx?DatasetCode=RGRADSTY
[4] http://stats.oecd.org/Index.aspx?DatasetCode=RGRADSTY
[5] http://www.itunovatto.com.tr/Brochure/booklet_web/PDF.pdf

Supporting mechanisms for valorisation and entrepreneurship

In Turkey, the most common valorisation type is based on University-Industry Collaboration (UIC). As a part of national development programmes, UIC has been emphasized and encouraged. Especially in the last 15 years, some laws and programs that can be considered radically have been designed and put into effect. Technoparks, "Technology Development Zones Law", University-Industry Joint Research Centres Program, and Technology Transfer Offices, are examples to be given in this context. According to Kiper (2010), the main mechanisms that provide direct or indirect University-Industry Cooperation can be classified under the following five headings[6];

a) **Project Oriented, Public Supported Cooperation Programs**
    a. Industrial R&D Project Supports (TUBITAK[7]-TEYDEB[8], TTGV[9] etc.)
    b. Scientific and Technological R&D Support Program (TÜBİTAK)
    c. Public R&D Projects Support Program (TUBITAK)
    d. Project Markets Support Programmes
b) **Institutional Cooperation Structures Shaped by Public Programs**
    a. Technology Development Regions
    b. Technology Development Centres
    c. University Industry Collaboration Centres
c) **Education Programs and Contract-Based Projects Conducted by Universities**
    a. Continuing Education Centre
    b. University-Industry Collaboration based career programs (Graduate and PhD level)
    c. University Funded Contracted Based Projects
d) **Service Centres for Cooperation in Universities**
    a. TTOs
    b. Collaboration Institutes and Centres
e) **Informal Cooperation Networks and Other Initiatives**

STEM Entrepreneurship Status

a. Valorisation Policy

[6] https://www.ttgv.org.tr/tur/images/publications/6005bd04eec7d.pdf
[7] The Scientific and Technological Research Council of Turkey
[8] Technology and Innovation Grant Programs Directorate
[9] Technology Development Fpundation of Turkey

In 1994, the Turkish government initiated a variety of policies aimed at empowering small and medium-sized businesses (SMEs) to be more creative. The Directorship for Small and Medium-Sized Enterprises (KOSGEB), the Directorship for Technology and Innovation Assessment (TEYDEB), and the Technology Development Foundation (TTGV) were the most important of these, with the overarching aim of assisting businesses in creating their own technologies through financial assistance. Companies are especially encouraged to partner with universities and research centres through these services (Temel & Glassman, 2013). According to Temel and Glassman (2013), most of these support programs take the form of government grants from the Ministry of Science, Industry, and Technology (MSIT), which can cover up to 75% of the overall cost of an innovation or R&D project.

Since 2012, TUBITAK has been awarding grants to early-stage companies through its TUBITAK BiGG[10] program. In 2019, 568 idea-stage startups were awarded 200,000 Turkish Liras each, while 823 early-stage startups and scaleups were awarded 123 million Turkish Liras in grants. KOSGEB awarded grants to 417 idea-stage and 160 early-stage startups over the same time span. In total, these two institutions provided 32.5 million dollars in financial support to technology-based startups, scaleups, and grownups in 2019[11].

TTOs at universities act as a link between academia and the private sector, assisting in the commercialization of research and the facilitation of joint ventures between academia and private companies. The total number of TTOs has exploded since 2013, thanks to grants given by TUBITAK and Regional Development Agencies, surpassing 139 in 2019, with nearly 60 of them developed through public grants[12].
Furthermore, Goksidan et al. (2018) argue that the operation of UICs to promote the commercialization and valorisation of public R&D results, necessitates a variety of institutional arrangements among the mentioned interfaces and intermediaries. As Hagedoorn, Link, & Vonortas (2000) noted, UIC may be classified as formal or informal. Institutional forms and arrangement of UIC are emphasized in Table 1.

[10] Individual Young Entrepreneurship
[11] https://www.invest.gov.tr/en/library/publications/lists/investpublications/the-state-of-turkish-startup-ecosystem.pdf
[12] https://www.invest.gov.tr/en/library/publications/lists/investpublications/the-state-of-turkish-startup-ecosystem.pdf

Table 1. Institutional forms and arrangement of UIC in Turkey[13]

Institutional arrangement of UICs	Type of arrangement (formal or informal)	Supporting interface and/or intermediary	Definition/forms of arrangement
Research partnerships and cooperative research	Formal or informal	TP, ARCs, TTOs, URC, SRP	Inter-organizational arrangements for pursuing collaborative R&D, including research consortia and joint projects
Research support and services	Formal	MOSIT, TÜBİTAK, DA, SRP, UL, TTOs, KOSGEB	Research-related activities commissioned to universities by industrial clients, including contract research, consulting, quality control, testing, certification, and prototype development
Knowledge transfer	Formal or informal	MOSIT, TÜBİTAK, DA, SRP, UL, TTOs, KOSGEB	Access to new knowledge that allow achievement of competitive advantage inc. new capability development
Shared infrastructure	Formal	TP, SRP, ARCs, UL, URC, KOSGEB	Use of university labs and equipment by firms, business incubators, and technology parks located within universities
Technology transfer	Formal or informal	TP, SRP, ARCs, UL, UR, TTOs	Achieving a better intermediary involvement, technology management, combine R&D capabilities and scientific and technical cooperation, technology commercialization
Academic entrepreneurship	Formal or informal	TP, ARCs, TTOs, SpnO, StrU	Development and commercial exploitation of technologies pursued by academic inventors through a company they (partly) own (spin-off companies)
Human resource training and transfer	Formal or informal	TTOs, TP, ARCs	Training of industry employees, internship programs, postgraduate training in industry and research staff, adjunct faculty of industry participants
Commercialization of intellectual property	Formal	TTOs, StrU, SpnO, TÜBİTAK	Transfer of university-generated IP (such as patents) to firms (e.g., via licensing)
Scientific publications	Formal	ARCs	Use of codified scientific knowledge within industry
Informal interaction	Formal or informal	ARCs	Formation of social relationships (e.g., conferences, meetings, social networks)

Source: Goksidan et al. (2018).

b. Clustering Structure

Another important characteristic about Turkish context is that the structure and contingencies illustrated in Turkey's major cities, such as Ankara, Istanbul, and Izmir, are entirely different endowments and disparities in terms of Higher Education Institutions (HEIs). The disparity between other cities is largely defined by social and cultural differences. According to Goksidan et al. (2018), cluster-like with UIC characteristics exist. In the case of Ankara, for example, UICs are a crucial source of information and entrepreneurs who have fuelled the growth of a cluster focused on the IT and defence industries, such as Middle East Technical University and Bilkent University. In addition, the authors also emphasized that the promise of UICs has paved the way for entrepreneurs

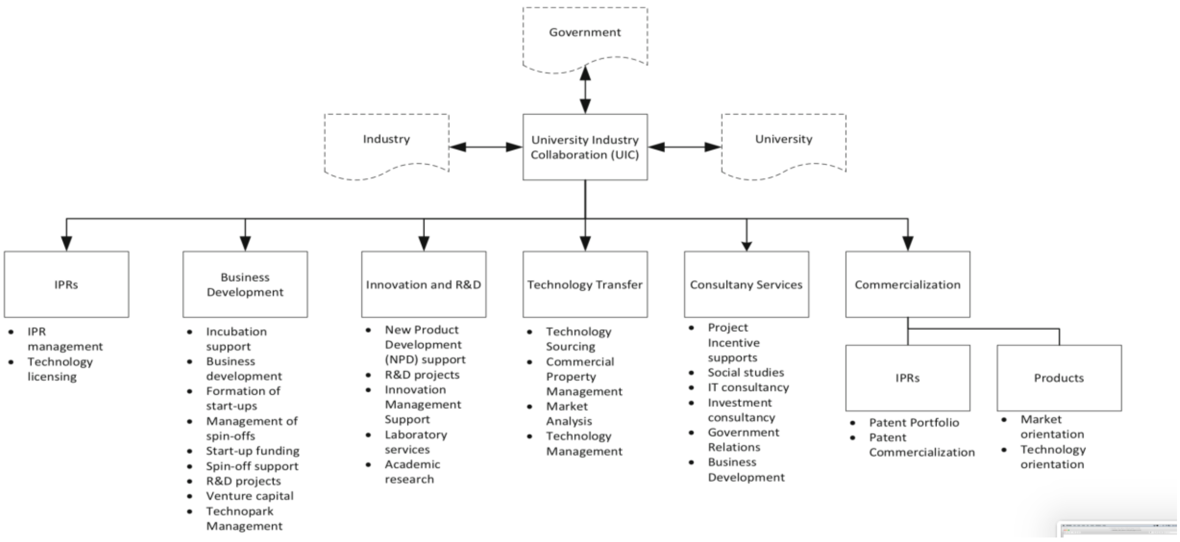
[13] **ARC:** Academic Research Center, **DA:** Development Agency, **KOSGEB:** Small and Medium Enterprises Development Organization, **MOSIT:** Ministry of Science, Industry and Techonolgy, **SPnO:** Spin offs, **SRP:** Scientific Research Programme, **StrU:** Start-up, **TP:** Technopark; **TTO:** Technology Transfer Center, **URC:** University Revolving Capital, **UL:** University Laboratories.

to achieve long-term profitability. In this light, administrative support for researchers at leading universities subsequently opens the door to new opportunities for start-ups or spin-offs. Furthermore, several start-up companies, which are becoming increasingly reliant on innovation to stay competitive, take advantage of new capability growth opportunities provided by Turkey's universities, Academic Research Centres (ARCs), and Technoparks (TPs).

c. Valorisation Funding

Turkish government is assisting a number of elite and research universities and research institutions in expanding their creative capacities and/or actively commercializing university-developed technologies and products; at the same time, the government is working hard to increase demand for R&D through institutional and fiscal incentives (Goksidan et al., 2018). As a developing economy and country, it is essential to emphasize that most Turkish universities are motivated to establish strategic partnerships with other universities around the world and International Research Centres (IRCs) in order to create new R&D capabilities, especially in the area of emerging technologies.

Figure 3. UIC Approach from a Turkish TTO Perspective



Source: Goksidan et al. (2018).

Impact of STEM valorisation at the institution

ITUNOVA TTO provides ongoing support throughout the commercialization of research outputs, such as:

- Creating project design
- Establishing consortia
- Support for proposal drafting

- Communication management between parties
- Budgeting
- Academic - project - company matchmaking
- Contract management

Legal counselling

- Patent application process management
- Commercial model development
- Legal counselling
- Contract management
- Project and process tracking[14]

In 2020, ITUNOVA applied for 22 national patents, and 8 international patents. Participated in 148 university-industry collaboration projects with the total budget of 29 million Turkish liras (around $3.75 million). Furthermore, ITUNOVA provided project writing support to 35 national and 18 international projects as well. Finally, another centre that highly engage in valorisation of research, namely ITU Technopark, yield significant results. Celebrating its 10th anniversary this year, ITU Çekirdek (Incubation Centre) has provided support to more than 3.000 enterprises and more than 6.500 entrepreneurs since its establishment. In 2020, more than 54 million Turkish liras (more than $6.5 million) was transferred to entrepreneurs, and 39 new ventures, 6 of them ITU graduates, were given additional investment from investors.

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A Status Quo Review of STEM research valorisation in Netherlands

National Background

The city of Amsterdam together with its Amsterdam-based higher education partners (namely the VU University Amsterdam, the University of Amsterdam, Amsterdam UMC, and other universities of Applied Sciences), industries and civic society, has managed over the years to create a vibrant, innovative, organised and effective eco-system supporting STEM researchers' journey into entrepreneurship. Although valorisation is a priority for all universities in

Amsterdam; the UvA seems to have made it part of its DNA for many years already; being the only one with a clear and accessible valorisation policy, agenda and indicators.

Background of the Amsterdam-based Universities

The University of Amsterdam (UvA), established in 1632, is one of the two publicly funded research university in the city and the third-oldest university in the Netherlands. It has seven faculties, of which the Faculty of Science consists of four departments with 1200 researchers and lecturers operating in eight research institutes. The main faculty buildings are located on the Science Park Amsterdam campus. The faculty was ranked number one in the Netherlands and 47th internationally in 2011. At the UvA, valorisation has been incorporated into its Strategic Plan and policy and management covenants. Valorisation falls under the heading of "social responsibility and innovation ", which pays attention to the UvA's role in society and surroundings. It is not specific to STEM but is part if the university's DNA and is connected to the university, regional, national, and European priority areas, as developed below.

The Academic Medical Center (AMC), is the university hospital affiliated with the UvA. It is one of the largest and leading hospitals of the Netherlands and consistently ranks among the top 50 medical schools in the world.

The Vrije Universiteit Amsterdam (VUA), founded in 1880, is the second publicly funded research universities in the city and ranks consistently among the top 150 universities in the world. Research at VU is organized mostly along the lines of the nine faculties. Their Faculty of Sciences consists of 12 departments, three other research groups and the faculty participates in numerous interdisciplinary research institutes such as the Amsterdam Sustainability Institute, or the Amsterdam Center for Multiscale Modelling. The VUA defines valorisation or impact as the creation of economic and social value with scientific knowledge. In their 2020-2025 strategy[15]; the VU positions valorisation as equally important as Education and Research and developed a Roadmap for Sustainability 2021 which includes important valorisation projects. The VUA is also since 2016 part of the Aurora Universities Network[16] which gather six renowned European universities with the goal to activate innovation and collaboration of students and academics on projects in line with key thematic such as Societal Impact and Relevance of Research (SIRR). VU University Medical Center Amsterdam (VUmc) is the university hospital affiliated with the Vrije Universiteit Amsterdam. It is rated as one of the best academic medical centers in the country in terms of patient care and research.

[15] VUA Strategy report 2020-2025.

[16] Aurora Network website: https://aurora-network.global/who-we-are/

The Hogeschool van Amsterdam, University of Applied Sciences (HvA), or Amsterdam University of Applied Sciences (AUAS), is a large institute for higher professional education in the Netherlands, established in 1993. HvA is a knowledge institution whose mission is to connect education and applied sciences research, and to enable innovation in the professional sector and community in, and around, the cosmopolitan city of Amsterdam.

Supporting mechanisms for valorisation and entrepreneurship

a. Valorisation Policy and Valorisation Indicators

Although all universities have knowledge valorisation as a key priority just after education and research, the UvA seems to have committed beyond by having communicated clearly through their policy document *Valorisation at the University of Amsterdam* and the *2018 UvA Regulations Governing Knowledge Utilisation.*

According to the UvA, the conditions for a successful valorisation policy include retaining focus and making results visible to a broad audience (see Table 2, UvA valorisation indicators). These results must be measured in terms of social impact, in order to identify the best instruments for valorisation, and in view of the financial requirement to spend at least 2.5% of all public research funds on valorisation.

The outline agreement concluded between the Dutch Ministry of Education, Culture and Science and the Association of Universities in the Netherlands (VSNU) in December 2011 specifies that the universities and the government should jointly develop indicators that can be used to measure valorisation over the long term.

Table 1. UvA valorisation indicators

	2013	Up to and including 2018
New patents and invention disclosures	12	+7
New licenses	12	+7
Partnership contracts concluded	2	+5
New ventures established	1	+2

b. Valorisation topics and priority areas

The UvA (including the AMC-UvA) has 20 research[17] priority areas, into which the best research has been grouped, of which 11 are STEM related, namely; Global Health, Cardiovascular

[17] Valorisatie bij de UVA, University policy papers, 2014.

Diseases, Metabolic Diseases, Infection and Immunity, Oral Regenerative Medicine (Bioengineering), Oral Infections and Inflammation, Brain and Cognition, Systems Biology, Gravitation and Astroparticle Physics (GRAPPA), Quantum Matter and Quantum Information, and Sustainable Chemistry. In the UvA Profile, dated June 2012[18], the research priority areas are clustered into seven themes, of which 5 are STEM specific (see Fig.1 below), and each subsequently related to ambitions at the European, national and regional levels. Precisely because of its alignment with the European Framework Programme for Research and Innovation 'Horizon 2020' and the national and regional 'top sectors', this clustering identifies the themes that offer the best chance of successful, large-scale valorisation.

[18] The UvA's response to the memorandum entitled Kwaliteit in verscheidenheid [Quality in Diversity] (OCW) and the outline agreement concluded between the Dutch Ministry of Education, Culture and Science and the VSNU in December 2011.

Figure 1. Chart of relationship between research themes and ambitions at the European, national and regional levels

Horizon 2020	National "top sectors"	Amsterdam Economic Board	UvA Research Priority Areas						
			Transnational Law & Governance	Human Health	Cogntion, Socio-Economic and Behaviour	Globalisation, Identity, Inequality and Urban	Communication and Information	Fundamentals of Natural Science	Sustainable World
Climate action, resources efficiency and raw materials	Chemicals								
Secure, clean and efficient	Energy								
	Water								
Food security, sustainable agriculture, marine and maritime research and bio-economy	Agri-food	Flowers and Food							
Health, demographic change and wellbeing	Life Sciences and health	Red life sciences							
Inclusive, innovative and secure societies									
	High Tech	ICT							
Smart, green and integrated transport	Logistics	Logistics and Trade							
	Creative Industry	Creative Industry							
	Financial Sector	Financial services							
		Tourism and conferences							

The **VU Amsterdam** has defined for their strategy 2020-2025 4 themes[19] around which education, research and valorisation will be mirrored and reinforced, namely: Governance for Society; Human Health & Life Sciences; Connected World and Science for Sustainability. The VU has defined three priority areas/ values namely *Sustainable* (achieving their sustainability aspirations in terms of contribution to the United Nations' Sustainable Development Goals (SDGs), *Enterprising* (that means seeing, creating and seizing opportunities. Being creative and courageous), *Diverse* (being open-minded to the uniqueness of others).

The **AUAS** has endorsed the 17 Sustainable Development Goals (SDGs) of the United Nations. Based on these SDGs, the university has established sustainability, diversity & inclusion and digitalisation as the three central dimensions (3 Ds) for their 2021-2026 strategic development[20] and as their guiding principles in all of their education and research as well as within their own organisation. AUAS has developed quadruple helix Centres of Expertise, based on metropolitan issues such as Urban Education, Urban Technology, Urban Vitality, Urban Governance and Social Innovation, Creative Innovation and Applied Artificial Intelligence. These themes are also in line with national and European agendas. At the national level, AUAS contributes to powerful research, such as the Netherlands AI Coalition, the Acceleration Agenda, the National Platform for Applied Research (NPPO), open science and other such joint ventures.

c. TTO offices

The joint Amsterdam-based Technology Transfer Office covers UvA-AUAS-AMC . The members of the TTO UvA-AUAS-AMC staff include professionals with backgrounds in science and/or business, who have expertise in the valorisation of academic knowledge. The TTO UvA-AUAS-AMC has a broad network within the institution and the business sector, as well as among funding bodies and in the social field. The TTO UvA-AUAS-AMC maintains active contact with researchers, working with them to consider possibilities for valorisation.

d. Pan-Amsterdam Technology Transfer Office

A formation of a pan-Amsterdam TTO consisting of the technology transfer offices of the Amsterdam-based institutions (UvA, VUA, VUMc and AMC-UvA) facilitated the access for a subsidy within the framework of the Ministry of Economic Affairs' Valorisation Programme. This subsidy has been allocated in two instalments, each amounting to €5 million. The formation of a pan-Amsterdam TTO was one component of the subsidy application.

[19] VU_Strategy 2020-2025
[20] AUAS_strategic-plan_2021-2026

e. Innovation Exchange Amsterdam (IXA)

IXA is a partnership between the Technology Transfer Offices of Amsterdam's universities and teaching hospitals and Amsterdam University of Applied Sciences. This partnership was set up in 2012 as part of the valorisation programme funded by the Netherlands Enterprise Agency (RVO). The RVO valorisation programme ended in late 2019, and IXA is now working on a new strategy to ensure all Amsterdam institutions continue to achieve valorisation. The new valorisation programme IXAnext: A Talent for Innovation, which will run until the end of 2021, completed a successful mid-term review in 2019. IXAnext is providing a major boost to entrepreneurship, innovation and valorisation in Amsterdam.

f. Valorisation Funds

IXA UvA offers a variety of funding and grants such as;

- the Patent Fund (also known as the IP Fund; the cost for patenting is paid for via the UvA Octrooifonds)
- the Proof-of-Concept Fund (PoC Fund €25-100k)
- Pre-Seed Fund (up to €100k)
- the Informatics Feasibility Fund (for researchers from the Institute of Informatics UvA; funds up to €70k)
- Physics2Market grant (For physics related projects, up to €10-35k)

g. Ventures Holding BV

Formed in 1992, UvA Ventures Holding is a wholly owned subsidiary of the University of Amsterdam that enables new technology to reach the market and was set up to separate the activities financed by public funding and private revenue streams. Its portfolio companies are classified in three categories: contract research, services and new ventures. It also manages the spin offs from the Academic Medical Center (AMC), through AMC Ventures Holding, and companies spun off from the University of Applied Sciences Amsterdam through HvA Ventures Holding.

h. Amsterdam Science & Innovation Award (AMSIA)

AMSIA is an annual competition for the most innovative research-based idea with a social and/or commercial application. The competition is organised by IXA in collaboration with the Municipality of Amsterdam, the
Netherlands Cancer Institute/Antoni van Leeuwenhoek and Amsterdam Science Park.

i. Impact Award

The Impact Award is bestowed on Amsterdam-based researchers whose research helps society move forward in a significant way. In 2019, out of four, three awards were delivered to STEM professors.

j. Collaboration with the Amsterdam region

Collaboration between research institutes and businesses is being strengthened, for example in the area of artificial intelligence (AI) where a range of new innovation labs have been opened, including in partnership with the Inception Institute of Artificial Intelligence in Abu Dhabi, Elsevier and TomTom.[21]

The partner knowledge institutes have committed to an ambitious list of objectives for the next ten years: (1) At least €1 billion of financial support earmarked for AI; (2) At least 800 people working in AI education, research and innovation; (3) At least 5,000 students trained in AI technology at the BSc, MSc and PhD levels; (4) At least 10,000 students taking a minor in AI; (5) At least 100 small and medium-sized enterprises (SMEs) affected by collaborative spin-off projects; (6) At least 100 AI start-ups.

STEM entrepreneurship status

a. Amsterdam Center for Entrepreneurship (ACE)

The Amsterdam Centre for Entrepreneurship (ACE) is a joint Amsterdam-based university incubator (UvA, VU, HvA and Amsterdam UMC). ACE Incubator helps students, researchers, alumni and tech professionals develop their innovative tech- and science-based ideas into successful companies. ACE offers training, support and access to an extensive network of mentors, entrepreneurs and business professionals.

The training is marked by an interdisciplinary character and a focus on both knowledge transfer and skills enhancement. One of the key activities the ACE will focus on in the next coming years is the **Science, Business & Valorisation educational programme** for research groups, in which research groups are offered valorisation tracks and instruments for implementation within their own group, thereby promoting the direct application of new academic knowledge.

b. STEM Incubator facilities: Amsterdam Science Park

Amsterdam Science Park (ASP) has one of the largest concentrations of academic education and research facilities in Europe. It was developed jointly by the UvA, the City of Amsterdam and the Netherlands Organisation for Scientific Research (NWO) and the shareholders include

[21] UvA Annual Report 2019

internationally operating companies. Around 3,000 researchers are currently working at Amsterdam Science Park, with around 900 people working in the 170 companies located there. The Matrix Innovation Center buildings offer high-value flexible office space and laboratories for approximately 120 of the 130 companies at Amsterdam Science Park.

The park emphasises research in the natural sciences, particularly in the areas of Digital Innovation, AI and ICT, High-Tech Systems & New Materials, sustainability, life sciences. The latest is reinforced by the prominent position of the UvA **Faculty of Science (FNWI**), which conducts research and provides teaching in the natural sciences.

Since 2016, the **Amsterdam Venture Lab (Startup Village)**, helps graduate students and researchers engaged in entrepreneurship in the natural sciences to take the next step towards realising a successful business. The Venture Lab offers accommodation, a growth programme, coaching and a network of relevant entrepreneurs and investors. Every six months, companies are assessed by the Venture Lab Committee. Residence at the Venture Lab is for up to two years. It currently hosts 35 start-up companies.

Furthermore, various renowned research institutions are located at Amsterdam Science Park, including the Dutch National Institute for Subatomic Physics (Nikhef), the FOM Institute, AMOLF, the national research institute for mathematics and computer science CWI and SURFsara (Computing and Networking Services). The park also hosts since 2014 the Advanced Research Centre for Nanolithography (ARCNL), a public-private collaboration between ASML, FOM, NWO, UvA and VU University.

Impact of STEM valorisation at the institution

University policies that support the process of valorisation, facilitates the involvement of staff in the process. A study done by researchers from AUAS and UvA found that making research FAIR – finable, accessible, interoperable and reusable – enables the interaction with a wider audience through open access. This open access also allows for the removal of financial, legal and language/jargon barriers that impede valorisation of research[22].

The collaborative ecosystem formed around Amsterdam could be considered as a best practice for valorising research. What seems key here is the importance of strong valorisation strategies anchored in regional, local, European priority areas and even global, through the United Nations' Sustainable Development Goals. The strong support from the TTO offices and Innovation Exchange as well as other commercialisation agencies or incubators who brings professionals and financial support to the research projects are also critical is transforming

[22] Woutersen-Windhouwer, S., & Kuijper, J. (2018). How to reach a wider audience with open access publishing: What Research Universities can Learn from Universities of Applied Sciences. *Liber Quarterly*, 28. https://doi.org/10.18352/lq.10237

knowledge into societal impact. The wide access to various grants and funds is key to motivate researchers is pursuing their ideas, as well as the various awards and career opportunities within the regional ecosystem.

A Status Quo Review of STEM research valorisation in Ireland

National Background

The Higher Education Authority (HEA) is the statutory planning and development body for higher education and research in Ireland while Quality and Qualifications Ireland (QQI) is an independent State agency responsible for quality assurance. These organisations collaborate through the National Framework for Doctoral Education (NFDE) Advisory Forum. Both the National Framework for Doctoral Education and Ireland's Framework of Good Practice for

Research Degree Programmes consider the range of skills required by researchers and seek to ensure that the acquisition of discipline-specific knowledge is complemented by the development of transferable skills necessary to support impact of the research in practice. The desirable range of transferable or non-discipline specific skills to be attained is informed by national and international models of good practice such as such as IUA's Irish universities PhD Graduate Skills Statement, the Eurodoc Report on Transferable Skills and Competences, the Vitae Researcher Development Framework, and Australian Council of Graduate Research Good Practice Framework for Research Training.

The national valorisation context in the Republic of Ireland is considered important by the government and by the national enterprise development agencies, although the term valorisation is not typically used. A key goal for the government Action Plan for Education 2019 is to intensify the relationships between education and the wider community, society, and the economy, as well as to develop individual and collaborative talent and ensure there is tangible and positive impact upon society and the economy.

The government focus is on transitioning PhD graduates successfully to the workplace and towards developing the adsorptive capacity of the workplace for PhD graduates, thereby effectively supporting innovation and development of products and services and improving the valorisation of research. Here, integration of the strands of the innovation quadruple helix of industry, education, government, and civil society is the focus.

At the government level, the Department of Business, Enterprise and Innovation articulates the need to ensure that our research and innovation system is aligned to our enterprise potential and objectives, to support entrepreneurship and to drive more and deeper collaborations between enterprise and research centres. The national enterprise development agency, Enterprise Ireland, coordinates the cross-governmental contact points for accessing Horizon Europe funding, effectively linking industry to research. Enterprise Ireland also facilitates a Small Business Innovation Research Initiative (SBIR) designed to stimulate innovation and development of goods or services that are not currently available in the marketplace, directly addressing challenges that impact on citizens and society. For example, in 2017, Cork County Council, in conjunction with Enterprise Ireland organised a seed fund challenge for applicants to deliver innovative ways to help local older citizens maintain good quality of life and to remain secure in their homes. A further scheme, the Small Business Technology Transfer or STTR involves partnering small businesses with non-profit research institutions, bridging the STEM/Commercialisation gap. The Innovation Voucher Initiative is a further incentive that links small-to-medium sized businesses with research and education through a €5000 grant to assist a company explore a potential business opportunity. The innovation voucher pays for early or proof of concept research with recognised research institutions.

Knowledge Transfer Ireland (KTI) was established to support the engagement interactions between the Irish Research base and business. Business benefits from access to Irish expertise and technology by making it simple to connect and engage with the research base in Ireland. KTI takes a national perspective on the knowledge transfer system in Ireland. KTI works with business, investors, universities, Institutes of Technology, State research organisations, research funders and government agencies to maximise State funded technology, ideas and expertise getting into the hands of business to drive innovation. KTI manages the Technology Transfer Strengthening Initiative (TTSI) programme on behalf of Enterprise Ireland. This funding programme, established in 2007, has been instrumental in driving the development of a professional Technology Transfer system at Ireland's public research institutions. The current TTSI3 programme is a €34.5 million programme, supporting the continued development of technology transfer offices (TTOs) within Ireland's research performing organisations (RPOs), by off-setting the costs of staffing and operations for a period of 5 years (2017 – 2021).

Knowledge Transfer Ireland - Technology Transfer Strengthening Initiative

The programme, first introduced back in 2007 by Enterprise Ireland, is managed and administered by Knowledge Transfer Ireland (KTI). It allocates funding across eight consortia comprising 26 research performing organisations that include Universities, Institutes of Technology, and state research bodies. The programme provides funding to the technology transfer offices (TTOs) that support these institutions around the country and it catalyses development of the knowledge transfer profession and the work it does. In doing so, the programme acts as an accelerator for commercialisation of research that would not otherwise be possible.

KTI 2019 report includes:

123 Active Spin-outs (3+ years post incorporation) – 1,000 jobs

2,168 Industry Collaboration Projects live at Dec 2019

459 new invention disclosures

137 new patent applications files

904 new consultancy services agreements signed

Science Foundation Ireland (SFI) is the national organisation for investment in scientific and engineering research. Through focused collaboration SFI aims to 'collectively achieve a national research and innovation system which is embedded in the fabric of society and realises the potential of research with and for all of Ireland's people.' Recently launched SFI centres for research training programme aim to meet future ICT skills needs by providing training for 700 PhD students. The €100 million programme is the first of its kind in Ireland and is focused on scientific advancement and enhancement of industry and enterprise in collaboration with researchers. In a move away from the traditional PhD training model these PhD candidates work and interact with industry and acquire cross-sectoral training and skills. The cohort approach to research training supports the development of transferable skills and exposes.

Advance Centre For Research Training
ADVANCE Centre for Research Training (CRT) is a Science Foundation Ireland CRT focused on Future Networks and the Internet of Things with applications in sustainable and independent living. ADVANCE will train 120 PhD students, recruited in four annual cohorts of 30 students across five partner universities. This initiative began in the academic year 2019/20. Meeting both the technical and societal challenges of global hyper-connectivity requires multi- and inter-disciplinary approaches. ADVANCE brings together STEM and AHSS researchers, drawn from the domains of ICT, social sciences, and health, to stimulate socially-responsible and inclusive creativity and innovation in the field of advanced communications and the Internet of Things. The ADVANCE training programme (TP) encompasses this vision with each student designing a personal training programme with core and elective elements. The TP will provide modules appropriate to each doctoral stage: **Foundation** M1-M12: basic starting skills – technical context, ethics and research skills; transferable skills to understand research impact and effectively communicate it to the broader community. **Development:** M12-M36 Discipline-specific modules supportive of their research programme; societal awareness; IP, innovation and entrepreneurship; support on outreach and public engagement; placements in industry, local authorities, NGOs and our international research collaborators **Completion:** M36-M48 Supported in thesis writing, career planning and IP, innovation /entrepreneurship; employer-engagement events to explore opportunities with our partner companies.

The Irish Research Council recently published their Strategic Plan 2020-2024. This report acknowledges that an ecosystem approach is required. Relevant key strategic goals include targeting of excellence in people, skills and ideas across all disciplines for discovery, as well as enterprise research. The third strategic goal calls for demonstration of the value of research to ensure knowledge and innovations are shared and exchanged to the maximum extent.

Background of the Munster Technological University (MTU)

Munster Technological University (formerly Cork Institute of Technology or CIT, and Institute of Technology Tralee or ITT) is in the southern province of Ireland. Munster Technological University (MTU) is a multi-campus technological university, contributing to the region through the provision of academic programmes that support student development and opportunities, education, and research. MTU has an extensive regional footprint with six campuses across the South-West region in the counties of Cork and Kerry, and a student body of 18,000. Across the MTU, faculties, constituent colleges and academic staff research interest range across Engineering, Science, Business and Humanities, Music and Art. The University offers over 140+ courses and programmes and includes 6 research centres of excellence. Education in MTU rests on the pillars of:

- providing education for career-focused learners
- developing and fostering long term partnerships with industry and community
- expanding the university networks regionally, nationally, and internationally
- fostering enterprise and innovation for a stronger economy
- engaging in multidisciplinary collaboration across the multi-campus university
- promoting a culture for success with a warm, welcoming, entrepreneurial, innovative, and people-oriented community.

Supporting mechanisms for valorisation and entrepreneurship

The Innovation and Enterprise Office is responsible for all technology transfer activities in MTU. It is part of the Bridge Consortium which includes University College Cork and Teagasc. The consortium builds on the significant success to date in terms of licensing, spin out companies and research income of the partners. The Technology Transfer Consortium creates an effective link for knowledge transfer expertise to be shared and used in the member institutions and is funded by Enterprise Ireland under TTSI 3 (Technology Transfer Initiative) and supported by Knowledge Transfer Ireland. Resources include a Regional Programme Manager for 3rd Level Student Entrepreneurship and some graduating students act as Enterprise Interns to support the activity.

This office also employs a commercialisation specialist and a contracts advisor who provide training and are available for consultation.

The Hincks Centre for Entrepreneurship Excellence is located on the Cork Campus, and supports entrepreneurship through research, education, and training. The Hincks has a strong local and international focus, is actively involved in many undergraduate entrepreneurship embedding initiatives and with international research and project partners in Europe, South Africa, Thailand, and Vietnam. The Kerry-based Campus features a Centre of Entrepreneurship and Enterprise Development (CEED) centre. Both centres' interdisciplinary approach spans across all departments within the MTU to stimulate an entrepreneurial spirit amongst both staff and students. Both centres currently host several post graduate candidates in entrepreneurship at both masters and PhD levels and often participate in knowledge transfer projects.

The Rubicon Business Incubator is located on the MTU Cork Campus and hosts over 100 companies ranging from early start-ups to scaling companies. On the Kerry-based campus the business incubator is called the Tom Crean Business Centre. Both centres, the Rubicon and the Tom Crean, offer a wide range of supports to new enterprises and are involved in a wide range of initiatives

The MTU Extended Campus facilitates initial needs analysis and consultation sessions for external organisations with a view to matching them with appropriate internal units and individuals. Following this initial phase, the external organisation or community group is introduced to the appropriate internal MTU unit(s). The goal is to enable knowledge exchange, lifelong learning, and responsive engagement, providing companies, enterprises, individuals and communities with pathways to access, to interface with and contribute to knowledge generation within MTU and impactful regional development.

Overview of Valorisation at Munster Technological University (MTU)

We consider STEM valorisation as encompassing all opportunities that STEM students and researchers must apply their research in the practice domain whether that is to improve products, processes, or services to enhance the experience for society at large or to develop their own idea into a novel solution which leads to patent, licencing or new business development. The skills that enable this transformation are embedded throughout the undergraduate and postgraduate journeys. They include formal learning outcomes embedded in modules as well as projects, competitions, awards, webinars, and other similar initiatives MTU has a long history of support for student projects and innovation and, at undergraduate level for example, our School of Mechanical Electrical and Process Engineering has a proud record of success in national and international competitions in engineering innovation, design, and entrepreneurship. Working with enterprise partners is integrated throughout the curriculum to ensure that the curriculum is current and relevant and is informed by the latest enterprise challenges and knowledge. Examples include master's programmes which incorporate a capstone project based on an industry-specified problem These collaborations with industry extend through the mechanism of student work placement, effectively exposing students to real-life, active workplace experience and skills development. Many programmes within MTU now routinely feature work placements in industry with defined learning outcomes, work-related projects, and live cases as a stimulus for student learning and this extension of work placement is becoming more common within postgraduate research programmes also.

The main MTU research activity is primarily (though not exclusively) organised around three Strategic Research Clusters that reflect MTU Cork's current dominant strategic research strengths. The three key research centres are the NIMBUS, BIO-Explore and Photonics. There are also new and emerging areas of research and several long-established centres that engage in research and consultancy. Many of MTU's research centres have links to Enterprise Ireland through its Applied Research Enhancement (ARE) Programme.

Located in a building beside the Rubicon incubator to physically link high quality research with innovation, commercialisation and start-ups or spin-offs, the NIMBUS Centre follows an integrated model of research, teaching and knowledge transfer. NIMBUS staff is actively involved in undergraduate and postgraduate teaching. The Technologies for Embedded Computing (TEC) Centre is located within the Nimbus building. Embedded systems can benefit all technology disciplines and can be used in many applications including sensing, energy, health, manufacturing, safety, environment, logistics and business, providing a key multidisciplinary platform.

Research knowledge on the key area of photonics resides in three research centres. (1) The Photonic Devices Dynamics Group focuses on the dynamics of semiconductor materials and devices. (2) The Centre for Advanced Photonics and Process Analysis (CAPPA) is industry led with a focus on optics and photonics. Given the regional industrial profile and its needs, the target sectors for CAPPA include medical devices, pharmaceuticals, electronics and naturally, photonics itself. (3) The Astronomy and Instrumentation Group focus on instrumentation and quasar research, mainly to support astronomy research. The final key research area comprises a multidisciplinary research group. The BioExplore research Group is a team of 6 principal investigators and 26 postgraduate students engaged in interdisciplinary projects involving the Departments of Biological Science Chemistry Mathematics and Computing. Their focus is on diagnostics, bio-analysis, peptide engineering, antimicrobial screening, and bioinformatics.

STEM entrepreneurship status

MTU has a strong entrepreneurial and innovation ecosystem with a range of innovative and accessible supportive activities. For university wide awareness and training March is designated as Innovation and Enterprise Month annually, organising over 35 events including competitions, talks, seminars, workshops and performances. This year (2021) events were held online. Examples were the MTU Innovation of the Year Prize and the annual MTU innovation challenge that involved pitches to industrial partners.

Through the Rubicon Incubation Centre there is access to Enterprise Ireland's New Frontiers programme. New Frontiers is a national programme linking Enterprise Ireland and the Universities and Institutes of Technology. The programme provides three phases of training including practical, interactive workshops, co-working spaces, mentoring, and financial support in a supportive environment for those who have business ideas that are scalable.

A further programme called EXCELL, which is delivered in collaboration with the Hincks Centre, encourages and specifically targets female entrepreneurs with a STEM background or business idea. This programme is delivered at weekends and on a part-time basis to encourage women with a STEM background to explore entrepreneurship as an option, while allowing time to meet other commitments.

At undergraduate level, embedding of entrepreneurship has gained significant traction. Modules are now routinely provided to engineering and other faculties at undergraduate level, as well as being available in the business school. Multidisciplinary Teams compete to solve real-life industry or societal problems. On campus societies include an entrepreneurship society and a social entrepreneurship society (ENACTUS).

The Student Incubation Programme also known as Student Inc. is a programme set up to encourage student entrepreneurs to develop their business ideas in MTU. It is a full-time programme running from June-August each summer. The undergraduate student applicants range across various faculties and courses. The students receive expert mentoring in the areas of market research, finance, business planning and much more. Each successful applicant entrepreneur receives €4,000 to fund their business. They also obtain a fully serviced office space in MTU located in the Rubicon Centre, Ireland's premier incubation centre, with successful completion of the Programme equating to one module worth of credits.

At postgraduate level, a range of modules are available to research students and to staff including a module on Innovation and Entrepreneurship. Aside from many research specific modules (Research Philosophy, Methodology, Research Skills Development, Data Analysis), the recent additions include two modules on career planning (one for early and one for late career researchers), Personal Wellness and Resilience, Research Communication, and Current Issues in

Research Integrity. Through our links with Centres for Research Training modules offered by other universities are also accessible.

Impact of STEM valorisation at the institution

A 2015 collaborative study of PhD students' perceptions of their own entrepreneurial and commercial capabilities within one Cork university showed that although increasing business/entrepreneurial capacity is desirable, there is a need to balance mastery of the core discipline with the development of entrepreneurial capability (Dooley 2015). No evidence was found in this 2015 study that the combination of university supports, and individual ability could be potential predictors for commercialisation of research or for research collaborations.

Currently, none of the spinout enterprises within MTU have come from postgraduate research. Spin out enterprise from staff research has been the norm, where it has occurred. This area of valorisation of doctoral research is currently under consideration by the university. Some MTU units are considering how to maximise the value from postgraduate research and are currently learning through partnership with other higher-level education actors already working in this area. MTU projects aimed at commercialisation of postgraduate and postdoctoral research are planned by the Innovation and Enterprise Office later this year (2021).

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A Status Quo Review of STEM Research Valorisation in France

National Background

Higher education in France is directed by the Ministry of Higher Education, Research and Innovation which is responsible for curriculum definition and setting national standards to form the scope of national qualifications. Higher education institutions are mostly autonomous in terms of finances, pedagogy, administration, and science. Regional strategic governance and institutional collaboration is encouraged by the law of 22 July 2013 establishing higher education institution clusters. The High Council for the Evaluation of Research and Higher Education (HCÉRES) is an independent public service agency responsible for the evaluation of institutions.

Recent challenges faced by the French government have been the ability of vocational graduates to access opportunity of further study in research areas, prompting changes to vocational pathways. Recent strengthening has focused on of apprenticeships and work-based learning in upper secondary schools as well as vocational programmes to fit low demand economic sectors and improve labour market transitions by connecting vocational programmes with higher education and research institutions.

France struggles with getting discoveries translated into application. Because of the lack of development from research into products, there is strong government interest in supporting valorisation to improve economic development and job placement. The "Investments for the Future" (Investissements d'Avenir) program initiated by the Ministry of Education, Research and Innovation aims to narrow the gap and better link public laboratories and companies through a 3.5-billion-euro plan. The plan promotes valorisation via Technology Transfer Accelerator Companies (Société d'accélération du transfert de technologie, SATT) to better support researchers in valorisation and link them with the industrial world, technological research institutions to remove the boundaries between public and private laboratories and increase collaborations and finally strengthening Carnot Institutes which are partner institutes developing links between research and business.

Further investments from the Ministry of Education, Research and Innovation have seen overhauls of research investment laws. The Research Programming Law 2021-2030 has created new government funding, improved career prospects including higher salaries and contract improvements for researchers, modernising evaluation by HCÉRES, strengthening links between business and research, simplifying daily life and functions of researchers and establishments and diversification of student bodies. These improvements' introductions attempt to make life as a researcher more accessible for a wider part of the population and allow for research and innovation to be brought to the industrial world. The Scientific Council of National research was created in 2018 to allow the educational community to access advancements in research in order to stimulate pedagogical reflection in universities.

France scores well in Europe as a strong innovator, performing near the EU average of the Commission's Summary Innovation Index and has shown solid growth of innovation since 2012. Since 2018 this performance has declined slightly. France's strongpoints are attracting foreign doctoral students, lifelong learning, venture capital expenditures and the percentage of the population with a tertiary education while they struggle the most with promoting an innovation-friendly environment, firm investment and intellectual assets when compared with other EU states.

Background of the Institute Mines Business Telecom School (IMTBS)

Since its founding in 1979 IMTBS combines the scientific engagement of the Institute Mines Telecom engineering programs with the business world. IMTBS engages in multidisciplinary research that has been critically acclaimed with commitments to both technological and social developments of France and the European Union. At the core of IMTBS is the idea of Uniting Skills, which is achieved not only by putting engineering and business students on the same campus, but also as the university strives to allow students, faculty, and partners to undertake their complementary areas of expertise and put them to work.

IMTBS offers a variety of entrepreneurship and innovation programmes within its degree outlines. For example, the Specialised Masters programme has specialisations in International Digital Business Development, Information Systems Management and Data Protection Management and the Master of Science with specialisations in International Management, ICT Business Management and Management of Innovation in the Digital Economy. There is also a specific major in Entrepreneurship and Innovation Management, providing the training to bring a vision into action. All education programs provide interactive courses, bringing field experts from one of IMTBS's close industry partners both into the classroom and as individual workshops and experiences.

Supporting Mechanisms for Valorisation and Entrepreneurship

a. Valorisation and Entrepreneurship Policy

One of the key principles at IMTBS is combining business with engineering, stemming from the school's place being the only management school within a web of engineering schools. The collaboration between engineers and managers allows a flow of knowledge from research into business to happen naturally on campus. IMTBS program requirements include mandatory work placements within a company. A commitment to an active involvement in developing research opportunities with partners positions IMTBS to support student and professional movement and development of entrepreneurial activities. Links to SMEs in research and education have allow IMTBS to perform ground-breaking and applied research supporting innovation and future employee education. The Major in Entrepreneurship and Innovation Management program trains students to be capable of designing and starting several forms of entrepreneurship projects through in class and hands on experience through the IMT Starter Incubator (more details on the incubator below).

This produces entrepreneurs who can manage projects and maintain creativity while utilising all of the resources available to them to create value for their projects.

IMT BS research is centred around five research teams, the KIND group, ETHOS group, SMART BIS group, RUN group, and CONNECT group. Each team works in rapidly evolving sectors and closely linked with industry, institutional, higher education and research partners in addition to students which allows each team to respond to challenges efficiently. Each team tackles different problems with societal impacts; the KIND team focuses on information and communication technology and the corresponding implications of private data, ETHOs evaluating modern organisations and society, SMART BIS developing and utilising information systems as part of organisational evolution, RUN studying the social challenge of digital transition and CONNECT analysing technological development's effect on consumer behaviour. Research at IMTBS is further supported by one laboratory and one research centre (discussed below). Each piece of the research puzzle at IMTBS is dedicated to responsible research, utilising collaboration with partners and improving diversity to create impactful and relevant research outputs that can be further developed.

STEM Entrepreneurship Status Quo

a) Entrepreneurship and Valorisation Facilities

The IMT Starter is the fourth best start-up incubator in France. Located on campus, the starter offers young entrepreneurs and students access to all of the resources they need to develop their innovations. Inside the Starter, students have access to a premises, coaching services, and technical support, and the Starter provides them with the tools they need to connect with investors and to get their ideas off the ground. The Starter places entrepreneurs within an ecosystem of entrepreneurship involving students, engineers, managers, coaches, and researchers, allowing effective knowledge transfer. It also partners with the C-19 digital interaction cluster to support startups in the digital and video game sectors while receiving tech platform and support expertise from C-19.

Figure 1. IMT Starter

IMT Starter
• 500m2+ of office space • 40+ teams launching companies • Access to all the resources necessary to get a company started, including research labs, conference rooms, professors and coaches

Other research facilities at IMTBS include the Laboratoire Sens et Compréhension du Monde Contemporain (Sense and Understanding of the Contemporary World Laboratory). Bringing together the digital world, the innovation sector and the social science research community, LASCO analysis "the conditions for the emergence of meaning at a time when subjectivities, interpersonal relationships, organizations and political spaces are at stake for major changes". Collaborations take place, internally, between IMTBS, IMT Atlantique and Mines Saint Etienne and externally, with the Interdisciplinary Institute of Contemporary Anthropology.

The Laboratory in Innovation Technologies, Economy and Management (LITEM) seeks to understand the requirements and transformations of the world and to support socioeconomic actors as they transition about in the world between their digital, economic and social interests. The lab specialises in information and communication technology, green IT and big data (among others) and their applications to sectors including health, agriculture and industry while maintaining a view towards sustainable development. This lab is shared with the University of Evry Val d'Essonne as well as the Law Economy and Management doctoral school at the University of Paris-Saclay.

b) Student Projects

Student projects are encouraged through a variety of challenges supported by the University. The Challenge Projets d'Entreprendre is France's largest entrepreneurship competition. In one week, students form hybrid groups comprising both business and engineering students, form their startups and the competition combines more than 500 students onto over 100 teams from IMTBS, Telecom SudParis and ENSIIE.

The Creativity and Innovation Week encourages students to develop their creativity and agility over five days. Students develop and work on new ideas and learn to promote them. The Corporate Challenge pairs students with partner enterprises. Students are coached by a representative from the enterprise to solve an issue that the enterprise has.

IMTBS shares campus and works in close partnership with Telecom SudParis, forming part of the IMT group specialising in engineering and management in digital sciences and technology. Student learning at Telecom SudParis is supported by a project-based curriculum where students apply theoretical skills onto six different projects, two of them Creativity and Innovation and Entrepreneurial Projects Challenge are shared with IMTBS.

Impact of STEM valorisation at the institution

Because of the resources provided by IMTBS, its graduates are known, both in France and globally, to be well trained to work with engineers. The IMT Starter helps to found on average 15 startups every year, overall, helping to create more than 200 startups and more than 2,000 jobs since its creation. In total, IMTBS graduate entrepreneurs have helped create more than 5,000 jobs. The Challenge Projets d'Entreprendre is internationally recognized and has inspired spinoffs at several different universities.

Barriers to valorisation include a lack of TTO or personnel offices. Drivers include the integrated educational programmes, combining research, foundational education and real-world experience. In addition, IMTBS has a wide range of industry connections, including hundreds of local and international enterprises and 120 universities worldwide. The workshops and training included in the curricula of each of the programmes increases industry knowledge for students and provides transferable experiences for when students participate in activities at the IMT Starter or in any of other projects.

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Case study summaries

The table below is a summary of 20 successful case studies on education and training in valorisation and entrepreneurship of STEM data that provided insights for the proposal of the development of STEM valorisation training /entrepreneurship training programs aimed to enhance STEM research valorisation skills. The table has been used as a matrix for the analysis of case studies that have been presented in the report. Table provides information on the training programs: country of origin, name, price, format, length, targeted group and number of participants, content (topics included) and learning methods, and skills and knowledge acquired through training.

Country	Name of the program	Price, Format & Lenght	Targeted group & number of participants	Content (topics included) & Learning methods	Skills and knowledge acquired through training
France	**Standard Essential Patent and Fair, Reasonable and Non-Discriminatory (FRAND) Licensing: The interplay between IP, competition and contract law** https://www.ceipi.edu/en/training-seminars/standard-essential-patent-and-fair-reasonable-and-non-discriminatory-frand-licensing-the-interplay-between-ip-competition-and-contract-law/	**Price:** professionals pay 1200-1400 euros; students 500 euros **Format:** Extra-curricular and face to face program **Length:** 2 and half days	**Targeted group:** Professionals and entrepreneurs in the digital and electronics, automotive, health and energy sectors, lawyers, decision-makers, judges and students; **Attendees:** Between 20-30 participants	**Main learning objectives:** • to provide better understanding on IP topics and enable attendees to be able to have more efficient approach to IP in general **Teaching methods:** • combining learning material with case studies (speakers started explaining principles and applied them to concrete examples in practice) • mentoring was not part of it	• understanding the legal issues related to Standard Essential Patent and Fair, Reasonable and Non-Discriminatory (FRAND) Licensing
France	**MIND student project (University of Technology of Troyes)** https://www.utt.fr/actualites/lancement-du-projet-mind-a-l-utt	**Price:** Free **Format:** Curricula bound and extra-curricular, face to face program **Length:**	**Targeted group:** Universities, students, and business entities **Attendees:** Over 60 students so far	**Teaching methods:** The MIND has its toolbox that includes: • link of projects to lectures, enabling students to validate skills and get ECTS credits; • new co-working space allows students to work and organize events; • provide equipment to test and carry out projects (3D printers, printed circuit engravers, CharlyRobot, etc.);	• Strengthen mastery of skills at UTU and acquire new ones (e.g. engineering, collaboration, innovation); • Stimulate innovation, creativity and entrepreneurships skills; • Develop experiences and working on concrete projects with application in practice (e.g. technology and start-ups)

		From 1 or 2 semester, sometimes even more depending on the project		• events - conferences, debates, round tables - created and organized within student projects; • social platform to connect all the actors of the project: students, teachers, companies, alumni (networking) **Activities that students can undertake during the program:** • propose projects or engage in other student projects, alumni, partner companies or the university related projects; • participate in a collaborative workshop that provides access to tools (3D printers, machine tools, engravers of several types, etc.) and offers manufacturing concrete possibilities - a way to turn an idea into real object; • meet, exchange and produce unscheduled interactions; • upload all projects, to monitor progress, make them visible to the whole community and manage connections that create innovation (in the process of being integrated into the IS); • use a hacklab, a space for training and demonstration	

				dedicated to forensic investigations and cyber security; • involve in events aimed at acculturating to innovation: arouse curiosity and creativity, raise awareness through conferences and organize opportunities to experiment.	
France	**Valorization of research: Marketing of technologies** https://www.curie.asso.fr/Valorisation-de-la-recherche-Marketing-des-technologies.html	**Price:** For members of CURIE Network 830 euros, non-member1230 euros **Format:** Face to face **Length:** 2 days	**Targeted group:** Business managers, scientists, engineers, involved in the engineering of valuation projects, business development and technology transfer and their consulting and business partners. **Attendees:** between 10-15 (mostly TT experts)	**Learning methods:** • non-confidential cases, followed by exercise that was a case study situation were participants could find solution to given problems; • basic concepts were explained on the TT and then participants could connect it to the examples from their daily business activities; • one person from the room is chosen to present practical example that was the most suitable and understandable to everyone; • last days of training serves to recap everything learned to show attendees that all learned during training is one set of skills in the form of toolbox they can use in the TT process in their responsibility.	• skills/knowledge on how to successfully market technologies; • mindset to work on the transfer of technologies and to connect with companies, while making bridge between companies and labs.

France	**MOOC Innovating with public research** https://www.curie.asso.fr/MOOC-Innover-avec-la-recherche-publique-673.html	**Price:** Free **Format:** Online **Length:** 5 weeks	**Targeted group:** Teacher-researchers, researchers, doctoral students, developers, or staff supporting research, to develop a culture of innovation. **Attendees:** N.A.	**The course consists of 5 modules involving:** • Innovation - the course takes participants through all parts of valorization process; • Valorization - explaining the whole valorization process (ecosystem) so participants can develop interest to engage in valorization and to effectively lead it. **Learning methods:** • shorter sessions to ensure participants stay engaged in the course and complete it; • makes the content user-friendly for online education and involve reading from the computer screen; • video content engages actors, each video is a rendezvous with the same person; • at the end participants have to complete a short test that assesses their knowledge and receive a certificate	• key concepts and tools for the socio-economic valuation of research result (e.g. how to protect an innovation, how to make the innovation ready for the market, how to market it, and then explain license negotiation) • renumeration (e.g. innovation through technology transfer and innovation through partnerships with companies)
United Kingdom	**3M Buckley Innovation Centre Fellowship** https://3mbic.com/	**Price:** Free **Format:** face to face	**Targeted group:** PhD researchers **Attendees:** N.A.	**Learning methods:** • access to equipment for 2 years, and general training to make use of equipment and contribution to materials	• access to leading expertise, R&D and facilities to those that are looking to scale-up their businesses or bring an

		Length: 1 or 2 years		• 50% funding to undertake special training for how to use the equipment • putting in research grants which researches will contribute to center by using the equipment and acknowledging the center as a sponsor	innovation to the market/society • business skills for those PhD researchers who would love to launch their own companies (e.g. how to open startup) • become proficient user of technology available in center (e.g. 3D printing, metal printing, X-Ray, CT-scan, and microscopy suite)
United States	**Cycloton Road** https://cyclotronroad.lbl.gov/	**Price:** sponsorship available **Format:** face to face **Length:** 2 years	**Targeted group:** entrepreneurial scientists and engineers who are developing technologies in advanced manufacturing, clean power, and electronics **Attendees:** 11	**Learning activities:** • Onboarding retreat – for meeting, socialising and covering some administrative processes • Once a quarter, there are community building activities, e.g. diversity, equity and inclusion topic bi-monthly **Learning methods:** • first 12 weeks of the program, participants are learning modules covering fundamental building blocks of entrepreneurship from Activate, called *Activate Learn* • after 12 weeks, participants attend weekly startup programming	• Building entrepreneurship (fundamental knowledge) • Networking building (e.g. core business and product development concepts, skill development workshops, VC pitch coaching and shared learning from other founders and alumni) • Mentoring/coaching within the team, where mentor in the team is fellow is someone who has

				- Every team has quarterly meeting/deep dive with Activate, specific to the project milestones and progress. This is where a lot of the coaching comes in - Fellows receive $100k spend at the national laboratory, that is managed by a cooperative R&D agreement and could have shared IP that was developed with the national lab	technical-innovation background; and external mentoring where fellows are assign mentors, experts and advisory boards from companies to help them when necessary.
Netherlands	**Demonstrator Lab** https://www.demonstratorlab.nl/	**Price:** Free **Format:** Face to face **Length:**	**Targeted group:** students, staff and academics from Amsterdam-based universities **Attendees:** N.A.	**Through the Lab, students can get access to:** - advice on all aspects of the idea-to-market process; - lab facilities, lab space, and office space in the field of product development (e.g. for fast prototyping); - access to mechanical and electronic workshop, Faculty of Science, VU; - seed grant (no-strings-attached, minimal bureaucracy) of up to €15,000; - flagship grant of up to €40,000 for a small, selected number of projects; - connection to the Demonstrator Lab network, which consists of mentors, coaches, a variety of	- Entrepreneurship skills (e.g. market analysis, product strategy, testing, pitching, networking, leading a team., financing, etc.) - Being coached at the Lab - Receive help to find the first funding for product or prototype

				experts, business strategists, venture capitalists, market analysts, and consumers	
Australia	**IMNIS - Industry Mentoring Network in STEM** https://imnis.org.au/	**Price:** Australian universities and Medical Research Institutes (MRIs) pay an annual subscription fee to join this program **Format:** face to face **Length:** 1 year	**Targeted group:** STEM researchers, academics. PhD, post-docs who want to transition from academia to industry access opportunities in industry **Attendees:** N.A.	**Learning methods:** • mentors and mentees must meet minimum for an hour once a month • mentees must commit to attending the events and engage with external stakeholders **Learning activities:** • attending professional development workshops with modules that layer onto the national program - those workshops complement the events and are be led by industry leaders who are experts in the area.	• networking and understanding the broader picture of the STEM ecosystem • mentoring (individual matching with an influential industry leader in the one year mentoring program, a series of four to five workshops and events, and structured support and networking through IMNIS TEAM) • increasing the researchers' influence both in and out of the workplace/industry (so that they have greater confidence to engage as a professional within the sector) • developing a strategy to career transition • understanding the innovation pipeline (ideas through to market)
Belgium	**KU Leuven Research &**	**Price:** Free	**Targeted group:** researchers	**Participants focus on three main**	• opening researchers' minds, and teach them the value of

	Development (LRD) Doctoral School Training programme https://lrd.kuleuven.be/	**Format:** online **Length:** 5 days over 7 months	**Attendees:**	**pathways of exploiting their research through:** • collaborating with industry • patenting & licensing • creating a spin-off company **Learning methods:** • introducing researchers to different technology transfer topics, including industry collaboration, IP and start-up creation • presentation of good practices case studies and testimonies • exposing researchers to industry experts **Learning activities:** • doctoral and post-doctoral researchers developing an exploitation plan in small teams, based on the research results of one of the team members or one of their research groups, while being coached by LRD staff and IOF innovation managers • presenting exploitation plans to a jury of industry experts an investors	intellectual property and what not to do when creating a company (e.g. building expertise in the process of establishing an intellectual property protection strategy, industrial partners search, patents application and follow up procedures) • developing negotiation skills needed when setting up agreements with companies • business creation methodologies and skills specialized for high-tech companies, the development of business plans, market validation, team management and growth strategies needed for spin-off activities
Canada	**Quebec Scientific Entrepreneurship**	**Price:** Free **Format:** online	**Targeted group:** researchers who are completing or have completed a master's, Ph.D.,	**Learning framework:**	• Developing an innovative project proposal from current or past research

	Program (QcSE) https://www.qcse.ca/	**Length:** 14 weeks	or Postdoc in STEM fields and want to explore the path from research to market **Attendees:** N.A.	• Phase 1 (3 Weeks): Discover the leading methodologies to disrupt markets • Phase 2 (8 Weeks): Explore potential markets for your technology. • Phase 3 (3 Weeks): Navigate the local startup ecosystem and learn how to pitch your start-up idea **Learning methods:** • practical exercises throughout its 14-week delivery encouraging the participants to work on their individual valorisation project • peer- to-peer learning and very close support of the participants by the organizers (mentoring) • participants use design thinking and meet with the community (cohort) and scientific entrepreneurs • participants use the business model canvas and meet many coaches and experts (in IP, commercialisation, financing, etc.) • participants learn about the start-up ecosystem in Quebec and how to pitch their projects	• Understanding the fundamentals of entrepreneurship and market validation • Learn to pitch project to a business audience • Learning to navigate the startup ecosystem • Developing entrepreneurial mindset among the scientific community of Quebec and guide the next generation of entrepreneurs looking for an alternate career path • Mentorship by the QcSE team through one-on-one meetings
Turkey	**BİLKENT**	**Price:** free	**Targeted group:** Senior undergraduates, graduates	**Learning framework:**	• organizational abilities, • communication,

	CYBERPARK_BIGG http://biggmarka.cyberpark.com.tr/	**Format:** 6 months **Length:** blended	**Attendees:** 50-60	• focused on the business plan (marketing, financial planning, etc.) • focus on field-work (doing customer discovery) • mentoring module with large companies involved, helping developing the projects to find the right product-market fit. The participants bring their own ideas, projects into the program.	• understanding technology • coordination pf project
Turkey	**İTU_BIGG** https://itucekirdek.com/en/apply-bigg-itu-cekirdek/	**Price:** free **Format:** blended **Length:** 6 months	**Targeted group:** **Attendees:** 20-25	**Learning framework:** • innovation – introduction • research – introduction • How to develop business plan • meaning of entrepreneurship and moving towards business plans • feedback and mentorship - everyone has to get mentorship from the instructors at least twice, usually lasting 30 minutes to an hour. This entire process lasts approximately 2 months. Usually, there are 20-25 projects per group and there are 2-3 groups per 6 months. There are 300-400 mentors in the program.	Program aims to develop entrepreneurial skill sets of the participants and their ability to take risks.

Turkey	**KWORKS / BIGG** https://kworksbigg.ku.edu.tr/	**Price:** free **Format:** online **Length:**	**Targeted group:** students, and academics **Attendees:** 25-30	**Learning framework:** • getting basic business knowledge (e.g. wiring a business plan, financial planning) • mentorship program where experts share their knowledge (out of 21 projects, 12 got BIGG support) • acceleration programs after 2 months where participants get more intense, shorter trainings focused on knowing the customer and understanding how to appeal to their need	• Business skills (e.g. how to communicate with investors, to improve sales and marketing • Communication skills - the program provides assistance in breaking the language barrier between professors and customers while also helping with the pricing
Turkey	**METU_BIGG** http://bigg.odtuteknokent.com.tr/	**Price:** free **Format:** online **Length:** 6 months	**Targeted group:** research assistants, postgraduates, and senior undergraduate students **Attendees:** N.A.	**Learning framework:** • focused on market narrative (e.g. how to determine the market, on what to pay attention in technology transfer, and what business plan should consists of) **Organization of training:** • starting with over 60 hours training • Bootcamp training for 2 full days • online education - divided content into 20-minute modules; for example, they need to watch five videos to complete a module. They can track the completion of the training on the	• marketing skills needed to place the products into market and have competitive business

				enocta platform, and at the end of each module, they are given homework to fill in the relevant part of the business plan. • all entrepreneurs' students and researchers are given one-on-one mentoring support, and mentors follow the development of entrepreneurs from the very first day	
Turkey	**Sabancı University_BIGG4TECH** https://sucool.sabanciuniv.edu/	**Price:** free **Format:** online **Length:** 3 months	**Targeted group:** students, graduates of an associate or undergraduate program **Attendees:** 22	**Learning framework:** • business plans • financial statements • market analysis • customer interviews • surveys, to reinforce the subjects. **Training organization:** • 56 hours of training that takes place on weekends for 4 weeks • after elimination procedure, those who pass will attended Sabancı University's *Introduction to Entrepreneurship course* and three ideas came out of that course to be sent to BIGG consortium for further development **Learning activities:** • assignments to complete	• mentoring • introduction to customers • collaboration development and pilot implementation with corporate companies • pre-prototype/MVP manufacturing • laboratory infrastructure usage

				• participation in experience sharing conversations with industry stakeholder • elimination according to the assignments given • after the 4-week trainings and assignments are completed, mentoring is given • at the end of the first phase of the program, the 5-minute pitch are made to the Innovent jury. After the presentation and 5 minutes of Q&A session, it is evaluated by the Innovent jury, and those who score above the average pass to the next stage, and those who fall below the average are eliminated.	
Ireland	**IRC Enterprise Partnership Postgraduate Scheme** https://research.ie/funding/eps-postgrad/	**Price:** scholarship includes a contribution of €18,500 as a stipend for the scholar as well as a contribution to the fees and a support for research expenses to a maximum of €27,500 per	**Targeted group:** full time research degrees in any discipline at masters and doctoral level **Attendees:** N.A.	The candidate will be supported through appropriate learning opportunities and modules in the university as well as industry specific training opportunities appropriate to their particular research question. The project and research question are co-designed by all three partners in the process (university, student and Irish Research Council). The candidate benefits from the supervision scheme of the university as well as a nominated enterprise mentor	**The aim is to:** • bring higher education and enterprise together to develop and foster great research ideas • ensure the PhD candidate gets the benefit of both academic and applications domain experience while developing their research

		annum. The Enterprise partner makes a contribution towards to value of the scholarship (€9,000 p.a.) **Format: face to face** **Length:** 12 to 48 months		that provides continued interaction and guidance from the perspective of enterprise for the duration of the awardee's studies.	
Ireland	**ADVANCE CRT –** https://www.advance-crt.ie/	**Price:** N.A. **Format:** online, face to face and blended **Length:** 4 years	**Targeted group:** postgraduate research students, particularly doctoral **Attendees:** N.A.	**Learning framework:** • professional development and induction processes • preparation for work placement (with an industry partner, NGO or research centre) built into each PhD candidate's learning plan • learners and research supervisors can take advantage of a wide range of formal modules as well as non-formal and informal learning (e.g. summer schools) • development of transferrable skills including research communication, time management, team-working, empathy, emotional intelligence,	**The aim is to:** • seeking solutions to the technical and societal challenges of global hyper-connectivity between large numbers of People and Things leading to exceptionally dense communications networks • cross-disciplinary approach ensuring that STEM researchers have an opportunity to develop the impact from their research work that will contribute to people and society

				resilience, workplace respect, career planning and entrepreneurial skills are provided for through external content providers, supervisors and the research community in a cumulative fashion phased over the first three years of each researcher's journey • where appropriate and where provided for in each university the modular learning, work placement etc. will attract credit and other personal development activities detailed in the candidates personal training log can be recognized through a series of micro credentials.	
Ireland	**Module on Innovation and Entrepreneurship (Munster Technological University)** https://courses.cit.ie/index.cfm/page/module/moduleId/10073	**Price:** free **Format:** blended **Length:** 12 weeks	**Targeted group:** researchers at Masters and PhD level across the University **Attendees:** N.A.	**Learning framework:** • concept of entrepreneurship • culture and workings of an entrepreneurial environmental as well as the personal and environmental factors which support entrepreneurial behaviour • principles underlying creative thinking, problem solving and innovation • scope to appraise the entrepreneurial and	**The specific skills are articulated in the learning outcomes to:** • Assess the economic and social benefits and supports for successful entrepreneurship for individuals, society and the economy • Evaluate the relationship between creativity, invention and innovation in research • Describe and distinguish the entrepreneurial process • Describe and discuss the range of skills, abilities, experiences and personal qualities that

				◦ commercialization potential of students' own field of research • evaluation of entrepreneurship as a career path **Learning methods:** • Interactive online workshops • Pre-reading and theory frontloaded • Virtual Incubator Tour • Links to University and events nationally and internationally • Team teaching • Guest lecturing – specialists/entrepreneurs • Self-directed learning • Building network of contacts • Mentoring sessions	successful entrepreneurs have and bring to their work in both the public and private sectors • Evaluate entrepreneurship as a career path
Ireland and United States	**The I-Corps@SFI Partnership** https://www.sfi.ie/resources/SFI-NSF-I-Corps-Entrepreneurial-Training-Programme-Call-2016.pdf	**Price:** N.A. **Format:** blended **Length:** 7 weeks	**Targeted group:** researchers and technology transfer/research translation/commercialisation professionals based at academic institutions **Attendees:** 40	**Under the I-Corps@SFI Partnership, there are 2 initiatives:** 1. **I-Corps@SFI Academy** which prepares researchers to apply to the ETP and trains TTO and other non-academic • a practice-based programme that employs two curriculum streams: **1.** instructor trainees are provided with training on how to deliver training in the NSF I-Corps Lean Start-up methodology to researchers; **2.** researchers are coached in applying the NSF I-Corps Lean Start-up	• Expertise in evidence-based entrepreneurship and experience in its delivery to researchers • Project/programme management to organise the structures under which support is provided • Relationship management to ensure that collaborations can be established and maintained successfully

				methodology to discover opportunities for their research • during practical experience, researchers are required to apply what they have learned and are expected to interview potential stakeholders to discover opportunities for their research. 2. **SFI/NSF I-Corps@SFI Entrepreneurial Training Programme (ETP)** • Following completion of the I-Corps@SFI Academy, researchers can apply to the SFI/NSF I-Corps@SFI Entrepreneurial Training • Applications to this programme are submitted by teams comprising two researchers and a mentor • Applications are in written form with review comprising two stages: telephone-based interview of teams with SFI/NSF programme staff; followed by international peer-review of written applications. • Applicants who are successful in their application receive a grant of ~€35k and participate in the NSF I-Corps Teams programme. **Learning methods for both programs:** • "inverted" or "flipped" classroom model - participants undertake	

				background reading and experience-based practice (stakeholder engagement) outside the classroom • during class time, researchers are expected to present their findings to the cohort and the discussion will takes place with instructors during class	
Ireland	**Module on Research Postgraduate Placement (Munster Technological University)** https://courses.cit.ie/index.cfm/page/module/moduleId/12567	**Price:** N.A. **Format:** N.A. **Length:** 1 semester	Targeted group: researchers at Masters and PhD level across the University **Attendees:** N.A.	• The module is offered as an elective option to registered research students • Learning framework is designed between student, graduate school and employer, with concrete objectives on the work to be done and how the work will contribute to the learning outcomes of the degree (herein the role of employer is to mentor and guide student) • The assessments methodologies consider written and oral communication through a developed planning process and written report or portfolio as well as a formal presentation process to allow the researcher to present the research findings in the appropriate context.	• Preparation of a detailed plan for the research to be conducted during the placement as a rationale for the inclusion of the placement within the learning pathway • Develop and apply existing and new knowledge, specialised skills and technical training to research in a placement organization • Exchange new knowledge and skills between the placement organisation and the Institute • Develop a professional report or portfolio evidencing their learning during work placement

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