SKILLS FOR INNOVATION
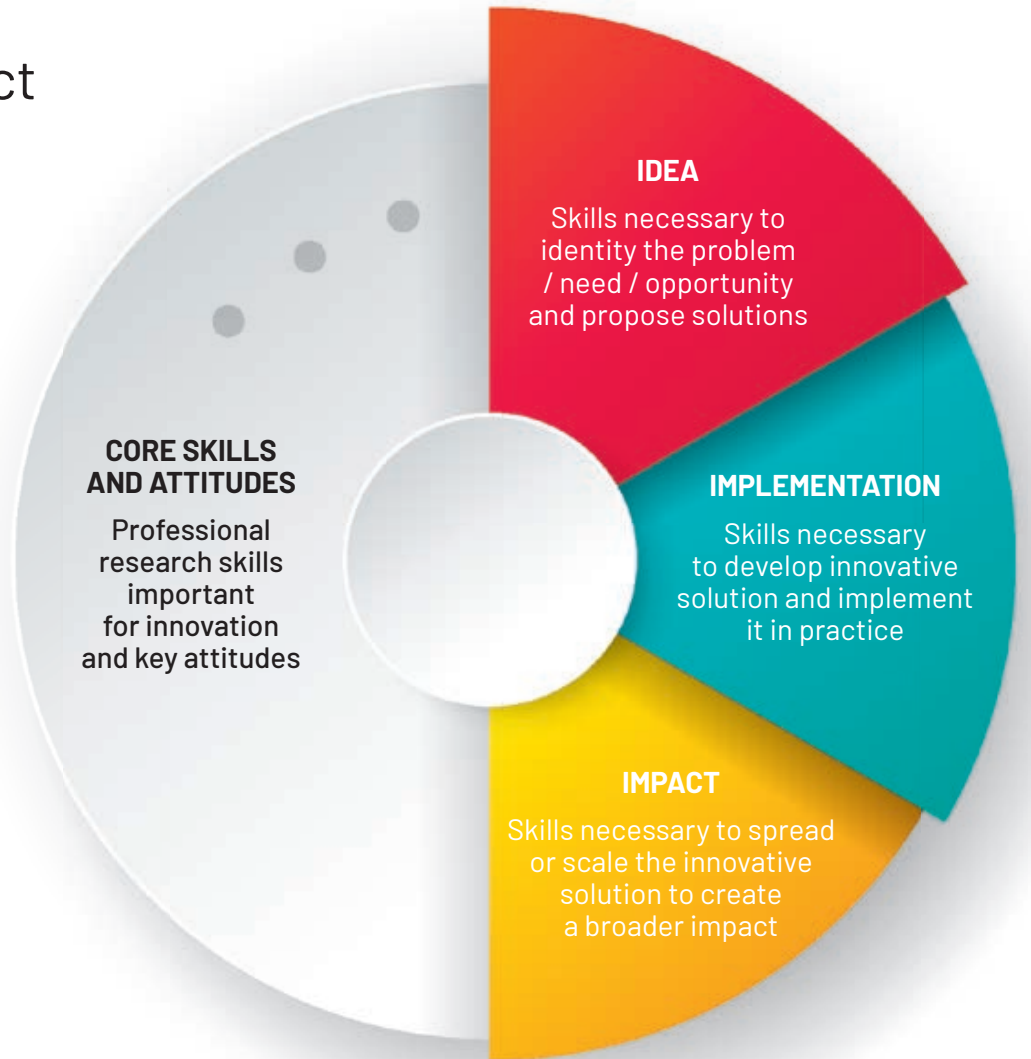## DL Skills ontology

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Discovery Learning
Skills Ontology: Innovations for impact

The skills ontology developed in the DL offers an overview of skills that help researchers contribute to innovation in different contexts. It tries to offer an answer to the question: What skills do PhD holders need to successfully engage in innovation processes (regardless of sector or type of innovation) and/or to create impact through the innovation?

The ontology works with the broad inclusive definition of innovation, understanding it as a practical and active implementation of ideas resulting in the concrete IMPACT in societies and, potentially, markets.

The core of the skillset included in the ontology, are skills that are crucial for innovation and on the same time they are the basic skills necessary for research profession. PhD´s usually develop those skills through regular academic training but it is necessary to help them reflect, ideally through direct experience, on how to implement those skills outside research context. By including these skills in the centre of the ontology we want to help researchers and potential employers understand, that PhD holders have a skills profile putting them in a very good position to initiate, drive or otherwise support innovations.

IDEA
Skills necessary to identity the problem / need / opportunity and propose solutions

IMPLEMENTATION
Skills necessary to develop innovative solution and implement it in practice

IMPACT
Skills necessary to spread or scale the innovative solution to create a broader impact

CORE SKILLS AND ATTITUDES
Professional research skills important for innovation and key attitudes

Structure of DISCOVERY LEARNING ontology

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To develop the skills included in the second layer usually takes an additional training (in the sense of training coming on the top of the standard academic preparation) or experience with or from outside the academic environment.

The skills included in the in the second layer focus on three broadly defined stages of innovation process. These are as follows:

⚙️ Idea

This stage includes the activities leading to generation of new ideas and solution alternatives. This means „creative" process on the one hand and systematic activities focusing on mapping and analysing the challenge and its context on the other.
To engage in this stage PhDs need skills that help them understand the broader context of (their own) research, identify the problem/needs/or opportunities that could be addressed by solutions generated by this research and propose a set of solution alternatives. In line with the principles of open innovation, they also need to know how to identify and engage all relevant stakeholders.

⚙️ Implementation

This stage includes activities necessary to transform ideas to a working solution or technology. For this stage skills for mobilising and managing people, processes, and funding within the existing legal and ethical constraints are crucial. Ability to engage those who should be users of/benefit from innovation is also inevitable for a viable solution and in line with principles of open innovation.

⚙️ Impact

This stage focuses on spreading of developed solution and its use and/or its adoption by target group or user that result in a desired outcome or change. To achieve this especially the skills related to communication, networking, getting buy-in and leadership are crucial.

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Who is the ontology for

Ontology should provide useful insights for various target groups:

⚙ PhD students

The ontology should help PhD students understand how their skills can be helpful in the innovation process and how they can use them to create impact through their research and beyond.
The ontology should also help them reflect on where they see themselves within the innovation process (are they idea makers/innovation managers/leaders...?) and what skill they already have or need to further develop to get ready for the innovation challenge. In case they take over the role of innovation leaders, the ontology also helps them identify the skills they will need to have within their teams.

⚙ Employers outside academia

The ontology aims to help employers across different sectors understand in what way PhD graduates can support or initiate innovation processes within their organisations.

⚙ Higher education institutions

Ontology should help HE institutions reflect on whether the PhD training they provide, facilitates development of innovation skills. It should encourage them in creating new training and learning opportunities leading to development of such skills.
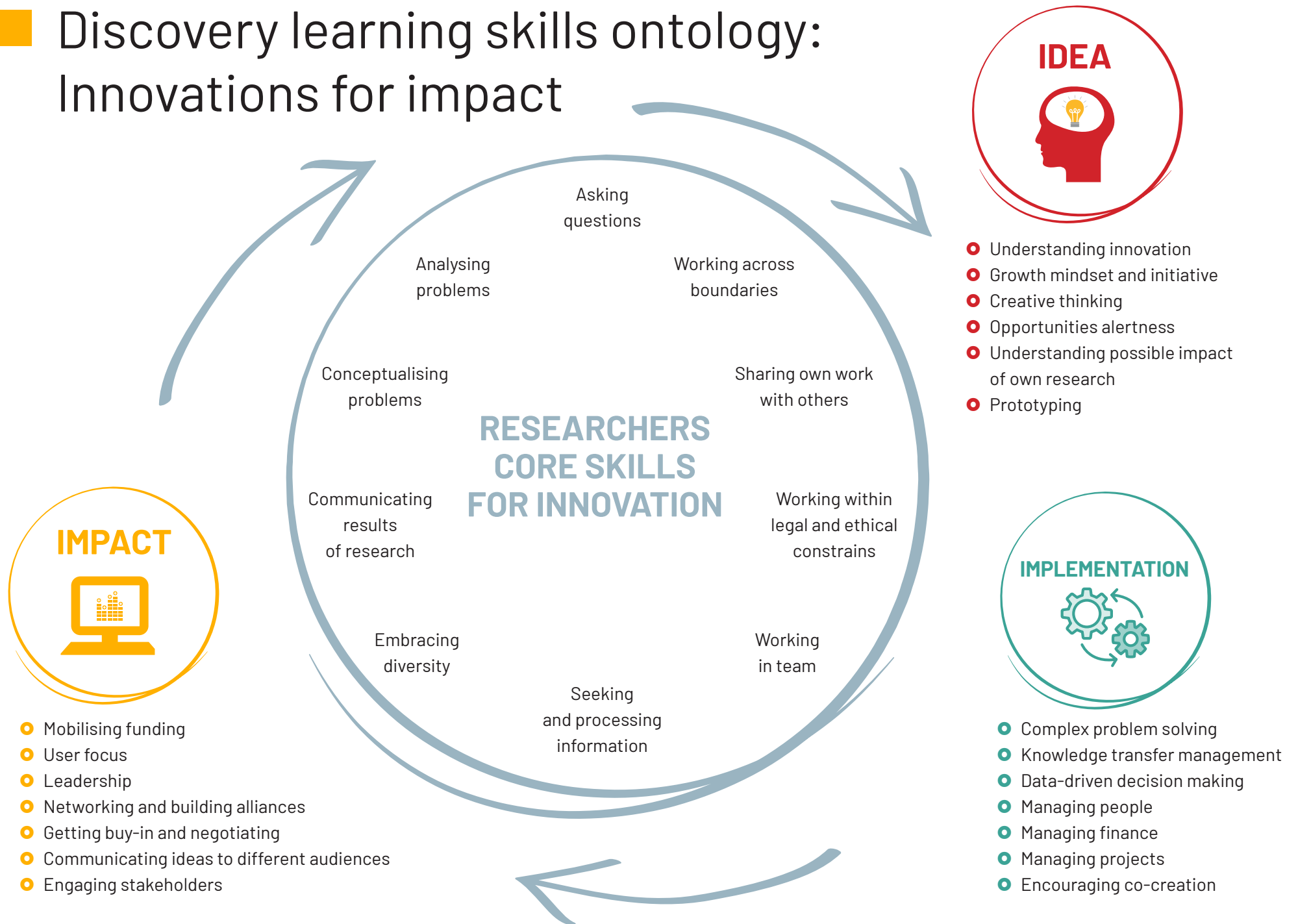
⚙ Training coordinators and career advisors

Ontology should help them understand what skills need to be reflected in the transferable skills training to develop innovative potential of PhDs either through introducing new training courses or integrating the topic into existing courses. They might also find ontology useful in providing a starting point for a career discussion about career paths in innovative sectors or innovation jobs outside academia.

⚙ Policy makers and other stakeholders

Those involved in drafting policies on innovation might find the ontology useful in developing measures focusing on the role of human resources within the innovation ecosystems. In general, the ontology also aims to highlight, that PhD holders might considerably contribute to developing innovative solutions across any policy.

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Discovery learning skills ontology: Innovations for impact

IDEA

- Understanding innovation
- Growth mindset and initiative
- Creative thinking
- Opportunities alertness
- Understanding possible impact of own research
- Prototyping

RESEARCHERS CORE SKILLS FOR INNOVATION

- Asking questions
- Working across boundaries
- Analysing problems
- Sharing own work with others
- Conceptualising problems
- Working within legal and ethical constrains
- Communicating results of research
- Working in team
- Embracing diversity
- Seeking and processing information

IMPACT

- Mobilising funding
- User focus
- Leadership
- Networking and building alliances
- Getting buy-in and negotiating
- Communicating ideas to different audiences
- Engaging stakeholders

IMPLEMENTATION

- Complex problem solving
- Knowledge transfer management
- Data-driven decision making
- Managing people
- Managing finance
- Managing projects
- Encouraging co-creation

Description of skills included in ontology

	SKILL	DESCRIPTION	EXAMPLES HOW THE SKILL CAN BE DEVELOPED
CORE SKILLS	Asking questions	The ability to ask questions that unlock new perspectives and solutions. It is closely linked to critical thinking and ability to question the one's own ideas or ideas of others.	These skills are or should be developed through the regular PhD training and direct experience of working as researchers. Some of them are acquired through directly practicing them, other require additional training which is however usually the part of the PhD curriculum.
	Seeking and processing information	The ability to find, capture and process information to increase knowledge or find solutions. Ability to use advanced methods and tools for this purpose.	
	Analysing problems	Ability to systematically break down complex problems and information into smaller and more understandable components or principles.	
	Conceptualising problems	The ability to recognize patterns or trends in a problem and understand it in a broader context.	
	Embracing diversity	Ability to work with people with diverse backgrounds and experiences (nationality, gender, culture…). Ability to mainstream diversity and gender equality into own research.	
	Communicating results of research	The ability to effectively adapt to a variety of situations.	
	Working across disciplinary boundaries	The ability to work multidisciplinary. Includes an ability to communicate own research to collaborators from other disciplines and sectors and understand ideas communicated by them.	
	Sharing own work effectively (Open Science)	Knowledge of how to share own research, including both data and results with wider scientific community and beyond in an open and transparent way.	
	Working in team	Ability to work with others towards a common goal. Ability to collaborate, listen to others and contribute with own ideas and share responsibility for the tasks to be completed.	
	Working within legal and ethical constrains	Ability to understand ethical and legal constrains of the own research. Ability to implement good ethical practice across all stages of research	
IDEA	Understanding innovation	Knowledge of how innovations emerge and how does the innovation process work. Ability to understand how this can be applied to different fields and sectors, including own area of research.	Training, case studies, discussions with innovators
	Growth mindset and initiative	The ability to be a self-starter and to meet the challenge of higher-level objectives	Mentoring and coaching
	Creative thinking	The ability to approach a problem or challenge from a new perspective and come up with new ideas and solutions	Workshops, open discourses within scientific community, supporting diversity of research teams
	Opportunities alertness	Ability to understand the context of how the opportunities emerge in the particular field/sector. Ability to identify those opportunities and link them to own research.	Training, case studies, discussions with innovators
	Understanding possible impact of own research	Ability to understand possible social and economic implications of solutions derived from (own) research (including the commercial potential of the solution). Ability to communicate those implications to relevant audiences (e. g. via policy papers).	Workshops, mentoring by external experts
	Prototyping	Ability to conduct tests and experiments to test a product or concept at an early stage of development. Knowledge of tools and processes for effective prototyping.	Trainings, workshops, use of gamification (to communicate the process)

	SKILL	DESCRIPTION	EXAMPLES HOW THE SKILL CAN BE DEVELOPED
IMPLEMENTATION	Complex problem solving	The ability to solve novel, ill-defined problems in complex, real-world settings.	Real-world "mini" projects focusing on solving tasks and problems defined by external organisations, participation in collaborative projects
	Knowledge transfer management	Ability to manage a process of transferring scientific knowledge to other contexts and sectors within the existing legal, social and technical constraints.	Trainings, participation in concrete task focusing on TT (e. g. in collaboration with TT office), workshops, use of gamification (to communicate the process)
	Data-driven decision making	Ability to understand how data can be uses to support strategic decisions. Ability to use data, facts and metrics to guide strategic decisions related to development of solutions. Knowledge of tools and techniques to support data-driven decision making.	Real-world "mini" projects focusing on solving tasks and problems defined by external organisations, simulations based on available open data sets
	Managing people	Ability to build a team and facilitate it work. Ability to inspire people towards a common goal. Ability to develop others.	Mentoring, coaching, reflecting on how teaching experience develops leadership
	Managing finance	Ability to understand the financial effects and process of planning, organizing, controlling and monitoring financial resources needed to implement innovative solutions.	Training, experience with managing own grant
	Managing projects	Ability to plan and execute projects. Knowledge of project management techniques and methodologies, including agile approaches. Understanding of specifics of projects management in innovative environments/development of innovative solutions.	Training with the use of gamification (to communicate the process), experience with managing own grant or participation in larger projects (on research group level, organisational level…)
	Encouraging co-creation	Understanding the principles of co-creation. Knowledge of tools and practices to facilitate co-creation process.	Workshops, use of the co-creation approach in regular working tasks, real-world "mini" projects focusing on solving tasks and problems defined by external organisations

	SKILL	DESCRIPTION	EXAMPLES HOW THE SKILL CAN BE DEVELOPED
IMPACT	Mobilising funding	Ability to generate sustainable income and funding necessary to develop viable solution and implement it in practice.	Training on funding opportunities and other fundraising possibilities, discussions with innovators and fundraisers
	User focus	Ability to properly identify and engage customer or user of the innovative solutions and continuously adapt developed solutions according to their feedback.	Training, reflecting on how participative research methods can be used
	Leadership	Ability to mobilise people and resources towards the achievement of a goal.	Mentoring, coaching, reflecting on how teaching experience develops leadership
	Networking and building alliances	The ability to build and maintain professional networks within and outside own professional community. Ability to develop collaborations to pursue common goals.	Mentoring, participation in events, organisation of events, training on how to use social media to network
	Getting buy-in and negotiating	Ability to resolve issues through effective strategic communication. Ability to get people accept an idea or proposed solution and take actions to support it.	Mentoring by external experts, workshops
	Communicating ideas to different audiences	Ability to present products, ideas or reports to different types of audience	Training workshops, elevator speech competitions, participation in science popularisation events and activities for different target groups
	Engaging stakeholders	Ability to identify internal and external stakeholders relevant to/impacted by the developed solutions. Ability to engage them in the formulation of solution.	Trainings, reflecting on how participative research methods can be used Real-world "mini" projects focusing on solving tasks and problems defined by external organisations

When to develop the skills

Most of the skills included can evolve, at least to the certain level of proficiency during the PhD training, either through dedicated training or direct working tasks. However, some of the skills require more time or specific types of activities to develop. We therefore also link the skills acquisition to different phases of doctoral training. We defined those phases as (adapted according Vurgun, 2017*):

⚙ Orientation phase

Throughout this phase PhD students focus on critically assessing existing knowledge, defining research questions and planning their research. They familiarise themselves with the environment of academic research. They develop information processing and cognitive skills such as analytical and critical thinking.

⚙ Research phase

Throughout this phase PhD students focus on carrying out their research, collecting and analysing data. They develop advanced research skills, skills necessary for managing their research project and working with other researchers.

⚙ Completion phase

throughout this phase PhD students successfully conclude their research project and focus on presenting its outcome to research community and beyond. They consider next steps in their research and career.

Assigning skills to different stages of PhD training should, however, not be understood as prescriptive. Main goal of such distribution is not recommending when the skill should be developed. Rather it is suggesting when the skill probably is developed and when there is the suitable time to reflect on how it could be used in the innovation context. Such information might be useful especially for the professionals involved in planning and implementing skills training for PhD students and career advisors.

* Vurgun, S. (2017). *Competencies of researchers: Development of a competency model.*

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Timeline: when it is the best opportunity to develop the skill throughout a PhD study

Orientation phase

- Asking questions
- Analysing problems
- Conceptualising problems
- Seeking and processing information
- Embracing diversity
- Creative thinking
- Growth mindset and initiative
- Understanding possible impact of own research

Research phase

- Working in team
- Communicating results of research
- Working across boundaries
- Sharing own work with others
- Working within legal and ethical constrains
- Understanding innovation
- Prototyping
- Opportunities alertness
- Complex problem solving
- Managing projects
- Managing finance
- Networking and building alliances
- User focus

Completion phase

- Data-driven decision making
- Knowledge transfer management
- Managing people
- Encouraging co-creation
- Mobilising funding
- Leadership
- Engaging stakeholders
- Getting buy-in and negotiating
- Communicating ideas to different audiences