



An investigation of university-industry collaboration for early stage development projects

Hezam Haidar

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THÈSE

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Une investigation de la collaboration université-industrie pour des projets de développement à un stade précoce

An investigation of university-industry collaboration for early stage development projects

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*An investigation of university-industry
collaboration for early stage development
projects*

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To my parents ♡

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This journey has been full of many highs and lows which I consider as a rich experience on the professional and personal level. I have deepened my understanding on collaborative innovation in general and open innovation in particular. This could not be achieved without the help of many people around me.

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Abstract

University-Industry Collaboration (UIC) is seen as essential engine of local economic development, where it helps in accelerating the process of innovation through the collaboration. This collaboration goes through different stages, from basic research to Proof of Concept to commercialization activities. However, the upstream part of the process is under-researched, little is known about initiating and establishing the collaboration and then conducting the operational activities such as generating, consolidating and testing ideas in order to build proofs of concepts. The purpose of this study is to explore and systematically describe the relevant characteristics of different aspect of the early stage development UIC from initial conditions to eventual outcomes. The in-depth analysis of multiple collaboration aspects will then be used to develop a comprehensive framework encompassing various components of the UIC at different stages. This ~~a~~ qualitative study, started by conducting a systematic literature review to identify UIC collaboration's factors that lead to initiating the UIC. The identified factors were considered as the predetermined themes for conducting semi-structure interviews to describe the early stage development collaboration in depth. Data collection was in four different engineering schools of Grenoble INP (Institut d'ingénierie et de management de l'Université Grenoble Alpes) and eleven companies based on industrial projects collaborations. The collected data was processed using NVIVO through an iteration process and two coding cycles.

The contribution of this study is related to three main parts: Characterizing UIC, UIC conceptual framework and Evaluating UIC. First part of the contribution, rich description of the relevant characteristics of multiple aspects of the early stage development UIC. In the second part of the main contribution of this study, we developed a UIC framework based on three stages: “before the collaboration”, “during the collaboration” and “after the collaboration”. Each stage includes different components of the collaboration. For the third part of the contribution, we developed a measurement system that evaluates the progress as well as the success of the collaboration. This measurement system is based on three sets of Key Performance Indicators (KPIs), each set corresponds to a stage of the collaboration. The sets are a combination of quantitative and qualitative KPIs. The measurement system and the KPIs sets were validated through two projects. Despite the broader applicability of the proposed tool (framework and performance measurement), however the purpose of this tool in this study is to improve the effectiveness of UIC. It is a twofold purpose:

- The framework will help in building university-industry relation by guiding the actors at different stages while considering various elements in each stage.
- Evaluating the progress as well as the success of the collaboration taking into considerations the different factors that might have positive or negative impact on the collaboration.

Keywords: University-Industry Collaboration, Early-Stage Development, SMEs, Conceptual Framework, Key Performance Indicator

Résumé

La collaboration Université-Industrie (CUI) est considérée comme un moteur essentiel pour le développement économique local, du fait qu'elle permet l'accélération du processus d'innovation à travers la collaboration. Cette collaboration passe par plusieurs étapes, en commençant par la recherche basique, en passant par la preuve de concept et en arrivant à la commercialisation. Toutefois, les étapes en amont de ce processus sont peu mises en évidence par la recherche scientifique. La littérature comprend un écart concernant l'initiation et l'établissement de la collaboration, par la suite, la conduite opérationnelle des activités de génération, de consolidation et de validation des idées se fait dans la perspective de construire des preuves de concepts. L'objectif de cette étude est d'explorer et de décrire, d'une façon systématique, les caractéristiques des différents aspects de la collaboration pour le développement de projets à un stade précoce, à partir des conditions initiales jusqu'aux résultats éventuels. L'étude approfondie de plusieurs aspects de la collaboration nous a conduit au développement d'un cadre conceptuel intégrant une multitude de éléments à différentes étapes de la CUI. Il s'agit d'une étude qualitative, où une revue de littérature systématique a été conduite afin d'identifier les facteurs de la CUI qui permettent l'initiation de cette dernière. Les facteurs identifiés ont été considérés en tant que thèmes prédéterminés pour la conduite d'entretiens semi-structurés afin de décrire, d'une façon approfondie, les étapes précoces de la collaboration pour le développement du projet. La collecte de données a été réalisée dans quatre écoles d'ingénieurs différentes de Grenoble INP (Institut d'ingénierie et de management de l'Université Grenoble Alpes) et onze entreprises à partir de projets industriels collaboratifs. Les données collectées ont été traitées grâce à NVIVO à travers un processus itératif et deux cycles de codage.

La contribution de cette étude repose sur trois parties majeures : la caractérisation de la CUI, la proposition de cadre conceptuel de la CUI et l'évaluation de la CUI. La première partie consiste en une riche description des caractéristiques pertinentes de plusieurs aspects des étapes précoces pour le développement du projet. La deuxième contribution majeure de cette recherche, consiste en le développement d'un cadre conceptuel basé sur trois étapes : "Avant la collaboration", "Durant la collaboration" et "après la collaboration". Chaque étape inclus différents éléments de la collaboration. Dans la troisième partie de la contribution, nous avons développé un système de mesures qui évalue le progrès ainsi que le succès de la collaboration. Ce système de mesure est basé sur trois ensembles d'Indicateurs Clés de Performances (ICPs),

où chaque ensemble correspond à une étape de la collaboration. Ces ensembles sont formés d'une combinaison d'ICPs quantitatifs et qualitatifs. En dépit de la large applicabilité de l'outil proposé (cadre conceptuel et mesure de la performance), la finalité de cet outil dans cette étude est d'améliorer l'efficacité de la CUI. Il s'agit d'une double finalité telle que :

- Le cadre conceptuel aidera à guider la construction des relations université-industrie par l'orientation des acteurs dans les différentes étapes en tenant compte d'une variété de éléments pour chaque étape.
- Evaluation de l'avancement ainsi que la réussite de la collaboration en tenant en compte des différents facteurs influençant positivement ou négativement sur la collaboration.

Mots-clés : Collaboration Université-Industrie, Stade Précoce de Développement, PME, Cadre Conceptuel, Indicateurs Clés de Performances,

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Glossary

CEO	Chief Executive Officer
COO	Chief operating officer
CTO	Chief Technical Officer
EDT	étude de terrain
Ense ³	École nationale supérieure de l'énergie, l'eau et l'environnement
Esisar	École nationale supérieure en systèmes avancés et réseaux
GI	Génie industriel
Grenoble INP	Institut polytechnique de Grenoble
HR	Human Resource
IP	Intellectual Property
KPI	Key Performance indicators
NIH	Not Invented Here
OEM	Original Equipment Manufacturer
OI	Open Innovation
PAGORA	École internationale du papier, de la communication imprimée et des biomatériaux
PIME	(Procédés Industriels & Management Environnemental
PoC	Proof of Concept
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
QDA	Qualitative data analysis
R&D	Research and Development
SATT	Société d'accélération du transfert de technologies
SECI Model	Socialization Externalization Internationalization
SMEs	Small and medium-sized enterprises
TTO	Technology Transfer Office
UGA	Université de Grenoble Alpes
UIC	University-Industry Collaboration
UK	United Kingdom
US	United States

General Introduction

This chapter presents general context and the objectives of the study.

Then it presents the overall structure of this document

1 General Introduction

This chapter is a general introduction to the study. First part will present general context and objectives of the study. Second part will present the overall structure of this document with a brief highlight of each chapter to have a global view of the thesis.

1.1 Context and Objectives

In the University-Industry framework, there is a great capacity in universities with the human potential (students, teachers, researchers, engineers and industrialists) as well as with the material potential (technological platforms, laboratories). Public authorities support the creation of value through co-development. Policy makers encourage university-industry collaboration, this motivates individuals (innovators, students, researchers, industrialists etc.) to collaborate and accelerate the knowledge transfer. Hence, university-industry collaboration (UIC) is seen as essential engine of local economic development, where it helps in accelerating the process of innovation through the collaboration. This collaboration goes through different stages, from basic research to Proof of Concept (PoC) to commercialization activities. However, the upstream part of the process is under-researched, especially the part that consists in generating, consolidating and testing ideas in order to build proofs of concepts (functional prototypes, models, architecture, etc.) that are robust enough to convince decision-makers to invest in the collaboration's project.

The problematic of this study is situated in the early stage development projects of university-industry collaboration where the engagement is mostly knowledge-related activities. This study will attempt to gain insight and explore in depth the aspects of university-industry collaboration. We intend to study the collaboration [before it starts, during and after it ends] to characterize the collaboration through industrial projects at the early stage development which

involve students within the framework of Grenoble INP (Institut d'ingénierie et de management de l'Université Grenoble Alpes).

One objective of the study will be characterizing different aspects of the university-industry collaboration of the early stage development projects. The characteristics include, but not limited to, the motivations to be involved in the collaboration, the challenge in aligning the different objectives of the partners. In addition, organizational characteristics such as structure, process and collaboration's activities. Another objective of this study is to develop a framework for the UIC with different stages, including initiating and establishing the collaboration. Defining measurement system with set of Key Performance Indicators (KPI) to evaluate the UIC of the early stage development projects is another objective of the study. These objectives were identified based on the research gaps (subsection 4.2.1)

1.2 Thesis structure

Figure 1 below presents the overall structure of the thesis. Here is a brief highlight of each chapter in this document:

Chapter 1: Is a general introduction to the study. It presents general context and the objectives of the study. Then it presents the overall structure of this document.

Chapter 2: In this chapter, the overview of the research problem is presented. The upstream of the university-industry collaboration "academic engagement" is under-studied. Little is known about initiating and establishing the collaboration and then conducting the operational activities such as generating, consolidating and testing ideas in order to build proofs of concepts (POC). This chapter also, highlight the importance of the study especially on accelerating the initiation, establishing the collaboration, evaluating the collaboration and the role of university as knowledge source.

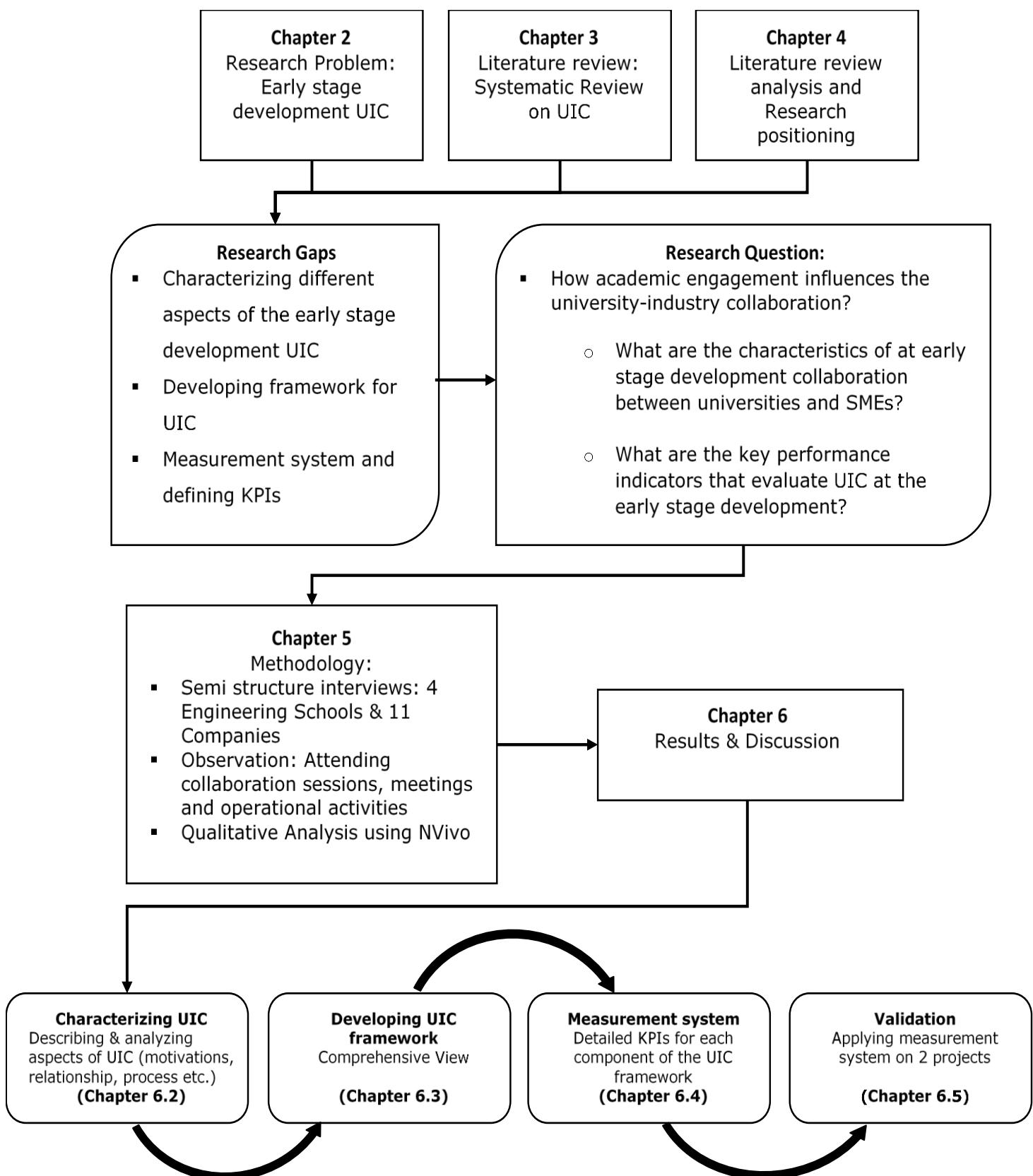


Figure 1 - Thesis's Structure

Chapter 3: After presenting the generic research problem in the previous chapter, this chapter reviews the state of the art based on systematic literature review of the UIC. The literature review identified two issues that are under-researched in the early stage development UIC. First issue is characterizing UIC based on multiple aspects of the collaboration. Second issue is evaluating the early stage development UIC.

Chapter 4: This chapter analyzes the literature review. These analyses will help to introduce the research gap and to identify the specific research questions. We identified two research gaps. Firstly, Lack of characterization of UIC due to the complexity of the collaboration as whole in which it involves several aspects. We identified the following collaboration's aspects that will be considered as the predetermined themes for the UIC characterization: **Relationship Type, Process, Structure, Knowledge, Intermediaries, IP policy, Funding, Alignment of goals and Culture of openness**. Secondly, evaluating the early stage development UIC. Evaluating the collaborations' results is a major issue of the collaboration. Moreover, at the end of this kind of collaboration, there could be a possibility to extend the collaboration or involve more actors in the collaboration for further development.

Broad Question: How academic engagement influences the university-industry collaboration?

Sub-questions

Based on the gaps in the literature our aims will be to answer the following questions:

- What are the characteristics of the early stage collaboration between universities and SMEs?
- What are the key performance indicators that evaluate university-industry collaboration at the early stage?

From the literature review, we developed an initial UIC framework. This framework will be further expanded and analyzed for a twofold purpose. First, we will study the

mechanisms and characteristics of the collaboration at the stage of generating, consolidating and testing ideas. Second, we will analyze how to evaluate the collaboration based on the developed UIC framework.

Chapter 5: This chapter describes the methodology of this study. Describing the overall research design used to carry out the study, the procedure of how the data was collected and how data was processed. Data collection was in four different engineering schools of Grenoble INP (Institut d'ingénierie et de management de l'Université Grenoble Alpes) and eleven companies (SMEs) based on collaboration of industrial projects at the early stage development. The collected data was processed using NVIVO through an iteration process and two coding cycles.

Chapter 6: This chapter is intended to present the results and discuss the findings. The findings of this study are related to three main parts: Characterizing UIC, UIC conceptual framework and Evaluating UIC. The first aim of the study was to have a comprehensive view of the early stage development UIC. Through the data collected based on the predetermined themes (chapter 4), we developed an UIC framework based on three stages: “before”, “during” and “after”. The characterization of the collaboration through the detailed analysis of the themes in the overall collaboration have helped us to construct and expand a framework of the collaboration encompassing different aspects of the collaboration at different stages. We developed a measurement system that evaluates the progress as well as the success of the collaboration. This measurement system is based on three sets of KPIs, each set corresponds to a stage of the collaboration. The sets are a combination of quantitative and qualitative KPIs. The KPIs were defined from the components of the UIC framework that was built based on the characterization of the UIC. The measurement system and the KPIs sets were validated through two projects.

Chapter 7: This chapter closes this document with a brief recap of the main findings & contribution of the study then includes the relevant future research and limitations.

Research problem

The aim of this chapter is exposing the problematic of the thesis to identify the research area. To do so, from the literature we will explore two concepts in the university-industry collaboration. The two concepts are the academic engagement and commercialization. In addition, this chapter will highlight the significance of the study and why we decided to conduct the study.

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2 Research Problem

This chapter is divided into two parts; first part presents the generic topic of the research by discussing the university-industry collaboration in two concepts (academic engagement and commercialization). In the first part also, the focus of the study will be highlighted. Second part will present the significance of the study by explaining why the study is needed and highlighting the importance of the study.

2.1 Research topic

University - Industry Collaboration (UIC) refers to the formal or informal interaction between university and industry aiming mainly to encourage knowledge and technology exchange (Siegel et al., 2003; Bekkers & Bodas Freitas, 2008; Ankrah & AL-Tabbaa, 2015). In the University-Industry framework, there is a great capacity in universities with the human potential (students, teachers, researchers, engineers) as well as with the material potential (technological platforms, laboratories). On the other hand, industry brings the capability to transform the research results into concrete application as well as the financial support.

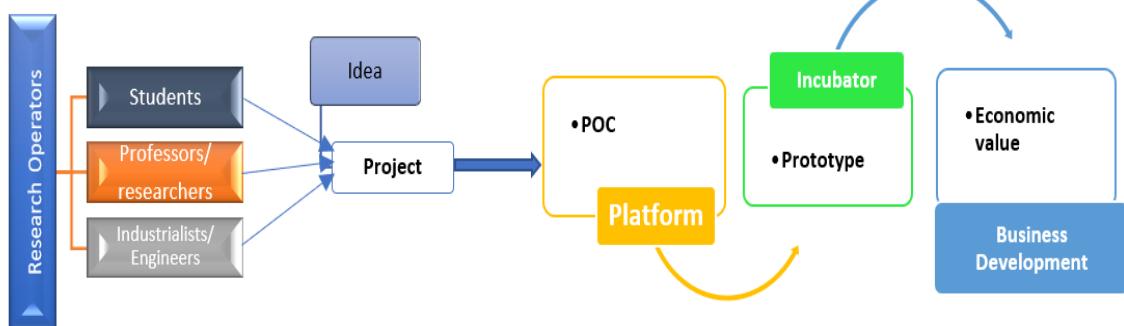


Figure 2 - Basic Collaboration Process

This exchange of knowledge or technology¹ process could be at different level with different characteristics regarding the actors and the organization. Figure 2, shows basic and general elaboration of the UIC. The operational activities start with an idea with actors from academia and industry. Upon the validation and maturity, a value will be created such as knowledge, technology, product, service etc.

In university–industry relations (Perkmann et al., 2013) identified two concepts, academic engagement and commercialization. In the following subsections, we will highlight the general characteristics of each concept as well as the relationship between these concepts.

2.1.1 Academic engagement

Academic engagement refers to the level of engagement in knowledge-related collaboration of the university with industry. There are various forms of academic engagement such as collaborative projects, contract research, consulting and informal relationship (Perkmann et al., 2013). These activities involve interpersonal interactions to provide new ideas and solutions for industrial projects (Cohen et al., 2002). The concept of academic engagement is characterized by two important aspects: objectives and organization (Perkmann et al., 2013). For the objective aspect, it is not solely for the academic purpose but also to generate a utility for the industry partners. This utility could be in form of generating new ideas, testing an idea or suggestions of solutions for a problem. In terms of organization, academic engagement represents an inter-organizational interaction. The inter-organizational collaboration in academic engagement is represented by person-to-person interaction (Cohen et al., 2002). The interaction between university and industry is an interactive mechanism as it is continuous process of developing the discovery (Nilsson et al., 2010).

¹ Similar to other studies (e.g. Agrawal, 2001; Bekkers & Bodas Freitas, 2008, S. Ankrah, O. AL-Tabbaa 2015), we use the terms ‘technology’ and ‘knowledge’ interchangeably.

The organizational context plays an important role in the involvement of university staff (professors, researchers) and their attitudes towards industrial engagement. An important aspect of this context is whether the interaction is formal or informal. The organizational characteristics of formal interaction is usually framed by contracts. These interactions include formal activities such as collaborative research, contract research, and consulting (Perkmann et al., 2013). On the other hand, in the informal interaction mode has less restrictions and more flexible organizational characteristic since these types of interaction are not constrained by contracts (D'Este & Perkmann, 2011). The informal interactions could be in form of providing ad hoc and networking with practitioners (Perkmann et al., 2013). These interactions usually are dedicated to a specific problem or task but also requiring little or no planning. This includes idea generation, brainstorming or receiving feedback on propositions.

2.1.2 Commercialization

Commercialization is defined as intellectual property creation and academic entrepreneurship, the commercialization activities include patenting, licensing and spin offs (Perkmann et al., 2013) (Jensen & Thursby, 2001). In the framework of university industry relationship, (Boehm & Hogan, 2013) indicate that commercialization is materialized in the science to business collaboration where scientific knowledge can be transferred to the market while acknowledging the role of science partners. This is achieved through the repeat of collaborations and the development of mutual benefits, which facilitate scientific knowledge commercialization. Converting scientific knowledge into economic value such as patent, license and spinoffs has attracted the attention of academic as well as the policy makers (Lee, 2012). Commercialization activities are characterized by the formal interaction between university and industry, but also through support for business creation and acceleration activities to transform innovative ideas and projects into new business value. (Lee, 2012)

indicated that, the commercialization activities promote collaboration between industrial and academic organizations. Nevertheless, unlike academic engagement there is evidence of higher degree of secrecy in commercialization activities.

As mentioned above, one of the commercialization activities is licensing. For example, in the United States (US), after the passage of Bayh-Dole Act² in 1980 the university licensing has increased dramatically (Jensen & Thursby, 2001). Consequently, as results of licensing, the science to business collaboration attracts more industrial partners to collaborate with universities. This vision has inspired different countries to implement similar innovation and technology transfer policies. (Takenaka, 2005) suggested that, the Japanese Bayh-Dole Act (which was enacted in 1999) successfully made universities ready for transferring their technologies to Japanese industry. The success of the Bayh-Dole Act in the US has led a number of EU member states to adopt or consider adopting legislative schemes similar to the Bayh-Dole Act. Some of these countries are: France, Germany, Austria, Denmark, Norway, Portugal, Spain, and Finland as well as the United Kingdom (UK) (Mireles, 2007). For example, in France, Innovation Act or "Loi Allegre" was adopted in 1999. This Innovation Act was profoundly influenced by a ministerial report (the Guillaume report in 1998)³ on the American example and the key role of the Bayh-Dole Act in the "spectacular" results in the innovation and technology transfer (Malissard et al., 2003)(della Malva et al., 2013).

The rapid growth of technology transfer in universities is due to the fact that commercialization process is accelerated as a result of licensing (Jensen & Thursby, 2001). Commercialization activities require specific competencies and lengthy administrative work.

² This law allowed American universities, (and non-profit organization) to patent and license inventions generated from their research which received federal funding.

³ Henri Guillaume, *Rapport de mission sur la technologie et l'innovation*, mars 1998. Rapport à l'intention du ministre de l'Éducation nationale, de la Recherche et de la Technologie, Claude Allègre, du ministre de l'Économie, des Finances et de l'Industrie, Dominique Strauss-Kahn, et du secrétaire d'État à l'Industrie, Christian Pierret

Some of these competencies are business development skills, legal competence in patent, licensing and Intellectual Property (IP) management. These activities require administrative effort and specific competencies, therefore they need dedicated organizational units (Migueis et al., 2018) (Baraldi et al., 2014). These activities include writing contracts, creating a licensing agreement, patent and IP management. Consequently, specific organizational structures/units are created within the academia to handle these specific tasks and to manage the relationship with the industry. Some universities have dedicated department or special structures within the university, such as technology transfer offices (TTO). The role of the TTO in universities is to help researchers to manage the relation with industry partners in order to commercialize the collaborative research results (Macho-Stadler et al., 2007).

In France as shown in Figure 3, to accelerate the transformation of French research into innovations, a Technology Transfer Accelerator (SATT) (in French: Société d'accélération du transfert de technologies) are French publicly funded TTOs, shared between several public research organizations, there are total of thirteen SATTs in the French regions. Their aim is to enhance the value and to accelerate the process of technology transfer from publicly funded research toward industry⁴. These structures (TTO, SATT etc) are very useful in handling the administration work especially Intellectual Property but also evaluating the maturity of ideas, market analysis and financing. In another words, this type of structures are bridges between the academia and the needs of industry by increasing the maturity and reducing the risks. However, university researchers emphasize on the personal relation for the success of the collaboration (Lee, 2012).

⁴ <https://www.satt.fr/societe-acceleration-transfert-technologies/>

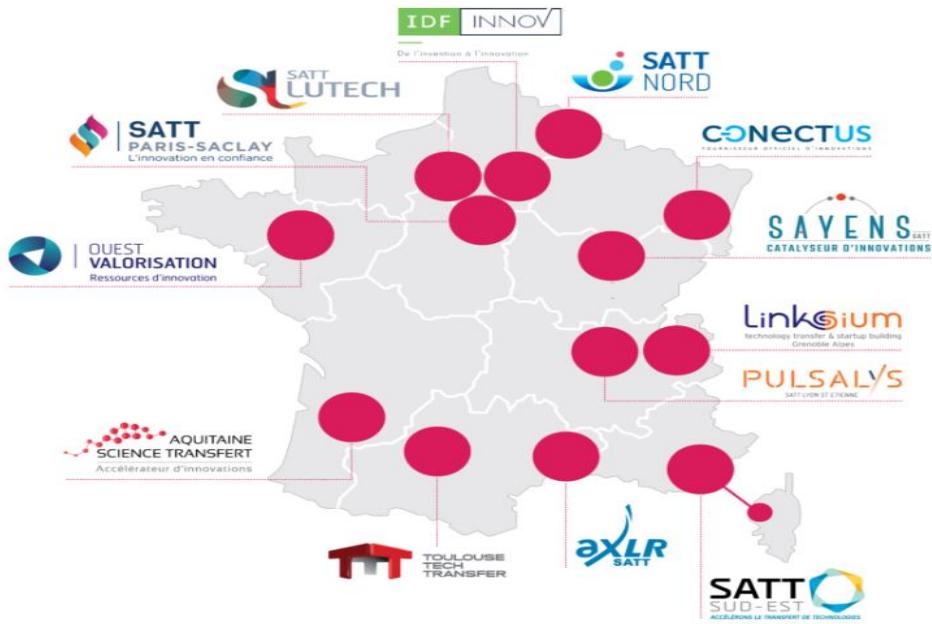


Figure 3 - Technology Transfer Accelerators in France

Unlike academic engagement, fewer academics are involved in commercialization (Perkmann et al., 2013). There are multiple reasons why academics avoid participation in commercialization's activities. One reason, is that industrial partners are strict in delaying the dissemination of scientific results of the collaborative research (Penin, 2010). In some cases, the publication would not be allowed or delayed by several years. For academics, this will decrease researchers' rates of publication, which is not a desired result by academics. Having a strict policy when managing the university-industry collaboration is not only a characteristic of the industrial partners but also universities. When it comes to formal technology transfer, universities tend have a very strict policy on managing conflicts of interest arising from its licenses and collaborations with industry (Breznitz et al., 2008). In general, there is higher degree of secrecy of commercialization activities (Louis et al., 2001). In the other hand, academic engagement tends to be viewed by academics as a publication-driven 'open science' activity by academics (Perkmann et al., 2013) which can appear as contradictory to Industrial practices.

To conclude, policy makers are trying to stimulate and accelerate the process of commercialization specially for the high-tech sector which produces more patents and licenses (Bosco, 2007). One of the stimulants is the university-industry collaboration through research collaboration fund. The focus of the literature is on highlighting the downstream process of the university-industry which is associated with technology transfer and commercialization (Pinheiro & Lucas, 2015). Therefore, this study will focus on the academic engagement.

2.1.3 Focus of the study

In the previous subsections, the big picture of university-industry collaboration was presented into two main concepts, which are academic engagement and commercialization. This study will focus on one concept of the UIC, which is academic engagement. As highlighted in subsection 2.1.1, academic engagement activities are mostly knowledge-related activities.

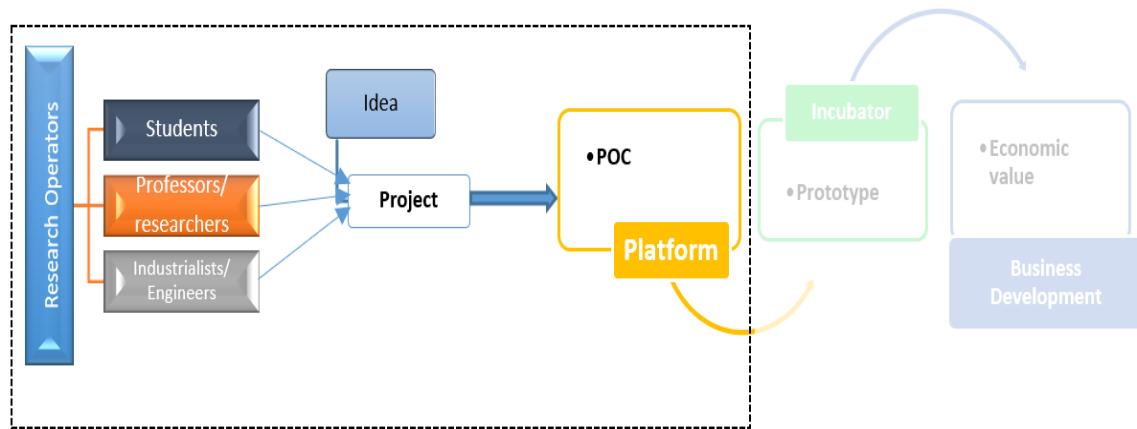


Figure 4 - Focus of the study

Figure 4 shows the focus of this study, which involves the operational activities such as generating, consolidating and testing ideas in order to build proofs of concepts. However, before the start of operational activities there are administrative activities. This includes the initiation of the contact between university researchers and the industrialists. Then, also, establishing the conditions of the collaboration (problem definition, objectives, project team etc.). Initiating the

contact at this stage will mostly be based on informal interaction and personal relation since it has less restrictions and more flexible organizational characteristic (Cohen et al., 2002) (D'Este & Perkmann, 2011) (Perkmann et al., 2013).

This study will focus on the academic engagement to analyze initiating, establishing and conducting collaboration at early stage development. Later in this document, we will present literature review analysis, which will provide more specific details about gaps in the literature and the issues that will be addressed in this study.

2.2 The significance of the study

In this section, we will introduce why the research was needed by highlighting the importance of the academic engagement. More focus will be on the role of university as knowledge source, accelerating the initiation and establishing the collaboration and evaluating the collaboration.

2.2.1 The role of university as knowledge source

University-Industry collaboration is increasingly seen as an essential engine that fuels local economic development. For the industry, efficiency of the innovation outcomes is increased through the access to university's knowledge (Cockburn & Henderson, 2000). Recent research results favor a new "open role" of universities to fulfil their functions as knowledge providers (Becker & Eube, 2018). In this sense,(Chesbrough, 2006b) subsumes this rather economics-centered view under the term "Open Innovation" (OI). Open innovation has been one of the trends of innovation practices in the last two decades. Open innovation is defined as "the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation respectively" (Chesbrough, 2006, p.2).

In this context, universities have an important role as sources of knowledge that industry can use within the open innovation paradigm (Chesbrough, 2003). The university's role as knowledge provider is very complex however, analyzing how universities interact with external stakeholders will provide more insight on the role played by universities (Jonsson, Baraldi, Larsson, et al., 2015). Hence, we will consider open innovation in the context of UIC to highlight how stakeholders initiate and maintain these types of collaborations. In addition, what influences or stimulates the

2.2.2 Accelerating the process of the collaboration

Organizational context is an important aspect of the UIC in order to understand the different practices in academic engagement. One important aspect is establishing the collaboration. Typically, collaboration is established through a lengthy process (by both partners) before an agreement can be formulated and signed. (Ankrah & AL-Tabbaa, 2015) indicated the university-industry collaboration takes multiple stages, the initiation starts by identifying the potential partners, then making contact. After that assessment and selection of partners, followed by negotiation and finally agreement signing. In the initiation stage of the collaboration, individuals play an important role because the decision to be involved in the collaboration is a decision that is primarily taken on an individual level since no commercialization activities are conducted at this stage (Perkmann et al., 2013).

As highlighted in subsection 2.1.1, the organizational practices in academic are more flexible. Nevertheless, it is important to address the role of these practices in accelerating the collaboration. In addition, it will be necessary to investigate how individuals initiate, build and maintain the interaction with other organizations. The role of a dedicated organizational structure to support the academic engagement is different from the role of the organizational support for commercialization activities. In commercialization activities, the organizational support handles the administration work as well as the formalities since the interaction is formal

and involves financial incentives. In addition, organizational support in commercialization manages the licensing, patenting etc. However, in academic engagement, the organizational support plays a role (with flexible mode) in guiding the researchers for establishing the contact with industry (Jonsson, Baraldi, & Larsson, 2015). The organizational support in academic engagement organizes particular meetings between the researchers and industry to establish the contact for example: forums, industry day (Jonsson, Baraldi, Larsson, et al., 2015).

According to (Perkmann et al., 2013), it is important to recognize that different types of collaboration projects may require different support structures and mechanisms. The setup (organization context) of these projects might have an impact on the results therefore, it will be important to address these differences.

2.2.3 Collaboration evaluation

There are different types of outcome from the operational activities of UIC at the early stage development. Measuring the UIC remains a challenge (Jonsson, Baraldi, Larsson, et al., 2015), which is another issue to be addressed in this study. The difficulties in measuring the progress of the collaboration lies in codifying the outcomes of the collaboration, since most of the activities conducted at this stage are knowledge-related activities and intended to generate knowledge. The operational activities of knowledge generation might take years before the outcomes can be visible (Baraldi, 2013) (Jonsson, Baraldi, & Larsson, 2015). In academic engagement, there are different types of collaboration projects. It will be necessary to distinguish between the different results of different projects. Unlike the commercialization, academic engagement is empirically more difficult to evaluate (Perkmann et al., 2013). Since some of the interactions are conducted in informal setup, it might be difficult to follow the progress. Furthermore, commercialization activities results are mostly tangible and could be easily counted such number of patents, number of licenses etc. Addressing this issue in this

study will help to understand the academic engagement impact on the university-industry collaboration as well as how to measure these intangible outputs.

stakeholders to invest in these collaborations

2.3 Summary

In summary, the UIC could be conceptualized in two parts the knowledge related activities (academic engagement/early stage development) and the commercialization activities. The broad research problem of our study is the upstream part of the university-industry collaboration "academic engagement", which involves initiating and establishing the collaboration and then conducting the operational activities such as generating, consolidating and testing ideas in order to build proofs of concepts.

Next chapter, chapter 3, will be the literature review to identify the different aspects of the UIC, better understand the aspects of UIC in general, and identify the research gaps

Literature Review

In the previous chapter, we identified a research area that appears interesting and relevant for further investigation. In this chapter, we review actual state of the art. This was carried out by conducting a systematic review, which will help to identify more specific issues to investigate.

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3 Literature Review

The main objective of this chapter is to review the state of the art based on systematic literature review. In the previous chapter, the generic problematic was presented with high-level analysis discussing the concept of academic engagement. The purpose of the literature review is to provide a better understanding and foundation of the general issue, which will be addressed in the study. This chapter will describe how the systematic review was conducted. Then, we will present a review of the state of the art by reviewing the issues, which were discussed in the final sample of the articles. The final part of this chapter will give a concise summary.

3.1 Systematic literature review

A systematic review is a study that seeks to answer a clearly formulated question by identifying relevant studies and evaluating their quality then summarizing the evidences by use of explicit methodology to answer that question (Khan et al, 2003). Systematic literature reviews are recognized methods for conducting evidence-based policy for medical research (Victor, 2008, Black, 2001). However, there is growing interest in methods of systematic research review as a means to accumulate a solid evidence for social science and management (Pittaway & Cope, 2007).

Systematic reviews differ from traditional narrative reviews in several ways. One difference is that, systematic reviews, typically involve detailed steps defined a priori, to avoid any bias in selecting the relevant studies on a particular topic. Another difference is that, traditional reviews unlike systematic reviews where they do not seek generalizations or cumulative knowledge of what is reviewed (Ankrah & AL-Tabbaa, 2015)

The research problem introduced in the previous chapter, initiating and establishing the UIC at the early stage development but also universities' role as sources of knowledge that industry can use within the open innovation paradigm. To better understand what influences

initiating open innovation collaboration between universities and industry. We employed a systematic review to answer our question: *what are the influential factors of initiating open innovation collaboration between universities and industry*. To conduct the systematic review, it is important to find the relevant keywords in order to collect the relevant work in the literature. We considered the fact that, there needs to be a balance in searching, between making the search comprehensive enough to encompass everything on the topic and precise enough to only capture those results that are specifically relevant. As mentioned previously, the objective of this literature review is to provide a better foundation and understanding of initiating and establishing the UIC within the open innovation paradigm. A clear and structured question was formulated: what are the influential factors of initiating open innovation collaboration between universities and industry. For a comprehensive search yet precise enough, from the broad topic and the precise question, we introduced two groups of keywords for the search. First group is more generic keywords such as: “University-industry collaboration” and “Technology Transfer”. These keywords will give more flexibility to include the studies relevant to the broader topic. Second group is related to the formulated question and more associated with that particular concept such as: “Open innovation”, “Investment incentives” and “Stakeholders”. The selected keywords were used to establish state of the art from articles held by Business Source Complete (EBSCOhost) database. These keywords were:

- Open innovation,
- University-industry collaboration,
- Technology Transfer,
- Investment incentives
- Stakeholders.

We conducted the research using all possible combinations between two keywords with all possible arrangements of combination of two keywords from the five keywords in titles, abstracts and author keywords as shown in Figure 5.

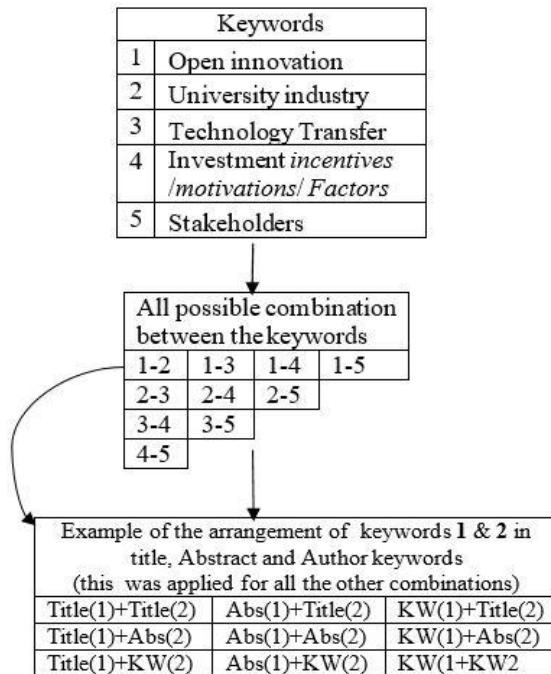


Figure 5 - Keywords Combinations

For a better understanding of Figure 5, in the first part each keyword is given a number 1 to 5. In the second part, we listed all possible combinations of two keywords (10 possible combinations). For the third part, we searched whether these two words (for example keyword 1 and keyword 2) can be found together in the title (Title(1)+Title(2)). Or one in the title and second in the abstract (Title(1)+Abs(2)); or one in the author keywords and second in the abstract (KW(1)+Abs(2)), and so on which leads to 9 possible arrangements.

We carried out this procedure for all keywords' combinations. As part of the identification process, our search was limited to within peer-review journal articles written in English for the period of January 2003 to November 2017. It is worth mentioning here, this thesis will conduct field study (data collection, interviews etc) which might take some time,

hence at later stage of this study, we will take in consideration the new development in the literature beyond this date and discuss that with our findings.

For keyword 4 (*Investment incentives*), we have noticed that, whenever it is combined with other keywords the research result was very low, therefore we replaced the word *incentives* with *motivations* and again with *factors* and we added all results of these words. The research retrieved 1988 articles, we excluded the duplicated ones and we introduced our first excluding criteria, we excluded all articles that discuss open source collaboration since and Industry-industry collaboration in general. As we used the keyword “open innovation”, the search returned multiple articles discussing the “open source” therefore these articles were excluded. Moreover, using the keyword “technology transfer” the search returned multiple articles the transfer within the Industry-industry collaboration, our focus is for UIC hence, we excluded the articles discussing Industry-industry collaboration. At this stage, we had 224 articles.

We gathered all author keywords of the 224 articles to perform statistical analysis, to check the recurrence of the authors’ keywords; we found the following 10 most frequent keywords as shown on figure 6.

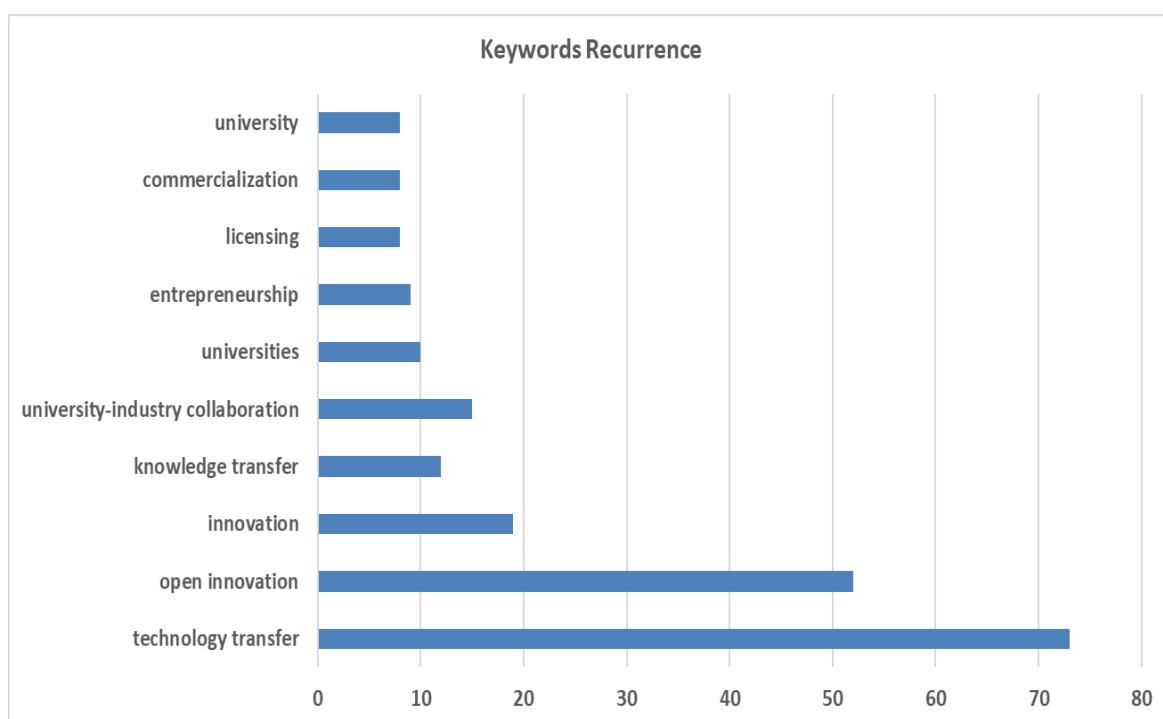


Figure 6 - Keywords Recurrence

We decided to take into consideration the first five most frequent keywords, but before that, it was obvious that there are words, which are considered broader for example (innovation) is used for open innovation, or repeated such (universities and university). Therefore, our first five most frequent keywords are: Technology transfer, Open innovation, Knowledge transfer, University-industry collaboration and entrepreneurship.

As part of the screening process, we went back to the 224 articles resulted from the identification process and check the author's keywords of each article, we included the articles have at least one of the most frequent keywords, the screening process results in 157 articles for the eligibility process.

These studies are based on interviews and surveys of key university-industry stakeholders (i.e., university administrators, academics, industry scientists, business managers, and entrepreneurs) as well as case studies of collaboration projects and qualitative studies from the literature. For the eligibility process, we manually screened the aims and main topics of the 157 articles to exclude the articles that are distant from our study but at the same time, we tried

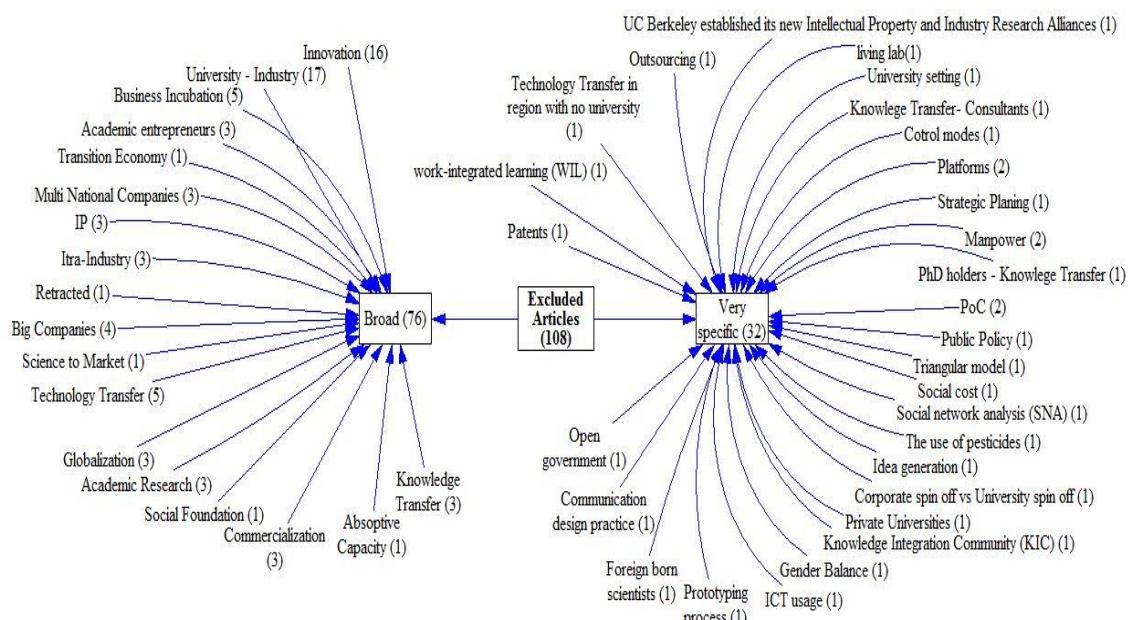


Figure 7 - Main topics covered in the excluded article

to ensure high quality relevant work is included. As shown in figures 7 and 8, we excluded the articles that are beyond the scope of our study. The final sample is 49 articles.

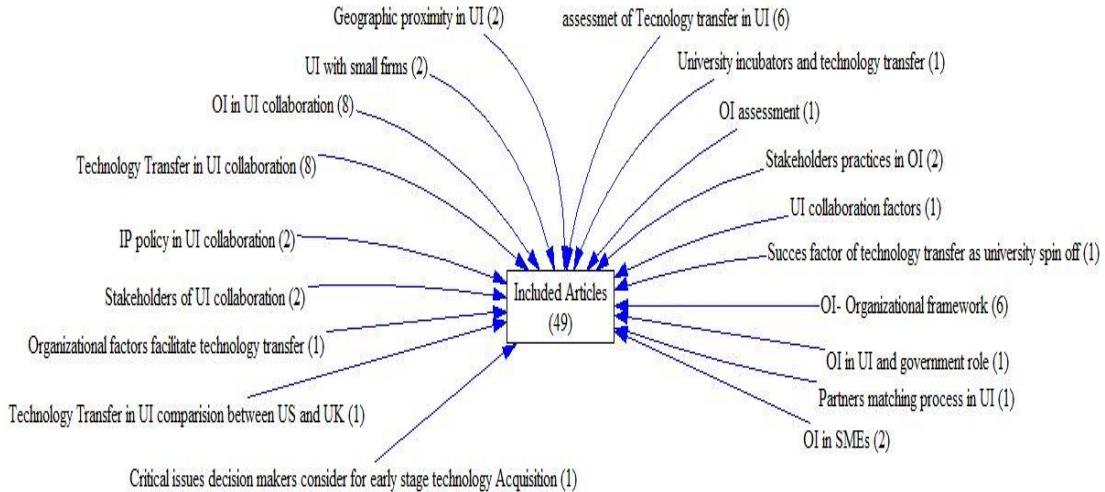


Figure 8 - Main topics covered in the included articles

Before starting analyzing the final sample, based on initial assessment of the literature and brainstorming sessions, we started identifying the predetermined categories for initial coding (Potter & Levine-Donnerstein, 1999; Hsieh, 2005) for the factors that influence the stakeholders. The predetermined factors categories were the following: *Organizational Structure, External Resources and Performance Indicators*. We decided to use Qualitative Content Analysis (Hsieh, 2005) to code and analyze the final sample. (Krippendorff, 2010) defined content analysis as “a research technique for making replicable and valid inferences from texts (or other meaningful matter) to the contexts of their use”. The content analysis is primarily classified to qualitative and quantitative research method (Hsieh, 2005). In qualitative content analysis, data are presented in words and themes, which makes it possible to draw some interpretation of the results (Bengtsson, 2016). Within the content analysis, there are three distinct approaches: conventional, directed, or summative. (Hsieh, 2005) explained the major differences between these approaches are coding schemes, origins of codes. (Hsieh, 2005)

explained, “in conventional, coding categories are derived directly from the text data. Directed approach, analysis starts with a theory or relevant research findings as guidance for initial codes (which is our case, where we defined categories of the possible influential factors). A summative content analysis involves counting and comparisons, usually of keywords or content, followed by the interpretation of the underlying context”. Directed Content Analysis is applied by using existing theory or prior research (Hsieh, 2005).

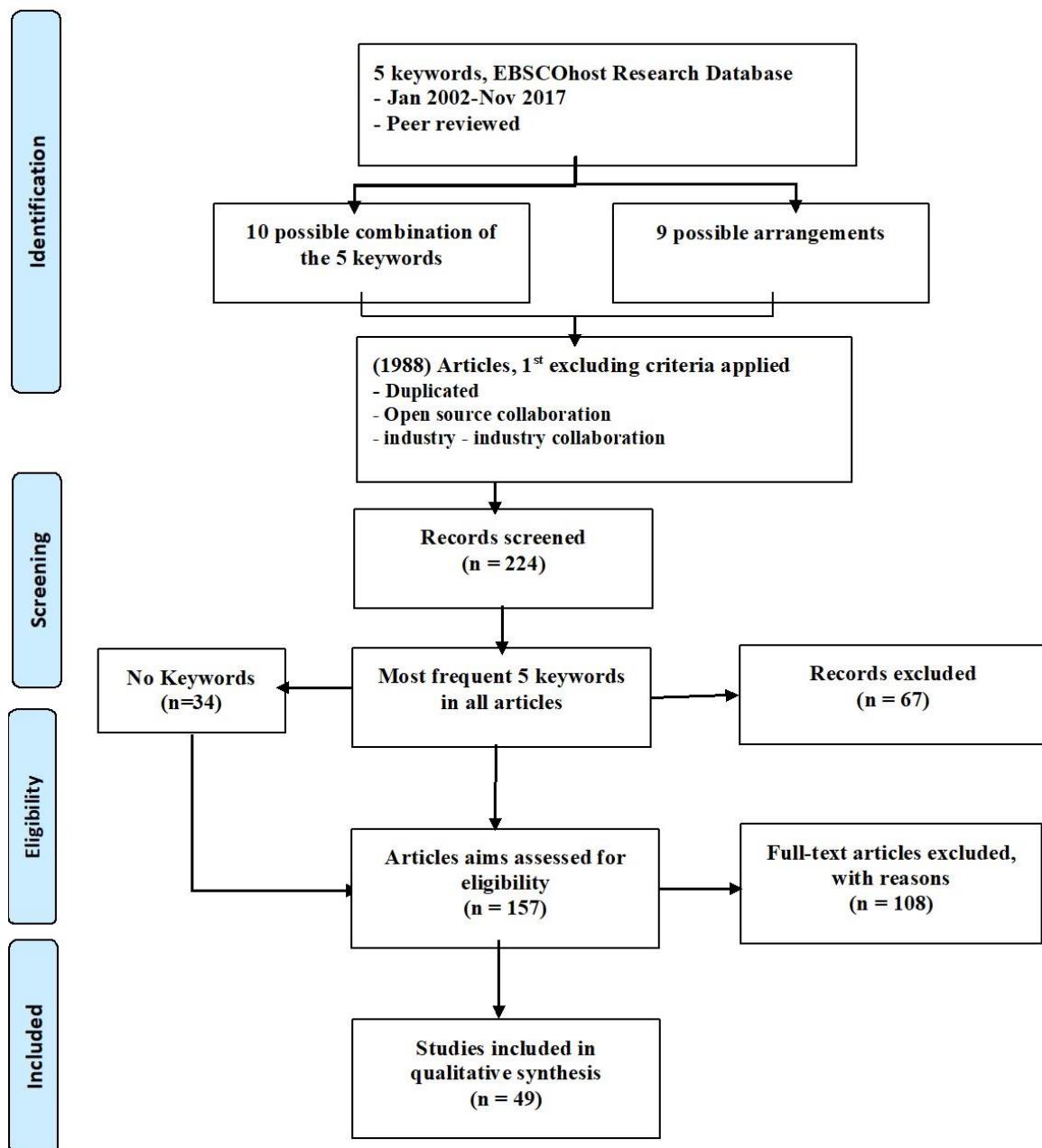


Figure 9 - PRISMA Flow chart of the systematic literature review

Figure 9, summarizes the four phases of the systematic literature review: Identification, screening, eligibility and included. It is summarized as a PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses)

3.2 State of the art based on the systematic literature review

After defining the predetermined categories, we started analyzing the findings of each article from our final sample and searched the data for text that matches the themes of the predetermined categories (Renner, 2000). The number of codes started expanding, it was necessary to introduce the subcategories for a better subsequent analysis. As we continued analyzing the data, we found texts that could not be categorized with the initial coding scheme (predetermined categories) hence it was given a new code (Hsieh, 2005). Some examples of the insertion of new codes are when the articles discuss how the geographical proximity influences the UIC. Furthermore, social proximity or the tendency to collaborate based on previous relationship. As a result, we added another category (*Proximity*). In the following sections, we will review the state of the art found through the conducted systematic literature review.

3.2.1 University-Industry collaboration

University–industry collaboration acts as a mean to foster economic growth for companies and provides an additional revenue for the universities, research opportunities and employment opportunities for students for the industry (Caldera & Debande, 2010). The main topics discussed in the literature were: the role of the university-industry collaboration, the support of public policy to stimulate the collaboration. Also, managing inter-organization relations and the patterns of the collaboration in the organizational context as well as the resistance to external knowledge.

3.2.1.1 The role of university-industry collaboration

The role of industry–university collaboration is to close the gap between industry and academia to accelerate the collaboration and innovation process, accumulate knowledge, and construct intellectual property rights (Lai, 2011). The benefits of closing the gap between academia and industry are reducing the development risk, increasing the efficiency of knowledge sharing , gaining the trust which leads to additional network linkages (Wang et al, 2006) and acknowledging the positive role of academia in the research and development (Wang & Shapira, 2012) (Festel, 2015). These benefits are bi-directional knowledge flow and learning gains (Pinheiro & Lucas, 2015). However it is very difficult to maintain the collaboration mechanisms since organizations will have to interact with multiple and external actors (Liliana, 2013).

There are many reasons for industry-university collaboration, but one important reason is acquiring external resources such as accessing new information, external knowledge, acquiring the people who develop the technology. Funding programs external resource, always stimulate interaction between collaboration partners. The external resources of organizations do not just maximize their power but also affect the behavior of the organization in the collaboration (Davis & Cobb, 2010).

Universities have a key role in encouraging university–industry cooperation by developing patents and licenses as they are an important factor in determining promotions and awards for university personnel's (Siegel et al., 2003; Feng, Chen, Wang, & Chiang, 2012).

Collaborations between academics and industry play an essential role in driving innovation processes. However, with poor management of innovation processes between collaboration actors, these activities are seldom translated into commercialization success (Razak et al., 2013). Furthermore, more efforts have to be made to overcome certain obstacles such as understanding the managerial complexity of the entire collaboration process. This

constitutes the first issue we identified in our literature review. Characterizing UIC based on multiple aspects of the collaboration.

3.2.1.2 Public policy supports the university-industry collaboration

Developed states have implemented different policies to bring Academia and industry to collaborate, which ensure dynamic innovation environment and improve economies based on fostering local and countrywide competitiveness (Vega-Jurado et al, 2015). Public policy supports the university-industry collaboration to accelerate knowledge and technology transfer since it has a positive impact on innovation processes (Sellenthin, 2011), particularly in the emerging fields and the creation of new high-technology enterprises (Wang & Shapira, 2012).

According to Arvanitis, et al., (2008) state policy intervention is essential for bringing universities and business closer. State policies and programs help in stimulating the interaction between innovation actors and encourage the collaborative projects (Mayer, 2010). Going through the whole process from basic research to market introduction independently is highly risky even for large companies (Saito & Sumikura, 2010) hence sharing the risk optimally between parties involved in the collaboration is always the choice for partners and influence the decision makers to collaborate (Caldera & Debande, 2010).

Governments promote innovation through funding research and development, that makes funding very important factor especially in patenting activity, university that receives higher amount of public research funding generates more patents and commercialize their products (Lopez et al, 2009; Hayter, 2013).

Government funding or sponsored research is an important factor in initiating collaborations and accelerating technology and knowledge transfer. Small companies rely heavily on funding programs similarly; university might need the access to private funding. Government-funded programs encourage collaboration between industry and universities to ensure the knowledge sharing in this collaboration.

The university-industry collaboration can be done through intermediaries that support university researchers during their patenting and commercialization efforts, these intermediaries could be technology transfer offices (De Beer et al, 2017; Sellenthin, 2011) or science and technology parks which have an influence on university–industry interaction (Shane, 2002; Muscio & Vallanti, 2014). Intermediaries can help to decrease barriers and ease the interaction between university researchers and industry (Aquilani et al., 2017). In addition, intermediaries play a valuable and crucial role in collaborative innovation processes (Agogué, et al, 2013).

However, lack of communication and bureaucracy in intermediaries are huge concerns for the partners (Padilla-Meléndez & Aguila-Obra, 2012), but some intermediaries such as incubators play a role in addressing several of the conflicts between partners and moderate the relationship (Maxwell & Levesque, 2011). Furthermore controlling the new technology is very sensitive issue when there are many partners in the collaboration (van den Berghe & Guild, 2007; Lai, 2011).

3.2.1.3 Managing inter-organizational relationships

The process of collaboration involves multiple and diverse actors, that requires a great deal of efforts to manage the interests of these actors. The process is critical in managing inter-organizational relationships but also it has important implications for performance. Ring and Van De (1994) highlighted the fact that the process influences the inter-organizational relationships in which they can emerge, grow and dissolve over time.

One Important aspect of the university-industry collaboration is the organization structure. The organizational structure is a key in stakeholders' identification and analysis where the power, interests, motivations, attitudes and legitimacy influence the stakeholder's actions. Might & Fischer, (1985) and Mitchell, et al., (1997) highlighted the impact of structural

factors in determining project management success. Furthermore, different R&D organizational structures have different practices in transferring knowledge or integrating capabilities (Chen, 2014). Sharing knowledge between units within an organization and or with other organizations depends on four sets of factors according to Rashman et al.,(2009): features of the source organization, features of the recipient organization, the characteristics of the relationship between organizations and the environmental context.

The collaborators try to achieve their organization objectives and avoid conflicts of interest with other partners (R.McAdam et al, 2012). There is a consensus that the firms will opt in favor of a partnership when there is an alignment of goals between partners (Guertler & Lindemann, 2016; Lakatos et al, 2015). Pursuing a common innovative objective is among the elements that make a collaborative project successful (Bianchi et al, 2011; Padilla-Meléndez & Aguilera-Obra, 2012).

Structure of organization is important factor that effects the decision of the partners to be involved in a collaboration (Petroni et al., 2012). SMEs interact with universities through personal contractual arrangements, whereas firms with high innovative and research competences interact institutionally (Freitas et al., 2013). Vega-Jurado et al., (2015) highlighted the importance of creating an organizational structure to support innovation activities by centralizing strategic decisions with flexible hierarchical supervision and coordination of the collaboration activities.

3.2.1.4 The collaboration interaction pattern

The collaboration interaction pattern in different fields is not uniform. In science-based fields, university departments have a distinct focus on basic research and the major interest of industry is the observation of science, however in less science-based fields, the solution of technical problems is a major concern of industry (Meyer-Krahmer & Schmoch, 1998).

There are some cultural challenges which may discourage partners from initiating a collaboration and work together (Maxwell & Levesque, 2011). Cultural barriers are pervasive in university-industry collaboration (Siegel, Waldman, Atwater, et al., 2003). It is also argued that interactions which are not based on financial resource provisions do not require greater openness than those where at least a partial resource provision of the firms is involved (Simeth & Raffo, 2013).

Academics are often demotivated by the university's procedures, mechanisms and environment from engaging in collaborative innovation activities (Miller et al., 2016). The processes of opening-in/out is very critical factor for the collaboration projects (Lapointe & Guimont, 2015). According to Hung and Chou (2013), engineers and managers need to consider the changes and complexity in their environment before engaging in external technology acquisition or external technology exploitation. Some firms might need to have some structure changes in order to coordinate, integrate and manage external and internal knowledge (Buganza et al., 2011). Designing flexible university policies on technology transfer was suggested as a managerial implication by Siegel et al, (2004) to encourage personnel to participate in collaboration projects. As well, it is demonstrated that intellectual property policies facilitate knowledge transfer between university and industry (Santoro & Bierly, 2006).

Good relationship between partners help in facilitating the work among teams working on the collaboration project (Bernardos Barbolla & Casar Corredera, 2009; Ki H. Kang & Kang, 2009). Personal relation is very important in defining potential partners (Kwiatkowski et al., 2016). Decter, et al., (2007) indicated that companies need to establish good relation with universities in order to access universities knowledge and facilities, moreover the trust between partners is very important for establishing the relationship (Albors-garrigós et al., 2011; Gopalakrishnan & Santoro, 2004).

The collaboration between university-industry happens in a cluster of a geographical distance (Kwiatkowski et al., 2016). Business funding is more likely to be obtained if the university is physically closer to the industrial district (Muscio et al., 2012). Arvanitis et al., (2008), indicated that engineering and natural sciences are strongly represented among institutes with an inclination to patenting which makes them potential partners for those who work in the same industry. Finally, social proximity or the tendency to collaborate based on previous relationship, is another factor which drives the collaboration projects (Myoken, 2013).

3.2.1.5 Resistance to external knowledge

Resistance to external knowledge within the organization is a common issue in such collaboration, internal resistance against externally developed knowledge and which is sometimes named as the Not Invented Here Syndrome. This is a negative attitude of employees against externally developed knowledge (Hussinger & Wastyn, 2016). However, by expanding the capacity for internal knowledge transfer organization can favor external knowledge integration (Segarra-Ciprés et al, 2014). The process of creating, sharing, using and managing knowledge is still limited in SMEs (Durst & Edvardsson, 2012) but an important element of success in managing knowledge within networked innovation is to be able to understand the motivations, interests, intents and the benefits of the partners (Valkokari et al, 2012).

Knowledge characteristics will have direct impact on the university-industry collaborations itself (Schofield, 2013). An effective university-industry collaboration involves knowledge transfer. However, knowledge transfer faces difficulties such as the capability to integrate the information obtained from the external sources into internal processes and structures, and how the geographical advantage still plays a pivotal role in facilitating knowledge exchange (Gould, 2012) (Muscio et al., 2012).

Research partnerships between universities and enterprises increase the efficiency of knowledge sharing (Di Tommaso & Schweitzer, 2010; Wang & Shapira, 2012). Knowledge sharing is an attraction for the industry to have an access to the existing knowledge (Ford et al., 2012). In addition, open innovation is effective when organizations have sufficient capability to integrate the information obtained from the external sources (Gould, 2012). It is worth mentioning that geographical distance is an important factor to facilitate knowledge exchange and motivating actors for collaboration (Myoken, 2013).

3.2.2 Open innovation

In highly competitive environment, the innovation model is evolving rapidly in which the sources of sustainable competitive advantage could be new ideas, shorter product development and company's capacity to innovate (Liliana, 2013). Furthermore, in the open innovation paradigm, university is considered as a source of knowledge for the industry (Chesbrough, 2003). The main topics discussed in the literature include the complexity of the open innovation, the link between the university-industry collaboration and open innovation. In addition, different practices in the collaboration are discussed also.

3.2.2.1 Complexity of open innovation

The open innovation model is substantially more complex than the closed innovation, that is because there are different actors involved in the collaborations and each has different motivations and expectations (Gould, 2012; Ankrah & AL-Tabbaa, 2015). It is important to coordinate the academia's mission for science and the industry's mission to make products (Saotome et al 2012). Timeline for each actor is different, and the technology transfer time is an important issue (Heinonen, 2015). Another issue for academia is that, they have teaching

responsibilities and external activities (Caldera & Debande, 2010). In addition identifying open innovation partners is far from straightforward and includes several aspects to be analyzed before making a decision (Guertler & Lindemann, 2016).

The shift to open innovation will have to be gradual where new procedures, patterns of behaviors, routines and maybe new structures to be implemented for the university-industry collaboration. Acquiring external knowledge is crucial factor for industry competitiveness, hence it is necessary to find academia partners (Freitas et al., 2013). Industries continuously search for competencies to develop breakthrough innovations, explore new technologies, new applications hence it is very important to acquire the talented people (scientific personnel) (Han & Heshmati, 2016; Puślecki & Staszków, 2015) and exchanging key people between partners (Festel, 2015).

3.2.2.2 Open Innovation in the context of university-industry collaboration

In the literature, the link between open innovation and university-industry collaboration has traditionally concentrated on knowledge flowing from one organization to another and the university role as a knowledge and technology supplier (Roshani et al , 2015). The essence of open innovation is that, the ideas come from external source which means of cross-disciplinary, cross-border and cross-institutional innovation (Mayer, 2010). Therefore, in university-industry collaboration, knowledge flowing in and out the organization represents one essential element of open innovation model. Enhancing companies' performance is one of the reasons in the shift towards open innovation model.

3.2.2.3 Diverse issues in University-Industry Collaboration

In open innovation model, enterprise should take advantage of external resources (Chesbrough, 2006, p.2), enterprises boost their ability to learn in strategic settings by tapping

into the experience of others through sharing knowledge (Berends, 2005). Industry has several motivations to be involved in an open innovation collaboration with the university. Some of these motivations are, accessing new knowledge, reducing cost, acquiring competencies and talents (Roshani et al , 2015). Another important motivation is reducing the risk, universities and public research perform basic research with high risk (Saito & Sumikura, 2010) in which academia acts as external partner for companies. For that reason, most companies no longer maintain their own in-house, early-stage, exploratory scientific research organizations, hence universities play a crucial role within this institutional framework (Razak et al., 2013).

Formal technology transfer takes forms of patenting and licensing of academic inventions to third parties for the purpose of commercialization while informal process known as complementary step for formal technology transfer includes academic presentation, scientific publication, scientific consulting, internships, informal meetings, personal contacts and research contracts (Agrawal, 2001). Some stakeholders still question the openness and to which limit to be open? there are different interpretations of the openness when it comes to sourcing, acquiring or providing access, (Dahlander & Gann, 2010). This openness mindset is a major key in open innovation model. Moreover, the openness will have a direct impact of the quality and progress of the collaboration.

The structure in universities is seen as a barrier for the industry where teaching obligations have a negative impact of the collaboration (Arvanitis et al., 2008). In the industry side, the pre-existing Research and Development R&D structure faces challenge in integrating the acquired knowledge and who within the organization will support this integration (Bocquet & Mothe, 2010) (Ford et al., 2012). Universities which have long tradition of industry–university collaboration tend to establish good relationships with the industry and generate more patents (Gopalakrishnan & Santoro, 2004). However, in universities, openness in innovation requires the desire for the change and the necessary mindset. IP policy plays an important role

in the collaboration however, scientists think of IP policies bittersweet. They believe the IP policy is needed to protect their work but at the same time, they do not want it to restrict them from communicating their research and findings with other scientists.

3.2.3 Open innovation in SMEs

Open innovation practices are very useful as competitive strategies for small and medium-sized enterprises (SMEs) and have positive impact on Knowledge flow (Cleveland et al, 2015). Open innovation practices also help in closing the gap between academia and industry to collaborate and profit together from the state funds and other forms of support (Petroni et al., 2012). The main topics discussed in the literature include the competitiveness of the SMEs by being open for collaboration and how the use of open innovation is different in SMEs from big companies.

3.2.3.1 SMEs Competitiveness

Enhancing companies' performance is one of the reasons in the shift towards open innovation model. Stakeholders believe that, adopting open innovation model will increase profitability and mostly accelerates the process of technology transfer (Calcagnini et al., 2016). SMEs need innovation to compete with large enterprise, which requires them to access different facilities and mature technologies therefor finding partners with these facilities is an important factor (Welsh et al., 2008). Launching new services or product would be faster thanks to the creation of the partnership and use of various tools and facilities from different partners (Sherwood & Covin, 2008).

Cost reduction is another factor, small enterprise do not bear the huge cost of development research and market introduction (Saito & Sumikura, 2010). Cooperating with academic institutions in the model of open innovation alliances by converting scientific findings

into marketable products can significantly reduce the cost of research (Sherwood & Covin, 2008).

3.2.3.2 Use of Open Innovation in SMEs

SMEs differ from large enterprises in their use of open innovation since they do not have the in-house capabilities to detect, assimilate and integrate external knowledge (Spithoven, et al., 2013). Research and development investment strategies of large and SMEs are different (Saito & Sumikura, 2010). SMEs decision to be involved in a new collaborations with academia depends on the current value of the expected future profits (Calcagnini et al, 2016).

Finding new potential partners is very complicated, decision makers consider several elements before considering the new partners, alignment the collaboration goals to the organizational goals is one of the crucial elements that makes a joint project successful (McAdam et al., 2012).

The collaborators work on eliminating cultural barriers that impede on the collaboration process (Siegel et al., 2004), this involve several aspects of the collaboration such as the openness for sharing knowledge, flexibility regarding R&D operations and mobility of human capital (Puślecki & Staszków, 2015).

3.2.4 Evaluation of university-industry collaboration

The complexity of university-industry collaboration creates a major challenge for its evaluation. The collaboration consists of multiple actors, several procedures and different components. In addition, and more specifically in the early stage development collaboration, the progress in finding a solution could take several years. This makes evaluating the progress of the collaboration very challenging. This is a challenge for universities and the industry alike.

Neely et al., (2005) highlighted the importance of performance Indicators has long been a practice for academics and practitioners from a variety of functional disciplines. In university–industry knowledge transfer performance indicators should include wide range of activities and reflect a variety of impacts to accurately represent their performance (Rossi & Rosli, 2014).

In public funding agreements, the scientific publications are important elements of performance evaluation (Simeth & Raffo, 2013) since academics tend to concentrate more on publications than on the patent production (Lopez et al., 2009). Another key performance indicator for universities is the number of collaboration projects per year (Al-Ashaab et al., 2011). Other elements that affect the SMEs performance is adopting of open innovation model as well on SMEs performance as the external technology acquisition.

Proof of concept (PoC) is an important instrument that could evaluate part of these type of collaboration projects. The term proof of concept has several definitions and practices based on domains. PoC is a common practice in several disciplines, PoC activities have been studied in several fields, both scientific and corporate (Kendig, 2015).

Practitioners are familiar with Technology Readiness Level (TRL) (Mankins, 2009) and achieving TRL3 is considered as proof of concept. “***Analytical and experimental critical function and/or characteristic proof-of-concept***” active research and development is initiated to validate the Technology concept and/or application which was formulated in TRL2. Analytical and experimental approaches are used to in this validation.

proof of concept research is defined by (Kendig, 2015) as “*a research that is framed in terms of a particular kind of research that provides justification in practice of the potential transportability of knowledge acquired through the experimental test case*”. The justification is associated with the knowledge transportability. This is due to uncertainty over whether specific knowledge will eventually resolve technical problems.

(Munari et al., 2017) *defined funding scheme proof-of-Concept as “PoCs refer to programs, encompass several funding schemes that combine money, expertise, and training to help new inventions lower their technological uncertainty at an early stage and validate their technical and commercial feasibility”* These programs aim to reduce the early stage development risk and increase the TRL level of technology maturity.

In engineering design, prototypes are used as proof of concept. (Houde & Hill, 1997) emphasized that “*prototypes act as proof that an artifact can be produced and how they are used by a designer to explore or demonstrate some aspect of the future artifact*”. This is in line with (Pahl et al., 2007) indicated “*Products to be made in large quantities (mass production) must have their technical and economic characteristics fully checked prior to full-scale production*”. *This is achieved using models and prototypes and often requires several development steps*” Furthermore, (Ullman, 2003) indicated that there are four purposes for prototypes: proof-of-concept, proof-of-product, proof-of-process, and proof-of-production. This has introduced the term "proof of concept prototype" which is adopted by (Ullman, 2003) (Yang & Epstein, 2005) (Yamaya et al., 2011). Prototypes have been extensively employed as transmitters in concept design and validation tasks by several industrial sectors(Yang & Epstein, 2005) (Arastehfar et al., 2013). Further research is needed to explore how the early stage development UIC is evaluated. This is another issue we intend to address in this study. This study will aim on developing set of KPIs for UIC as whole considering the different elements in the UIC. We will also focus on prototypes as PoC since it covers multiple purposes in the engineering design and development process.

3.3 Summary

We conducted the systematic review to answer our question: *what are the influential factors of initiating open innovation collaboration between universities and industry*. Table 1 below shows the different influential factors of initiating open innovation collaboration between academia and SMEs (Haidar et al., 2019). These factors were grouped into four categories:

Organizational Structure, Performance Indicators, External Resources and Proximity.

Organizational Structure	Performance Indicators	External Resources	Proximity
Organization Changes	Number of Patents /Products /Service	Profitability	Social
IP policy	Number of Projects	Facilities	Industry
Openness/Culture	Effectiveness	Alignment of goals	Geographical
Process	Environment impact	Cost Reduction	
Relationship Type	Number of Publications	Funding	
Structure		Human capital	
		Intermediaries	
		State Policy	
		Reducing the Risk	
		Knowledge	

Table 1 - Summary of Influential factors

The literature review identified two issues that are under-researched in the early stage development UIC. First issue is characterizing UIC based on multiple aspects of the collaboration. Second issue is evaluating the early stage development UIC. In the next chapter, a descriptive and qualitative analyses of these factors as well as our final sample resulting from the systematic review will be presented to help in positioning our study and identifying the main aspects of UIC, consequently defining a specific research question.

Literature review analysis and Research positioning

The aim of this chapter is to analyze the literature review, which was presented in the previous chapter. These analyses will help to introduce the research gap and to define the specific research questions.

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4 Literature review analysis and Research positioning

This chapter is composed of two main parts. First part is about the analysis of the literature review. The analysis is divided into two sections; one is general analysis about the final sample of the articles. Second section is descriptive analysis of the influential UIC factors. Second part of this chapter will also present the research gaps and research questions based on the analysis of the literature review.

4.1 Analysis of the literature review

In the previous chapter, systematic literature was conducted to identify the influential factors of initiating open innovation collaboration between universities and SMEs. As shown in table 1, the factors were grouped in four categories: Organizational Structure, External Resources and Performance Indicators. We will present the analysis of the categories as well as the factors.

4.1.1 General Analysis

The final sample of our data shows that there is an increase research attention over the last ten years to the open innovation collaboration between universities and SMEs. The general topics treated by these researches are related to knowledge and technology transfer. An interesting finding is the particularities of geographical context where the majority of the studies (59% of our final sample) have been done in certain countries such the US, Italy, UK and Spain as shown in figure 10. In some studies, there is a comparison of university-industry collaboration between two countries.

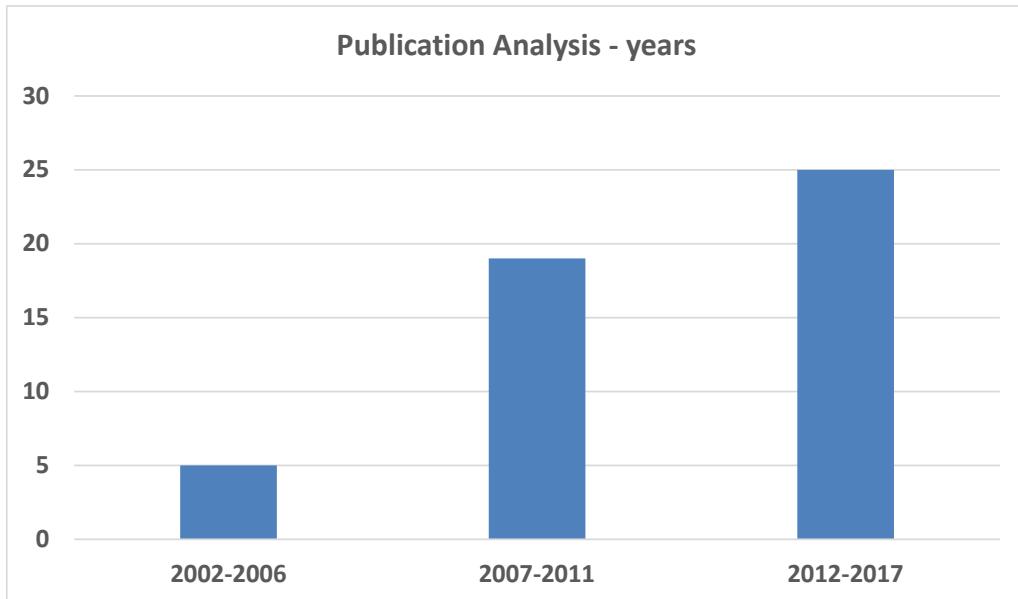


Figure 10 - Number of articles per period

As shown in figure 10, there are five articles in the period 2002-2006 all of these articles were from the US. These articles covered two main topics, firstly the organizational aspects of university-industry collaboration, the ways in which university interacts with SMEs differ from those with large established companies. Second topic discussed in these articles was technology and knowledge transfer in the university-industry framework. Identifying the key issues in promoting successful technology and knowledge transfers.

In the period, 2007-2011 there were 19 articles in our final sample that shows an increase attention in the literature. These studies were from different countries which include the US, Spain UK, Italy, Canada, Switzerland, Germany, Sweden, Austria, Japan, Korea and Taiwan. It is worth mentioning that the US and Spain have the majority of the studies where each has four articles.

The articles studied the following main topics: the university-industry relationships, the complexity of intellectual property and exclusivity of licensing and identifying the factors for success or failure of these collaborations. Another main topic discussed in these studies was technology and knowledge transfer activities between science institutions and private corporations through university-based incubators. Some of these articles have examined the

impact of public policies on the emerging model of open innovation and the effects of open innovation on SMEs performance.

As for the final period 2012-2017, 25 articles are included in our final sample, and a majority of these studies was from Italy and the UK (5 and 4 respectively). These studies covered a wide range of topics such as the early-stage technology acquisition, the critical issues of the external technology acquisition and the effects of collaboration on the enterprise's performance. Another topic covered in these studies is analyzing technology transfer through resource spill over, which captures the various ways in which enterprises can benefit from collaborations with university's scientists. The studies also investigated how geographical proximity affects the determinative factors for collaboration between universities and private sector.

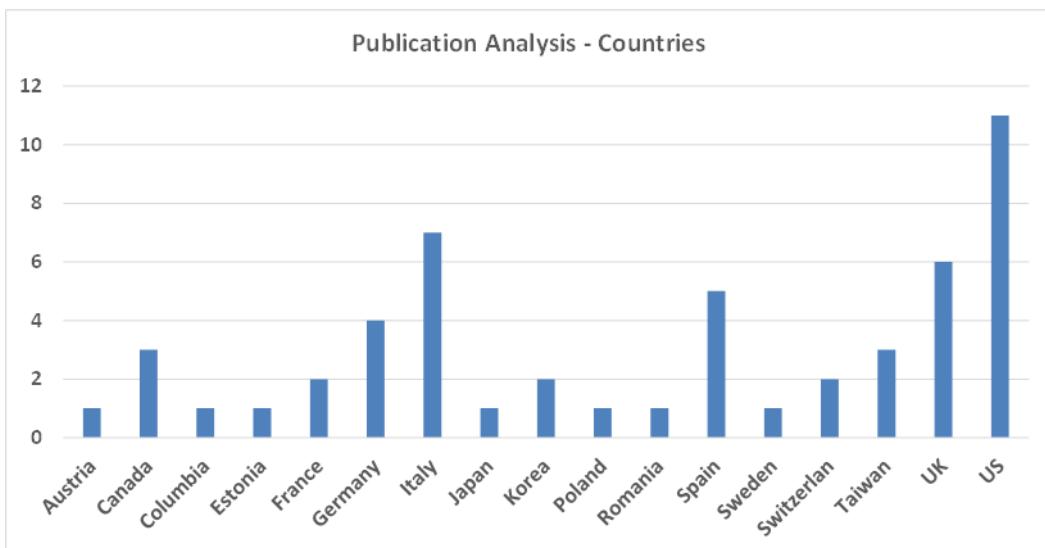


Figure 11 - Final sample analysis – Countries vs Number of Papers

4.1.2 Descriptive analysis of the factors

The categories of the factors have different levels of attention in the literature. Figure 12, shows that at least one factor from the organizational structure factors has been discussed in about 91% of our final sample of the articles. The external resources factors come second in our final sample where at least one factor has been studied in 83% of the total articles. The performance indicators and proximity factors have less attention in these articles with 26% and 14% respectively.

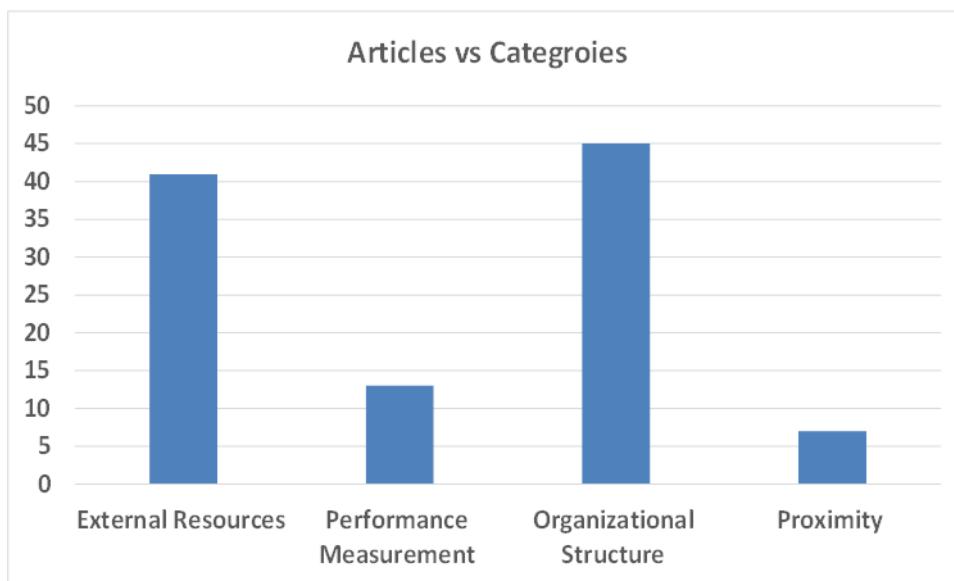


Figure 12 - Final sample analysis – Articles vs Categories

As shown in figure 13 below, the factors (sub-categories) that have been studied with different levels of attention. The type of relationship between the actors of the collaboration is the most frequent factor that has been investigated in our final sample; over 55% of the total articles have focused on this topic. The studies agreed on the importance of the relationship however, they differ on why it is difficult to establish the relationship. Industry have difficulties in developing strong and long-lasting relationships with universities due to the perception of professors and researchers on teaching obligations, research and collaboration activities (Kristel

Miller , Maura McAdam, 2014). In contrast, universities scientists see the difficulties differently, working with industry is very complicated relationship, which can restrict communication among scientists (Welsh et al., 2008).

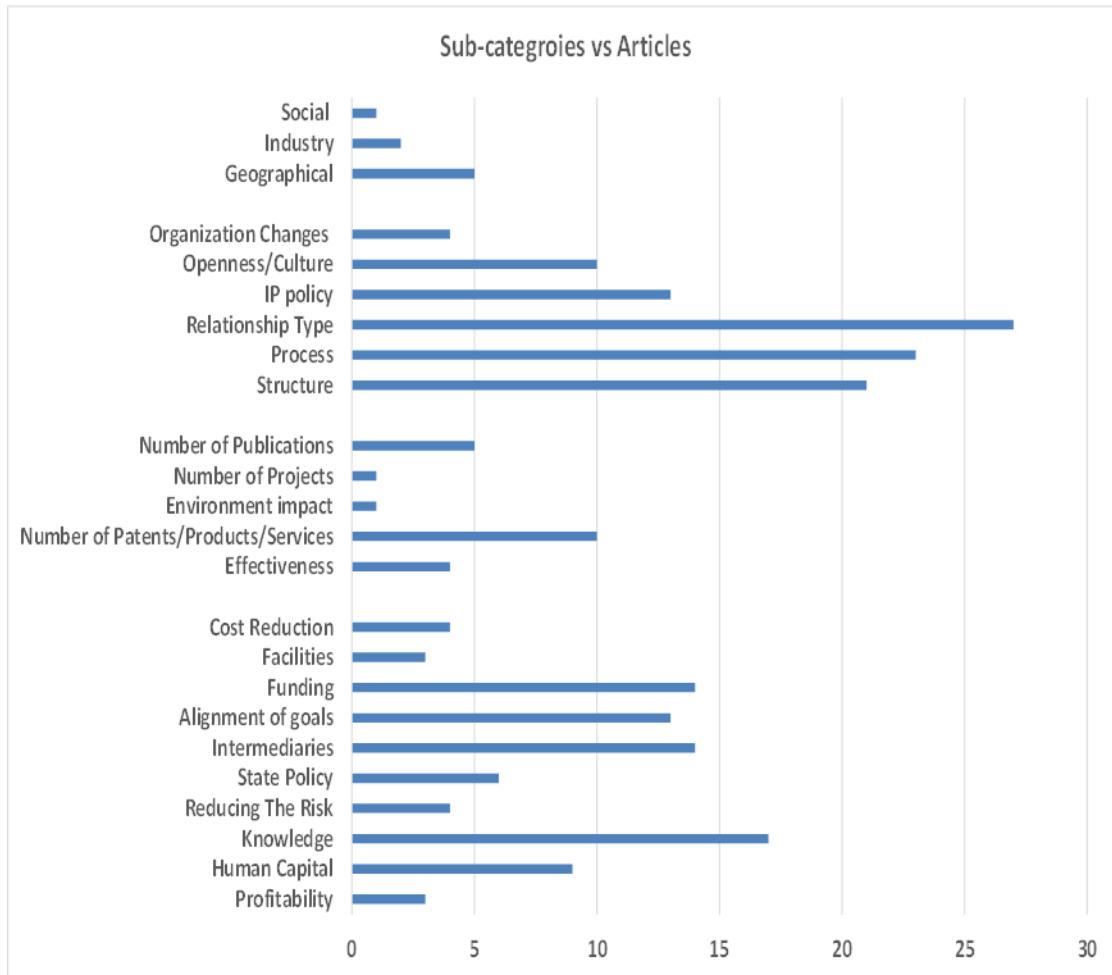


Figure 13 - Factors (subcategories) vs Articles

Collaboration processes is a challenge for collaboration and demotivate the teams to collaborate since the teams come from different organization. Around 46% of the final sample of the articles discussed the collaboration process. The analysis highlighted the importance of flexibility in the processes of completing activities rather than managing and taking control of procedures and mechanisms of the collaboration (Liliana, 2013). Contrary to this finding,

centralization of tasks for the working groups is essential to meet the due dates and facilitate the communication to resolve conflicts between the collaborators (Muscio & Vallanti, 2014).

The structure in universities is seen as a barrier for the industry where teaching obligations have a negative impact of the collaboration (Arvanitis et al., 2008). In the industry side, the pre-existing R&D structure faces challenge in integrating the acquired knowledge and who within the organization will support this integration (Bocquet & Mothe, 2010) (Ford et al., 2012). Despite the fact that this factor was studied in almost 43% of our final sample, only few articles demonstrate the industry attempts to overcome this challenge by creating an organizational structure to support innovation activities rather than squeezing it within the pre-existing R&D structure (Hung & Chou, 2013; Schweitzer et al, 2011).

As indicated earlier, one issue will be addressed in the study is characterizing the UIC considering different aspect of the collaboration. From this analysis, we identified the following collaboration's aspects that will be considered for the UIC characterization: **Relationship Type, Process, Structure, Knowledge, Intermediaries, IP policy, Funding, Alignment of goals and Culture of openness.**

Another outcome of this review is integrated in figure 14 below, as a conceptual framework of the collaboration stages (Haidar et al., 2019). We constructed this framework based on the analysis of the literature review. We divide the collaboration into three stages, before, during and after of the collaboration. Before the collaboration, the decision makers consider the objectives and motivations of the potential partners. Selecting partners is far from straightforward and includes several aspects to be analyzed before making a decision (Guertler & Lindemann, 2016) which we indicated as selection criteria in figure 14.

During the collaboration, the collaboration moves to operational stage. The activities of the stage are influenced by the organizational structures as well as the collaboration process and

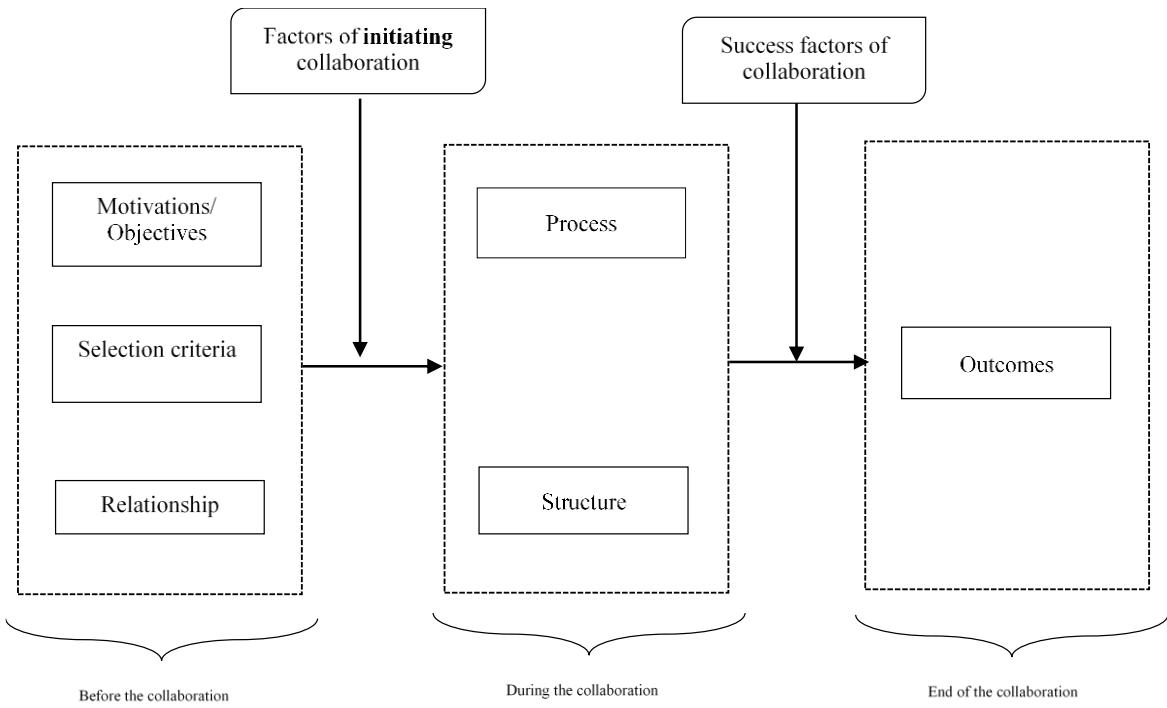


Figure 14 - Conceptual framework of the collaboration stages (Haidar et al., 2019)

interactions. At this stage, there could be different important factors which will facilitate or inhibit the collaboration success (Ankrah & AL-Tabbaa, 2015). In certain collaboration, the objective or the result generating knowledge or an idea or reach a proof of concept.

4.2 Introducing research gap

In this section will introduce the research gap by highlighting the issues and questions related to academic engagement, which are under-studied in the literature. In addition, the research questions and sub questions will be presented.

4.2.1 Research gap

Most studies regarding university-industry collaboration focus on describing the downstream processes associated with technology transfer and commercialization (Pinheiro & Lucas, 2015). The upstream part of the process that is associated with knowledge-related activities is poorly studied. Particularly few is known about the factors that lead decision makers to initiate the collaboration project.

In the literature, university-industry relationships have been extensively studied however, there is little systematic understanding of organizational practices of the different actors considering the differences in motivations, behaviors and environment (Siegel, Waldman, Atwater, & Link, 2003; Freitas, Geuna, & Rossi, 2013; Ankrah & AL-Tabbaa, 2015). The organizational characteristics of open innovation is studied in general but these characteristics are never analyzed at each early micro phase of the inbound open innovation process (Liliana, 2013). There is a lack of investigation done to improve the efficiency of a process of open innovation (Buganza et al, 2011) even though some tools were developed in order to bring known products into the supply chain which is different from acquisition of earlier-stage technologies since the risk is very high (Ford et al., 2012).

We identified two research gaps. Firstly, Lack of characterization of UIC due to the complexity of the collaboration as entire process in which it involves several aspects. We identified the following collaboration's aspects that will be considered for the UIC characterization: **Relationship Type, Process, Structure, Knowledge, Intermediaries, IP policy, Funding, Alignment of goals and Culture of openness.**

Secondly, evaluating the early stage development UIC. Evaluating the collaborations' results is a major issue of the collaboration. Moreover, at the end of this kind of collaboration, there could be a possibility to extend the collaboration or involve more actors in the collaboration for further development.

4.2.2 Research Questions

The purpose of this research is to study the upstream part of the process. The part that consists in generating, consolidating and testing ideas.

Broad Question: *How academic engagement influences the university-industry collaboration?*

Sub-questions

Based on the gaps in the literature our aims will be to answer the following questions:

- What are the characteristics of the early stage collaboration between universities and SMEs?
- What are the key performance indicators that evaluate university-industry collaboration at the early stage?

The framework presented in figure 14, will be further expanded and analyzed for a twofold purpose. First, we will study the mechanisms and characteristics of the collaboration at the stage of generating, consolidating and testing ideas. Second, we will analyze how to evaluate the collaboration based on the developed UIC framework.

Methodology

The aim of this chapter is to describe the methodology of this study.

Describing the overall research design used to carry out the study, the procedure of how the data was collected and how data was processed.

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5 Methodology

This chapter is divided into four parts, research design, data collection, bracketing and data analysis. The first part gives an overview of the overall strategy used to conduct the study by recalling the problematic and the research questions the elaborating how to tackle these questions. The second part describes with details where the data was collected, the types of projects, how university-industry collaboration is established in these projects. Furthermore, the second part presents how data was collected through interviews and its protocols. The Third part describes bracketing method used to minimize the bias in the research process. The fourth part shows how this data is processed, reorganized and synthesized.

5.1 Overall Research Design

The research problem is the upstream part of the university-industry collaboration, in other word knowledge-related activities, which involve initiating the collaboration, and the operational activities such as generating, consolidating and testing ideas. The research question: How academic engagement influences the university-industry collaboration? As indicated in the previous chapter, there are sub questions regarding the characteristics of this collaboration at the early stage as well as the Key Performance Indicators (KPI). To answer these questions with the aim of describing experiences and understanding the concepts from both perspectives (universities & industry), a qualitative study is conducted to gain in-depth understanding of a specific context. This study was conducted in the context of Grenoble INP (Institut polytechnique de Grenoble) which is a French technological university system consisting of eight engineering and management schools. The study was conducted in four schools which are the following:

- The École nationale supérieure de génie industriel or **Génie industriel** (School of Industrial Engineering) (**Grenoble INP - Génie Industriel**)
- The École nationale supérieure de l'énergie, l'eau et l'environnement or **Ense3** (School of Engineering in Energy, Water and Environmental Sciences) (**Grenoble INP - Ense³**)
- The École nationale supérieure en systèmes avancés et réseaux or **Esisar** (School of Engineering in Advanced Systems and Networks) (**Grenoble INP – Esisar**)
- The École internationale du papier, de la communication imprimée et des biomatériaux or **Pagora** (School of Engineering in Paper, Print Media and Biomaterials) (**Grenoble INP – Pagora**)

These schools are located in Grenoble, except ESISAR which is located in Valence.

Each school has multiple projects with different industry partners at different level of maturity.

For our study, we have chosen five projects from these four schools. The common characteristic between these projects is that, they are at the early stage development and students are involved in these project. The projects are:

- Grenoble INP - Génie Industriel : plateaux projets and Etudes de terrain
- Grenoble INP - Ense³ : Projet industriel
- Grenoble INP – Esisar: Projet industriel
- Grenoble INP – Pagora : Procédés Industriels & Management Environnemental

After the projects were selected, the data collection started through interviews. Semi-structured interviews were conducted to collect primary data in two segments:

- At the university side: Interviews with professors who work with students and industrialist. Also, with administration staff who manage university-industry relations

- At the industry side: Interviews with industrialists who work with university on these types of projects.

Another technique used to collect data was observations. Where we attended collaborative sessions, meetings and operational activities with professors, students and industrialists. It was important to observe them undertaking some of the collaboration activities, to know what they do under different circumstances and follow the evolution and progress of the collaboration.

For the data processing, NVIVO was used which is qualitative textual & audio-visual analysis software. We started by categorizing the data guided by the initial coding categories based on prior research from our literature review analysis. Data that cannot be coded under the initial coding categories are identified and analyzed to determine if they represent a new category or a subcategory of an existing code. That to ensure it is data driven process based on the emerging content. Then coding and closely examining the data to identify and report recurring patterns within the data.

Figure 15, shows the overall methodology. The context and setting of each the chosen project, the data collections process and how data was analyzed will be described in details in the following sections of this chapter.

Methodology Flowchart

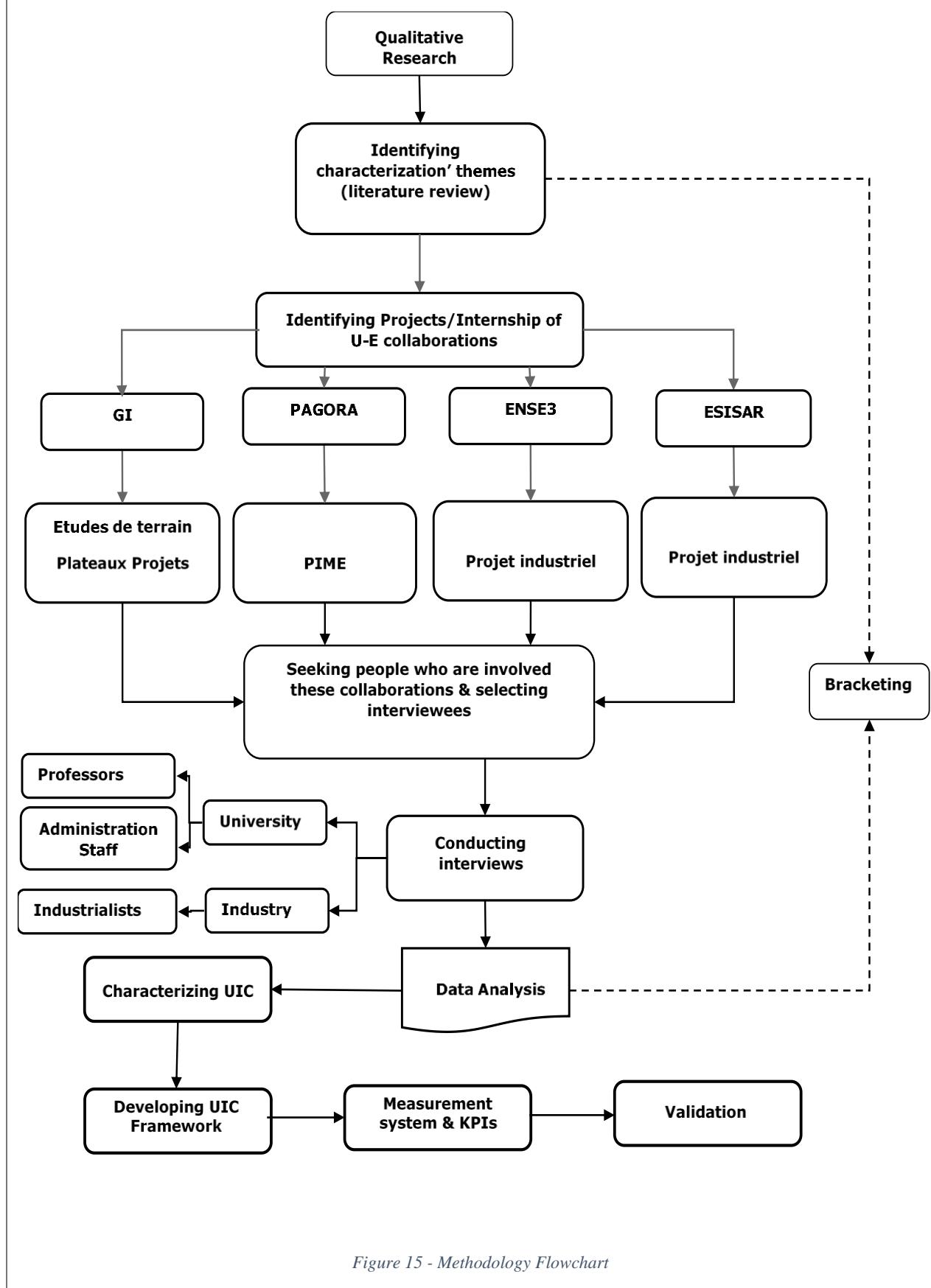


Figure 15 - Methodology Flowchart

5.2 Data collection

This section will introduce and explain in details how data was collected. We started by studying the projects types in different schools of Grenoble INP websites to select the projects which could offer rich context of the collaboration between university and industry and provide details in depth of the activities and practices. More importantly, these projects must be at the early stage development and show the context of academic engagement with the industry. Then we searched for people who are involved these collaborations and willing to help us in conducting our study.

5.2.1 Where data was collected

Data was collected based on five projects in four schools of Grenoble INP - UGA Institut d'ingénierie et de management (Graduate schools of engineering and management at



Figure 16 - Grenoble -INP Schools

Grenoble Alpes University). **Grenoble - INP** is a major public institution for higher education, a recognized research hub and a founding member of the Grenoble ecosystem. Grenoble INP is consisting of eight engineering and management schools.

Grenoble INP Graduate schools of Engineering and Management, plays a major role in the scientific and industrial community⁵. It focuses on the major challenges: energy, the environment, the digital society, micro and nanotechnologies, and the industry of the future.

As mentioned earlier, in this study data was collected based on multiple projects in four schools of **Grenoble INP: GI, Ense³, PGORA and ESISAR**

5.2.1.1 Grenoble INP - Génie Industriel

Grenoble INP - Génie industriel is the Industrial Engineering and Management School. The school offers a large variety of study opportunities for undergraduates, graduates, foreign students, researchers and engineers. Its training is orientated towards product engineering, supply chain engineering and sustainable industrial performance engineering. The school prepares the students to master the entire industrial cycle, from innovation and product design to recycling, including production and distribution. For this, the school relies on the interdisciplinary of teaching and gives an important place to human and social sciences (economics, sociology, management) in its training cycle ⁶. This interdisciplinary education is based on the values of sustainable development. The students have the opportunities to use the different resources and facilities available in the school. One of these facilities is GINOVA technological platform^{7,8}, which is an innovation space to simulate and experiment.

Grenoble INP - Génie Industriel trains engineers to be capable of improving business performance and mastering the entire industrial process from product design, manufacturing, marketing to recycling while meeting the dual challenge of competitiveness and durability.

⁵ <https://www.grenoble-inp.fr/fr/l-institut/les-ecoles-d-ingenieurs-et-de-management>

⁶ https://genie-industriel.grenoble-inp.fr/fr/l-ecole?RH=GI_LECOLE

⁷ <https://genie-industriel.grenoble-inp.fr/fr/formation/la-plateforme-technologique-ginova>

⁸ <https://s-mart.grenoble-inp.fr/fr/s-mart-grenoble-alpes/plateformes-ressources-1>

These trainings integrate industrial realities, moreover Grenoble-INP forges close links with companies, which allow to anticipate the skills needed in the industry.

Grenoble INP - Génie Industriel has a network of 500 partner companies ⁹ participating in internships and recruitment. The school has a dedicated structure to activate and manage its partnerships with industry, ecosystem actors and other entities. The structure is called “Cellule Relations enterprises” / Enterprise Relations Unit. The objective of the unit is to make the industry present in the school’s programs and activities. Many industry professionals are involved in students’ training through projects collaboration, internships, certain courses, seminars and conferences. This involvement presents an opportunity to illustrate and question the new knowledge acquired by students. For the industrialists, it is also the occasion for dedicated meetings with the teaching and research staffs in school to discuss the industry needs.

Since its foundation, Grenoble INP - Génie Industriel has always made the efforts to have a strong relation with industry. Through their knowledge of the industrial, business world and the requirements of the engineering profession, the industrial partners have made invaluable contributions not only to the organizational development of the school but also to the curriculums and networks. In the school, there are two main mechanisms for the collaboration with its partners: Industrial Club and Industrial Circle.

Industrial Club (Le Club des industriels)

The objective of the industrial club is to be a reference on the strategic orientations of the school. The club help to develop the school in its organization, its educational content, its network to respond to the changing needs. They help engineering students, teachers and researchers to understand the industrial environment. Within the club, they can discuss best practices with other partners. They share their expertise and know-how with in areas of

⁹ https://genie-industriel.grenoble-inp.fr/fr/l-ecole?RH=GI_LECOLE

industrial engineering skills. They will also have the opportunity to recruit students from the school as interns during their studies or as engineers after they graduate. Each year, they offer numerous internships and meet students at the Partners Forum day¹⁰.



Figure 17 - GI Industrial Club Members (2020-2021)

The Club is governed by a charter. By signing the club charter, industrialists make a commitment to the development and evolution of the school. This Charter defines the fundamental principles of this commitment between the industrialists and the School.

The Club operates under the responsibility of a President. A member chosen by the club holds the presidency for two years. The club meet four times a year (usually four full days), and one of the days is held in one of the industrial sites of the club. The president of the club and the management of the School establish the agenda of these meetings jointly. It is desirable that the club be representative of the major areas of competence of the School (mechanics, production, and logistics). The maximum number of partners, members of the Club is set at 15. Each member engages for a minimum period of three years, which is the period of an intake/class of engineering students. At the end of this period, a company may wish to leave the Club. The Club chooses eight representatives appointed to sit as external members on the School Council.

¹⁰ <https://genie-industriel.grenoble-inp.fr/fr/entreprises/le-club-des-industriels>

The main activities of Club members are of three types:

- Support for the development of the School
- Direct participation in the training of students (future engineers)
- Support for research activities carried out by laboratories associated with the School

The club members involve in the operation and development of the school, enabling the School to develop in different industrial engineering fields that characterize the major engineering trainings. The Club member participate in the admission committees each year alongside the School's teachers in the student's selection for entry to the School programs.

The professors will be able to request the industrialists to participate or presents during the courses, during colloquiums or specific conferences. In addition, to organize visits to industrial sites and field studies to illustrate theoretical knowledge and share concrete work situations and with students and their professors.

Club members support the production and dissemination of scientific knowledge in industrial engineering in partnership with the laboratories associated with the School. They participate in the advancement of research by proposing fields of experimentation within a various level: masters, “cifre”¹¹ theses (Convention industrielle de formation par la recherche/Industrial Agreement of Training through Research), targeted studies, multi-year research programs.

Industrial Circle

The Grenoble INP - Génie Industriel created the “industrial circle”. This intended to welcome any industrial actor wishing to develop an in-depth and lasting collaboration with the school also to accommodate any company wishing to become a partner of the School without

¹¹ <https://www.anrt.asso.fr/fr/cifre-35654>

however belonging to the industrial club. A charter specific to the Circle governs the functioning and objectives of this Circle.

The objective is to bring together companies and the school to create a dynamic contributing to the development and to formalize the school-industry partnerships. Each member commits for a minimum period of three years by signing the industrial circle chart. At the end of this three-year period, a company may wish to leave the Circle or renew its engagement. The list of members of the circle is updated each year¹².



Figure 18 - GI Industrial Circle Members (2020-2021)

Industrialists rely on:

- in-depth relationships with future engineers
- contacts with the teaching staff,
- opportunities for collaboration with research laboratories associated with the school,
- Exchanges with other partners on best practices.

¹² <https://genie-industriel.grenoble-inp.fr/fr/entreprises/partenariats>

The Enterprise Relations Unit of Grenoble INP - Génie Industriel, manages the activities of the industrial circle. This unit handles and organizes the events with the industrial partners. Grenoble INP - Génie Industriel teaching staff can assist companies on specific tasks for short periods by giving advice or acting as a consultant in areas relevant to their research expertise such as: Optimization of the development and innovation process, supply chain, additive manufacturing and prototyping, virtual reality and experimental studies on consumer behavior. The industry partners have the opportunity to present a technical problem to discuss the possibility for a collaboration with one of the school laboratories. Furthermore, conferences and open discussion sessions are organized per year to share best practice in industry-academia partnerships. Industrial partners can also access the school events to offer internships and end-of-study projects or recruitment.

To summarize the activities in which the industrial partners from **industrial club** or **industrial circle** are involved:

- Participate in the strategic management of the School
- Participate in student admission committees
- Designate a sponsor for each class/intake
- Offer site visits and field studies
- Offer internships and end-of-study projects
- Give some lectures, in conferences or on the occasion of meeting days
- Provide financial assistance to the school through the allocation of the apprenticeship tax.

Proof of concept in collaborative projects

Although no financial contribution is requested from partner companies, Through the apprenticeship tax, companies will be able to contribute to the school's revenue. An assessment of the actions will be presented each year by the school management.

For Grenoble INP - Génie Industriel, with **industrial club** or **industrial circle** collaboration is not exclusive of other relationships with industrial companies, in particular within the context of industrial projects, welcoming interns and recruitment for engineering students. Companies can propose a project or professors can contact a company that is active in a theme that interests the professor.

The table below shows an example of the projects and internship in **Grenoble INP - Génie Industriel (GINP-GI)**.

Academic Year	Internship	Duration	Timing	Receiving offers
1 st year (Bachelor)	Trainee	4 weeks	July-August	March
2 nd year (Master 1)	Field study (logistics/supply chain)	13 days	February-April	November
	Team project *(product industrialization)	126 hours	September-April	June
	Assistant engineer	3 months	June-September	March
3 rd year (Master 2)	End of studies project	5 months	February-July	November

Table 2 - Internships & Projects in GINP-GI

During their 3 years at Grenoble INP - Génie Industriel, students spend approximately 9 months working in companies. These internships, which can last from 2 weeks up to 6 months are a vital part of their training because they provide students with an increasing understanding and an in-depth insight into the world of work and its challenges.

Throughout the internship the teaching team to provide guidance to the students. An industrial tutor will be involved as well.

For this study, at Grenoble INP - Génie Industriel, we will conduct our interviews and analysis on two of these projects: Field study & Team project which are for 2nd year or Master 1 students.

Field study (Etude de terrain/EDT)

This is a field study based on a company's problem/case. A 100 hours practical exercise, which requires a weekly presence in the company. Several visits to the company's site where a Group of 3 or 4 students will provide assessments/recommendations on logistics and supply chain problems that are identified by the industrial partner. Two members of the school teaching team and a designated member from in the industrial entity will support the group. A fresh look at the situation in context by students with cutting-edge theoretical knowledge, leading to an effective proposal adapted to the company.

Objective

The students will have the opportunity to implement the knowledge acquired at the classroom to the industrial world, integrate into a professional environment and organize themselves within their working group. The group must describe the context, the objectives of the study and define a timeline. The company and the school must validate this plan. This development plan clearly indicates the problem, proposes solution with a framed timeline, and analyzes the conditions for the implementation.

Organizational context

In general, every year there are 25 or 30 field studies proposed. To approve EDT projects, the topics of these projects should be related to "Supply chain", logistics, project management. When a project is not fully elaborated, the pedagogical team contacts the company to adjust and provide more clarifications.

Students are grouped in teams of 3-4 students to conduct one field study at a company in the Rhône-Alpes region for 13 days during the months of February, March and April (mostly Tuesdays of each week). The Enterprise Relations Unit assigns the students to the projects through random draw. An industrial tutor and two professors supervise students. Students are

not remunerated but the company covers possible transport cost. The results of the study are the property of the company. The interaction between the school and the industrial partners is very frequent on weekly basis minimum. The pedagogical team have two sites visits to check and see students work in the company, at the beginning and in the middle of the internship, and then there is the defense. The industrial tutors will attend the students' defense.

Project outcome

Since this is a short project, the typical outcome of this collaboration is a feasibility study. Students will have to write a report on a problem faced by the industrial partner analyzing the difficulties and propose plan or method that is technically and financially feasible to tackle this problem. The problem could be incorporation of a new machine or new production line, improve production flows, set up a new process etc. Students present orally and defend their conclusions before a jury made up of industrialists and teachers from the School.

Team Projects (Plateaux Projets)

This project is set to design and/or manufacture a product that meets customers' needs, whose description and specifications are forwarded to Grenoble INP - Génie Industriel pedagogical team. A group of 3-4 students will then design (and, if time allows, build or construct) the product using the school facilities. Two members of the school teaching team and a designated industrial tutor will support the student in conducting their activities related to the project.

Objective

The general objective is to design and build a technical object that meets a customer's needs. Students will benefit from the project where they have to perform a teamwork to achieve the project objective. They will experience different project situations also, they will have the opportunity to materialize their solutions (prototyping). Students will be able to justify their

choices and decision-making then present and communicate their results. The pedagogical team will provide guidance for the students to apply a structured approach, use of design methods and project management tools.

Industrial partners will have the opportunity to explore and test ideas to respond to need or technical problem through the work of enthusiastic students and with help and guidance of teaching team. Furthermore, industrial partners will have access to the school facilities as well as the project team.

Organizational context

In general, every year there are between 15 - 20 Team Projects. Groups of 5-7 students carry out the proposed project. Students will work in teams for 30 sessions of 4 hours (each sessions) over two semesters, then, one full day will be dedicated to final presentations. The industrial partners formulate their needs in terms of requirements and desired results. (Industrial partners may propose some directions, ideas for the solution but students do not have to follow these propositions as long as they achieve the desired results).

Industrial tutor will be a reference for framing the problem, the objectives, understanding the context and eliciting the requirements. The industrial tutor will take part in the final evaluation of student's performance in the project. The teaching team will assist the student's relation with the client (industrial partner) as well as with the school platform or laboratory. The teaching team will guide students throughout the project, frame the team's activities, assist and check the project management process (deliverables, milestones, decision-making, etc.)

Project outcome

The outcomes of this project are related to 3D printing, virtual reality, mechanical parts, production line and supply chain. During the two semesters, the project team will conduct the project through clarifying the client needs, eliciting and formalizing the requirements then elaborating and selecting the most appropriate solution by demonstrating a prototype then finally reporting and communicating the findings.

In Grenoble INP - Génie Industriel, these projects interest our study since they are at the early stage development and collaboration session are conducted with the students' involvement. We will conduct interviews with professors and industrialists to discuss the characteristics of the early stage such as what types of objectives and motivations of the potential partners. We will attend collaborations sessions, meetings and operational activities with those who are involved. To observe and analyze how activities were carried out.

5.2.1.2 École nationale supérieure de l'énergie, l'eau et l'environnement (Ense³)

It is a Graduate School of Energy, Water, and the Environment. Ense³ provides engineering training in the fields of energy (production, transport, distribution and management, and information processing), water (hydraulics, hydrology, civil engineering) and environment (renewable energies, energy efficiency, geotechnical, soil pollution, and environmental water quality).

Grenoble INP - Ense³ trains engineers, master's students and high-level doctors, with a solid set of skills responding to societal and economic challenges with strong industrial convergence. Graduating from Ense³ school means facing the challenges of energy transition, the growing problem of water resources, planning and sustainable development ¹³.

¹³ <https://ense3.grenoble-inp.fr/fr/l-ecole>

The school is heavily involved with its industrial partners to meet the needs of research and industry. Large part of practical training periods takes place within the companies. This involvement could be through research projects, benefiting from the expertise of the school. More than 10% of the master degree students continue with a PhD taking advantage of the exceptional research environment in the domains of energy and environmental sciences. Industrial partners can boost their innovation through industrial projects. These projects are oriented towards feasibility studies, proof of concept, modeling, etc.

A dedicated unit manages the relation with the industry called: Les Relations Industrielles (Industrial relations). The aim of this unit is to increase the school's presence in the industrial sector by animating the network of partners through the following main activities:

- Organize industrial-student meetings via industrial events
- Negotiate and prepare partnership and sponsorship agreements with the industry
- Manage the collection of the apprenticeship tax
- Manage the follow-up of young graduates (Alumni)

Industrial partners can benefit from partnership with the school from the expertise of the research laboratories associated with the school where they develop teaching and research on scientific themes of common interest responding to major societal challenges. Pooling resources with the school to participate in national, European or international projects, furthermore propose projects and internships for the school's students of different levels.

The school has an active approach to cooperation with industrial actors. The school's partners participate in its strategy and influence its pedagogical orientations, by being members of "Council of Ense³". Industrial partners can take part in the teaching activities through seminars or conferences. Promoting their companies, sharing experiences and best practice

during numerous industrial-students' events or business forum, end of studies project awards, company presentations, industry conferences, graduation ceremonies, Alumni Day, study trips etc.



Figure 19 - Companies and organizations that are members of the Council of Ense³ 2020/2021

The table below shows an example of the projects and internship in **Grenoble INP - Ense³**. During their 3 years at Ense³, students spend between 36-40 weeks working in companies. These internships can last from 4 weeks up to 26 weeks. These internships and projects give the students the chance to have their first professional experience in order to implement what they learn in classrooms. Throughout the internship a pedagogical team as well as an industrial tutor supervise the students.

Type	Title	Academic Year	Duration	Timing	Receiving offers
Internship	Industrial Discovery	1st year	4 weeks	June-August	January-May
	Assistant engineer	2nd year	10 weeks	June-August	January-April
	End of studies	3rd year	22-26 weeks	February-June	September-November

Project	Research project	2nd year	240h	February-June	June-October
	Engineer project	2nd year	120h	February-June	June-October
	Industrial project	2nd year	400h	February-June	June-October

Table 3 - Internships & Projects in GINP- Ense³

For this study, in Grenoble INP - Ense³, we will conduct our interviews and analysis on the Industrial projects which are for 2nd year or Master 1 students.

Industrial Projects (Projets Industriel)

An industrial partner with an innovation project at the early stage of the development can rely on the school and the associated laboratories of excellence to move forward with the development by a collaboration. This collaboration could be framed by a contract to conduct the project activities with a commitment to confidentiality and respect for Intellectual Property. The proposed project is conducted over a period of 5 months. A group of 3-4 engineering students supervised by one of the school's teachers. Whether the industrial partner is a Start-up, an SME or a large company, they can participate in an industrial project.

Objective

The main objective of the Industrial Project is to offer the second-year students a professional experience in order to implement an engineering approach to meet specifications set by a client. Students will be confronted with the business world, specific requirements and a timeline to perform the operational activities. Another objective is to create innovation through a bilateral (Ense³ and Enterprise) collaboration in order test and validate new ideas. This includes: feasibility studies, proof of concept, ideas testing, modeling, prototyping etc. Since the activities are hosted at the school facilities, industrial partners will benefit from the available resources and expertise, the know-how and technologies of research laboratories in connection with the school.

Organizational context

In general, every year there are between 15 – 20 industrial projects. These projects are proposed by the industrial partners and validated by the pedagogical team, sometimes there might be some adjustments to the proposed project to be adequate with the student's level.

The school sets up a project team, a supervisor from the pedagogical team, 3-4 students as well as an industrial contact reference to discuss the progress of the development along the project period. The project team analyzes the needs, objectives, defines planning with the industrial partners. The project duration is five months (from February to June) full day a week between February and May then fulltime in June. Dedicated technical and logistical resources and technicians support are at the disposal of the project team. The activities are conducted at the school platforms or one of the associated laboratories.

Project outcome

The industrial partners propose project theme related to Automation, Electrical engineering, Thermal and Hydraulic Engineering, Robotics, Water Conservation and Energy Efficiency. The project team starts by analyzing the needs and defining the specifications with the industrial partners to perform study feasibility and develop a prototype to demonstrate a proof of concept. The deliverables could include a code, a user manual, a model, a bibliographic study. The deliverables are property of the industrial partner.

Industrial projects at Ense³, develop or test solutions for an expressed need by the industrial partners. This interests our study to analyze and characterize the evolution of the development and operational activities. Different types of the outcomes of these projects are important for our study to characterize the UIC.

5.2.1.3 École internationale du papier, de la communication imprimée et des biomatériaux (PAGORA)

PAGORA is the Graduate School of Engineering in Paper, Print Media and Biomaterials. The school programs spread over three years where it trains engineers for the paper and graphics industries: physical chemistry, process engineering, paper production and conversion, and printing techniques. These skills, acquired by Grenoble INP-Pagora engineers, are important since they play a fundamental role in the promotion of plant biomass and its derivatives¹⁴.

The school has a strong partnership with innovative business sectors and industries undergoing rapid technological changes. Within this partnership formed, partners will participate in supervising student project teams, final year projects as well as developing collaborative research projects. Furthermore, recruitment is another aspect in this partnership, industry partners can recruit engineering students for apprentices on work-study programs as well as recruiting graduate engineers. The interaction with the industry could be through company visits, internships, conferences and case studies etc.

Laboratoire Génie des Procédés Papetiers (LGP2¹⁵) is associated with PAGORA. LGP2 helps the industry partners to develop their projects by utilizing various facilities and available resources. Pagora and LGP2 follow a common approach in supporting the R&D projects of their partners, by combining educational and scientific processes to meet their requirements. This unique combination is configured according to the nature of the project, the challenges and time frames involved, the degree of technological maturity (Technology Readiness Level) and the resources mobilized within the company¹⁶.

¹⁴ https://pagora.grenoble-inp.fr/fr/l-ecole?RH=EFP_PRESENTATION

¹⁵ <https://lgp2.grenoble-inp.fr/>

¹⁶ <https://pagora.grenoble-inp.fr/fr/recherche>

The school has a structure to activate and manage its partnerships with industry, ecosystem actors and other entities. The structure is called “des relations partenariales” / Partnership Relations. The objective of this structure is to create and manage partnership between the school and the industrial actors. In addition, this structure organizes industrial events to help the students to connect with the industrial.

The table below shows an example of the projects and internship in **Grenoble INP - Pagora**. During their 3 years at Pagora, students have internships and projects lasting between 6 weeks and 5 months, with a total of 8 months over three years. These internships place engineering students in a variety of real-world situations to validate their innovation management capabilities and their scientific and technical skills. Throughout the internship a pedagogical team as well as an industrial tutor supervise the students.

Academic Year	Internship	Duration	Timing	Receiving offers
1 st year	Trainee	4 weeks	June-August	March
2 nd year	Engineer assistant	2 months	June-August	November
3 rd year	Industrial project	5 months	September-January	June

Table 4 - Internships & Projects in GINP-PAGORA

For this study, in Grenoble INP – Pagora, we will conduct our interviews and analysis on industrial project (Procédés Industriels & Management Environnemental) PIME.

Industrial Projects (PIME-Projets Industriel)

This project is part of the Industrial Processes & Environmental Management program. This project represents multidisciplinary and combines the skills of different engineering students while responding to an industrial environmental problem encountered by a partner. The topics of these projects could be carbon footprint, life cycle analysis, environmental management, waste management channel, recycling, etc. The project takes place

over a full-time semester. It allows the 3rd year engineering student to lead the scientific and technical activities on an industrial site or in a research laboratory.

Objective

The main objective of the Industrial Project is to offer third year students a professional experience in order to implement an engineering approach to meet specifications set by a client. This project creates an opportunity for the industrial partners to design and produce demonstrators or prototypes of objects or structures using biomaterials, paper and cardboard. In the other hand, these projects give students a concrete situation in order to validate the aptitude for innovation, project management and technical skills.

These projects allow students to:

- Find a solution to a problem posed in accordance with specifications provided by an industrial partner
- Mobilize resources allowing self-training if necessary
- Team work environment
- Project management skills.
- Presenting their solutions in the form of a report and defense

Organizational context

In general, every year there are between 5 – 10 projects. The project team is made of 4 to 5, 3rd year engineering students. These projects are proposed by the industrial partners (which could be a company, public entity, research laboratory), the problematic is validated by the pedagogical team, which might sometimes need a calibration of the expectations according to the number of students who work on it and their level which is 3rd year engineering students.

The project starts in September and ends in January. Two tutors, one from the pedagogical team and one industrial tutor to guide the project team. Teams will have a workspace at the school facilities and they will have an access to LGP2 scientific equipment.

Project outcome

The ideal outcome of this project would be to produce a demonstrators or prototypes of objects or structures using biomaterials, paper and cardboard. These projects can be used as a basis for writing case studies. However, there is an intangible outcome, which is gained by the students during the project period. Students improve their knowledge of the industry and apply what they studied in the classroom to the in industrial reality.

We will conduct our interviews and analysis on PAGORA's industrial project PIME. To analyze how the collaboration is initiated and established, the criteria to select partners for the collaboration. Furthermore, we will discuss their approaches for evaluating the quality of the collaborations' results of the collaboration. Moreover, we will consider if the collaboration is extended for further development.

5.2.1.4 École nationale supérieure en systèmes avancés et réseaux (Esisar)

Esisar is part of the Grenoble INP and it is located in the Valence campus, Esisar major programs are in in Embedded Systems, Electronics, Computer Sciences, Control and Networks and IT technologies with innovative teaching and cutting-edge curriculum. Esisar welcomes around 400 students each year, among which 15 % is international students. Grenoble INP - Esisar, trains high-level engineers in the fields of advanced systems and networks, electronics, IT, automation and embedded technologies. Thanks to the quality of its academic and industrial network, it places innovation at the center of its activities¹⁷. Esisar also hosts a laboratory in

¹⁷ <https://esisar.grenoble-inp.fr/fr/l-ecole>

systems design and integration “Laboratoire de Conception et d'Intégration des Systèmes (LCIS)”¹⁸.

The school has developed its courses and programs in close contact with the industry. The study of basic scientific disciplines, mathematics and physics, is spread over the entire course. The programs are broadly open to administration, management, teaching industrial methods, as well as communication, sports and languages. Students must complete a six-month full-time industrial project in their final year. The school have a complementary structure to run the industry relationships, it is called Technology Transfer Department (Direction Transfert de Technologies). Its activities are related to R&D collaborations and technological partnerships in connection with companies. This structure initiates innovative projects with Startups, SMEs and actors of the ecosystem of the Auvergne Rhône-Alpes region. Technology Transfer Department offers an adapted collaboration to industry issues. This pragmatic partnership takes the form of knowledge transfer, know-how and technical achievements under optimal conditions. Esisar mobilizes its resources and skills to support innovative companies as well as respecting major commitments such as ethics, technological neutrality, and above all confidentiality and intellectual property.

Under the Technology Transfer Department, a well-structured platform with the necessary resources to accommodate the industry different needs in specific specialties. The platform is called: Esynov¹⁹ platform. Esynov was created within the Grenoble INP - Esisar school in Valence, carries out technology transfer actions for the benefit of companies in the fields of Electromagnetic Compatibility (EMC), radiofrequency, embedded systems, cybersecurity and the cloud. It brings together the skills and means of investigation for the analysis and characterization of on-board communication and information systems. It

¹⁸ <https://lcis.grenoble-inp.fr/>

¹⁹ <https://www.esynov.fr/>

contributes to the initial training of the engineering school, to continuing education and participates in research projects in connection with the LCIS laboratory. The platform supports companies in their innovation and Research & Development project through expertise and training²⁰.

The service offered by Esynov platform take shape through bilateral contracts giving access to the following services:

- Sharing Expertise
- Technical feasibility
- Numerical simulation
- Technological watch
- Standards watch
- Design review
- Testing and investigation
- Training and consulting

Esynov provides three technical departments (specialties), which provide more specific services to dedicated domains and help industrial partners in different aspect such as training, research and technology transfer missions. The three technical specialties are the following:

- The RFTLab platform brings its expertise in investigation in the field of electromagnetic compatibility: EMC Industrial and Aeronautical. In addition, this platform has recognized expertise in Radio Frequency and Radio Frequency Identification Technologies.
- The SACCO platform brings skills in the field of communicating embedded systems. SACCO (Systèmes embArqués Critiques Communicants) has

²⁰ <https://esisar.grenoble-inp.fr/fr/l-ecole/la-plateforme-technologique>

developed expertise around Internet of Things, cyber-physical systems, in the field of security and operational safety in cooperation with the LCIS laboratory.

- The NuméricLab platform provides resources and skills in the field of new digital technologies. NuméricLab is developing expertise and training in IT, networks, web technologies and cybersecurity.

These specialized infrastructures make it possible to initiate collaborations and partnerships with businesses in the area. Using expertise and Esynov technological platform, industrial partners benefit from support for innovation, and gain access to know-how or available resources to develop a collaborative R&D project, research contracts, expert missions, participation in national or European projects, etc. Furthermore, industry partners involve in other activities which help them to promote their business. Some of these activities could be:

- Participating in the training of the students by giving courses or seminars also by
- Welcoming students through internships, Industrial Projects, End of Studies Project.
- Participating in the school's events, forum, end of studies project defenses, company presentations, industrial conferences, graduation ceremonies, Alumni day,
- Attracting graduates for job offers in recruitment events.

In this sense, the table below shows an example of the projects and internship in **Grenoble INP - ESISAR**. During the education cycle, each student is encouraged to discover the industrial world thanks to projects and internships. During these projects and internships the students are supervised by a pedagogical team as well as an industrial tutor.

Academic Year	Internship	Duration	Timing	Receiving offers
1 st year	Technician	6 weeks	June-August	January-May
2 nd year	Industrial project	6 months	January-June	Throughout the year
3 rd year	End of studies project	22 weeks	February-July	September-December

Table 5 - Internships & Projects in GINP-ESISAR

For this study, Grenoble INP – ESISAR, we will conduct our interviews and analysis on the industrial projects.

Industrial Projects (Projets Industriel)

Each year there are 25-30 industrial projects. Industrial partners come with propositions to initiate a collaboration as R&D developments, technological watch, feasibility, modeling, functional demonstrator. Esisar forms a project team for a period of 6 months. In the school facilities, a project team of students as well as a supervision by the teaching team and industrialists work for 6 months on a need expressed by an industrial partner. This mechanism is particularly suitable for SMEs. Partners can benefit from the dedicated logistical, technical and human resources available for the industrial projects. The project team has an educational and scientific framework that also allows the industrial partners to have a fresh and different perspective on its development issues.

Objective

The general objective of this Industrial Project to enhance the industrial experience of the future engineers. As for the technical objectives, there are two main specialties of these projects. The first is Embedded systems, where topics vary in several technological fields such as electronics, IT and automation. The second is Information Technology & Security, in which the themes could be cloud computing, web technologies and cybersecurity. The project team will be able to design, implement and integrate embedded systems or information systems complying with the client specifications, which include technical, environmental and cost

constraints. Each year there are different types of partners such as startups, SMEs, multinational companies as well as public organizations. These partners will have the opportune to validate their ideas, test it and reach a proof of concept stage by using the school facilities.

Organizational context

In general, every year there are 25 or 30 industrial projects. Teams of 3-4 students from Grenoble INP – Esisar work together on a project. The project is conducted over a period of 6 months from January to June as fulltime. The project is co-supervised by the pedagogical team at Esisar and a tutor from the industry. Industrial tutor and the pedagogical team will have a continuous communication over the period of the project. The industrial tutor will also take part on the finale evaluation of student's performance in the project. The teaching team will assist and guide students throughout the project where they will frame the team's activities, plan and validate the project management. The school has full commitment to confidentiality and respect for industrial property.

The resources available for projects teams:

- A secure room of 25 m² allocated to the project
- Computer workstations and infrastructure
- Telephone and videoconferencing tools
- Design and development tools
- Instrumentation, scientific equipment
- Testing, testing and validation
- A period of 6 months of full-time R&D activity

In general, the industrial project is a dynamic innovation mechanism where it addresses a core business case for the industrial partners and help them to progress in the development with the help of the facilities and available resources at the school.



Figure 20- ESISAR Industrial Project Partners (2020)

Project outcome

The typical results of projects in the specialty of embedded systems are the realization of a functional demonstrator or solutions prototyping in different domains such as internet of things, wireless sensor network and motor control. The projects of Information Technology & Security focus on IT, software engineering etc. The results will be applications of Human machine interface, Virtual and augmented reality, Machine learning, cybersecurity, Web technologies and database.

Industrial projects at Grenoble INP – Esisar interest us because these projects involve students and involves knowledge-related activities at the early stage development. Attending collaboration sessions and operational activities will give us an in-depth and rich understanding of the collaboration's situations and the different settings. In addition, we will interview professors, university staff and industrialists to analyze different aspects from the beginning until the end of the collaboration

To summarize, in this study data is collected based on multiple projects in four schools of Grenoble INP: **GI, Ense³, PGORA and ESISAR**

For our study, we have chosen five projects from these four schools. The common characteristic between these projects is that, they are at the early stage development and they have yet to reach the POC stage. The projects are:

- Grenoble INP - Génie Industriel : plateaux projets and Etudes de terrain
- Grenoble INP - Ense³ : Projet industriel
- Grenoble INP – Esisar: Projet industriel
- Grenoble INP – Pagora : Procédés Industriels & Management Environnemental

These projects provide us a rich context of the collaboration settings, activities and practices. More importantly, show the context of academic engagement with the industry. We conducted interviews with professors, administrative staff and the industrialists about different aspects of the collaboration. In addition, we attended collaboration session, meetings and operational activities to observe how the collaboration take a place.

5.2.2 Interviews

Interviews provide in-depth information related to experience and opinions of the interviewees about a particular topic (Turner, 2010). We conducted semi-structured interviews to collect data and have direct contact with the people, situation of the collaboration. Majority of the interviews were conducted face-to-face, however some of the interview were conducted via online tools due to the geographical distance, covid19 restrictions and the availability of the interviewees.

In our study, we focused on investigating the following aspects (predetermined themes):

Relationship Type, Collaboration Process, Structure, Knowledge, Intermediaries, IP policy, Funding, Alignment of goals, Culture of openness, outcomes and main success factors These issues were decided after an exhaustive systematic review of the literature on collaboration between universities and industry in the previous chapter.

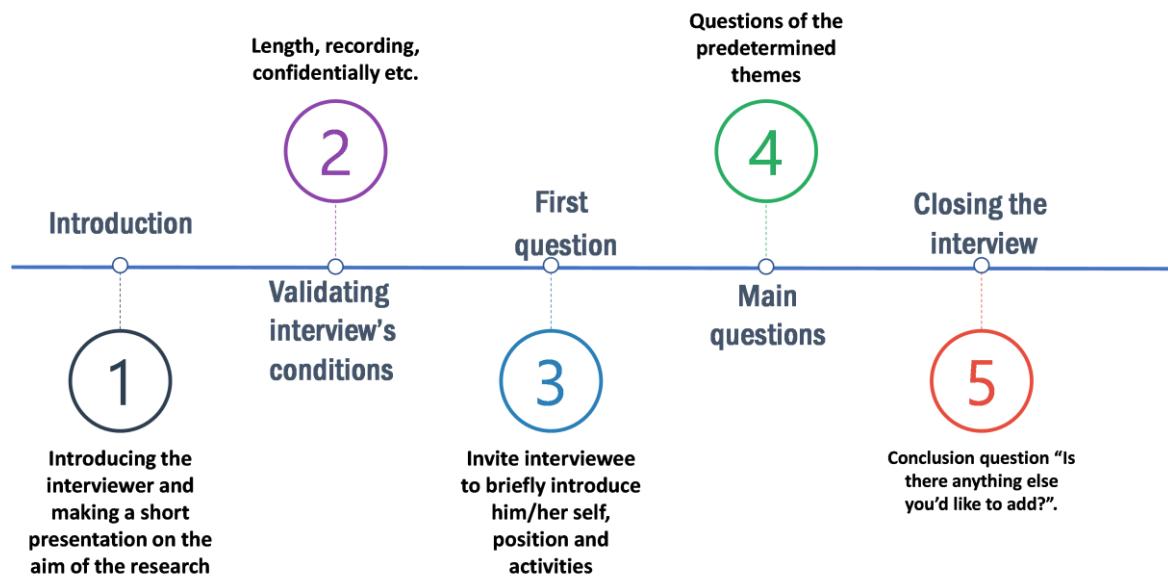


Figure 21 - Interview Guide Structure

As part of the protocol, we used interview guide shown in figure 21. An *interview guide* is a mechanism to help the interviewer conduct interviews (J. Mason, 2002). it allows us to systematically approach different interviews on the same themes. In addition, it will facilitate the subsequent analysis; moreover, qualitative interviews require a great deal of planning (Kallio et al., 2016). We used this guide that serves as a checklist to ensure that all interviews have the same settings and all interviewees provide information on the same themes. These themes were identified as results from the systematic literature review analysis as explained (Section 4.2).

5.2.3 Conducting Interviews

We conducted interviews with the university staff as well as with the industry. This study is focused on gathering information and having an in-depth understanding of the university-industry collaboration in the context of the early stage development, how to initiate, the process, the organization, operational activities, situations, interactions etc. Therefore, for deciding the sample size we relied on the concept of saturation as it is the most important factor for sample size in qualitative research (M. Mason, 2010) (Dworkin, 2012) (Saunders et al., 2018).

We conducted twenty-six interviews in four different engineering schools and eleven companies. We noticed a systematic repetition of ideas, comments, explanations that is already collected in the previous interviews, hence we stopped conducting more interviews.



Figure 22 - Interviews (4 schools, 11 companies)

The four different schools were described in subsection 5.2.1. From the industry, we conducted the interviews in ten companies as shown in figure 22. below also is a table gives an overview of these companies

Company	General description
Chabloz orthopédie	Specializes in the manufacture of all types of orthoses and prostheses. A member of the "Clinical Services Network" of Ottobock, a company specializing in the design of high-tech medical devices.
L'herbier du diois	Active in the food industry. Supplier of aromatic and medicinal herbs, spices and teas exclusively from organic farming. They provide also different services for the producers such as various cut sizes, steam sterilization and vacuum packaging.
Time Sport International	Sport Manufacturer, designs and produces innovative cycling products including bicycle frames, cycling shoes, clipless bicycle pedals, cranksets, and gloves.
Short edition	A publishing house of short literature: poetry, short stories, and flash fiction via short story dispensers for the public to raise literary awareness, encourage new and emerging writers, and highlight the importance and timelessness of literature.
Ateliers du Fontanil	Specializes in metal fabrication and mechanical welding. They work with different materials such as steel, aluminum, stainless steel
Reyes Group	Solution provider and integrator of electrical engineering and equipment in harsh environment: Oil & Gas, Nuclear power plant & process, Hydraulic power plant, electric power plant, Mining, solar, infrastructure, Data center, OEM (Original Equipment Manufacturer), and Food.
Finoptim	Start-up specializing in wood heating, designs open-insert fireplaces while increasing efficiency and reducing pollution to meet environmental standards thus revolutionizing fireplace design and optimizing existing fireplaces.
Inovalp	Active in environment and renewable energy. It designs, and manufactures heating solutions based on renewable energies for domestic use.
Cofret	A small start-up in the agriculture sector which aims to supply the city with affordable local agriculture products.
HYDRAO	Start-up specializing in smart solutions for water conservation and management. Main product is a shower head which indicates in a pleasant and playful way the number of liters of water used in the shower, in real time.
SOLYSTIC	Specializes in end-to-end logistics process automation solutions for the postal industry, express parcels and mass distribution. Providing solutions and services to the parcel and postal delivery industry

Table 6 - Basic description of interviewed companies

These interviews were conducted with three different types of interviewees, administrative staff and professors from the university then industrialist from the industry. We

discussed the predetermined topics. In these topics we asked series of open-end questions which encourages the interviewees to share rich descriptions (DiCicco-Bloom & Crabtree, 2006). Since the interviewees express their views in their own terms, some follow-up questions were asked during the interview based on the interviewee's descriptions and experience. Beside these predetermined topics, each type of interviewees was asked more specific questions in line with his/her position and experience.

Some of the specific themes which are discussed with different types of interviewees:

Administrative staff (gestionnaires)

- Communication with the industry for the possibility of a collaboration
- Explaining the different type of relationships with the industry
- Conflict of interest, trust, confidentiality and IP policy
- Management of the industry relations, the structure within the university to manage different types of collaborations

Professors

- Operational activities of the collaboration
- Expectations /Deliverables of the collaboration
- Intensity and frequency of communication with the industrialists

Industrialists

- Type of results that the company look for when initiating a collaboration with the academia
- Openness for the collaboration
- R&D activities, secrecy

5.2.4 Observations

For rich analysis of the collected data, interviews are coupled with other forms of data collection (Turner, 2010). Since the study focuses on the early stage development collaboration projects, we were interested on how the operational activities were conducted. We attended collaborations sessions, meetings and operational activities with professors, students and

industrialists. Attending these sessions and activities gave us an in depth and rich understanding of the collaboration's situations and different settings. Observation have provided some insight about the collaboration in general, moreover it gave us some contextual elements, which will be discussed in the results analysis. It is important to indicate that during the observation we had limited interactions with the participants. However, these observations' sessions were very helpful to avoid any bias or influence on the data collected. This bias could be our own personal experience or interest concerning the collaboration's issues.

5.3 Bracketing

Bracketing is the process of setting aside personal experience, biases, preconceived notions about the research topic to understand the view of participants and avoid previous research findings or our own views/bias to increase the rigor of the research (Tufford & Newman, 2012). Researchers need to make efforts to put aside their perceptions, experience to accurately describe participants' experiences (Chan et al., 2013). Bracketing is a means of demonstrating the validity of the data collection and analytic processes (Ahern, 1999).

To minimize the influence of the researchers on the research process in qualitative research, it is essential to use reflexivity to identify areas of potential bias and to “bracket” them (Ahern, 1999). Throughout the data collection and data analysis, we used a bracketing journal to take notes and memos during data collection and analysis, in which notes were taken every time we sensed a bias or preconceived notion arise. Using Reflective journals creates transparency in the research process and achieved methodological rigor and paradigmatic consistency (Ortlipp, 2008) (Jootun et al., 2009).

5.4 Data analysis

Data analysis stage is where we started systematically searching and arranging the vast collected information. As shown in figure 23, this section describes the different phases of the data analysis, which could be divided in two parts. First part is describing familiarity with the data as well as the computer-based tool used. Second part describes the coding process, which is a repeated and iterative process.

5.4.1 Nvivo

Interviews were recorded using a recording device as audio (mp3 files), then transcribed. The interviews transcription was done manually to guarantee the maximum accuracy, Although we conducted semi-structure interviews, the amount of data generated by the interviews is extremely large, particularly when compared with traditional quantitative data collection, and making sense of pages and pages of interviews can be overwhelming (DeNardo, 2002). In order to obtain rigor processing and analysis of the data, electronic techniques of data coding are gradually being more employed (AlYahmady & Al Abri, 2013).

As (Bazeley, 2013) highlights computer basically “ensures that the user is working more methodically, more thoroughly, more attentively”. We used NVivo 12 to conduct the data processing and analysis. NVivo is a qualitative data analysis (QDA) computer software package produced by QSR International²¹. The software indeed reduces a great number of manual tasks and gives the researcher more time to discover tendencies, recognize themes and derive conclusions (Wong, 2008). NVivo supports qualitative analysis by enabling visualizations to be created. It is important to indicate that, the use of computer software (including NVivo) in

²¹ <https://www.qsrinternational.com/nvivo-qualitative-data-analysis-software/home/>

qualitative data analysis is limited, we still have to create the categories, code, identify the patterns and draw meaning from the data.

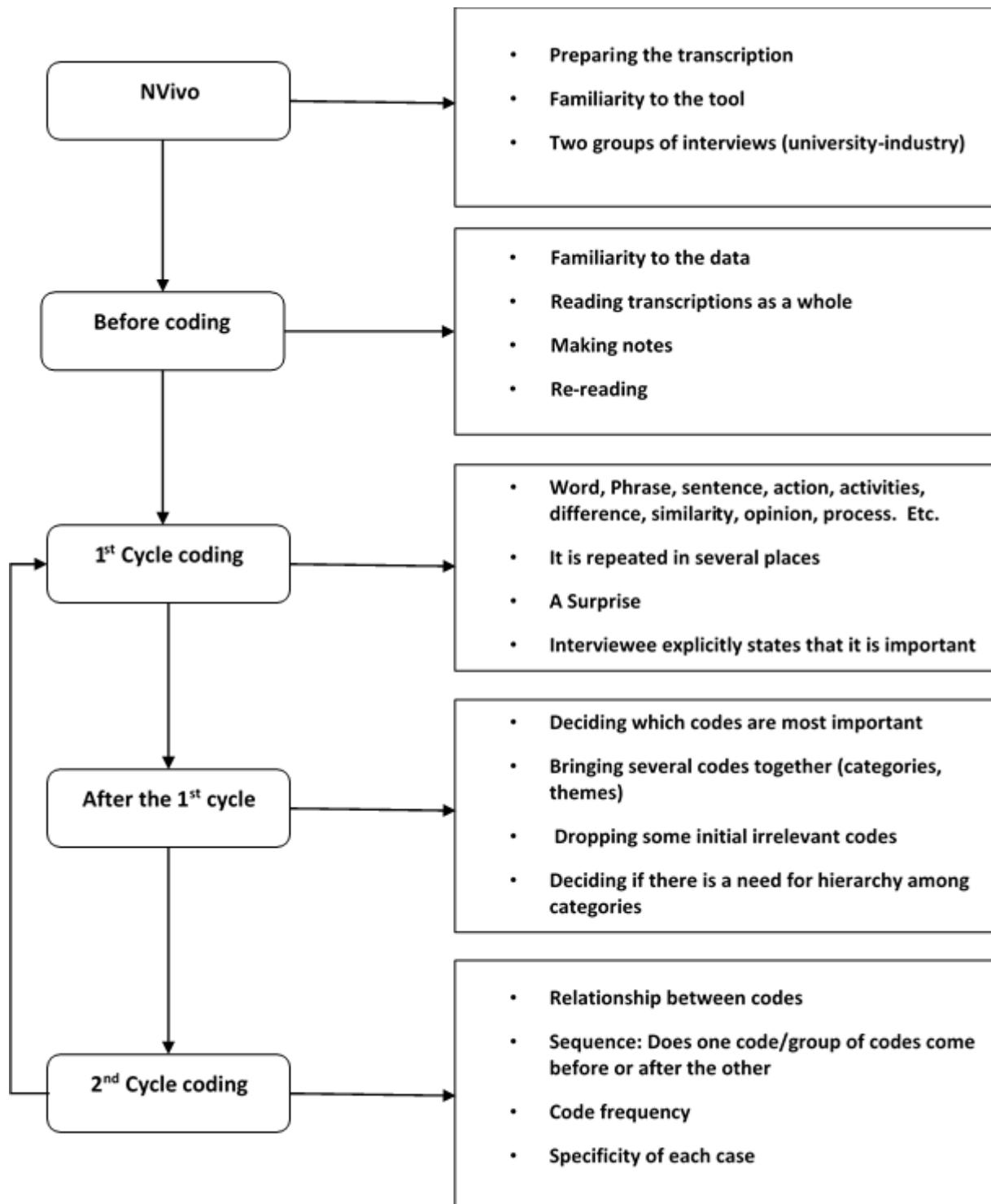


Figure 23 - Data analysis

5.4.2 Before coding

The goal of the phase is to increase the familiarity to the data. This is done by reading transcripts as a whole, making notes about the topics and themes discussed. Being familiar with the data will not only be useful for the coding process but also in the analysis stage.

5.4.3 1st Cycle coding

As Data analysis is the most important aspect of qualitative research and coding has a crucial role in data analysis consequently on the qualitative research since coding organizes and makes sense of the collected data (Basit, 2003). As (Saldaña, 2013) defines code:

"A code in qualitative inquiry is most often a word or short phrase that symbolically assigns a summative, salient, essence-capturing, and/or evocative attribute for a portion of language-based or visual data"

As we have conducted were semistructured interviews, the data collected from different interviews had the same sequence of topics and themes discussed. This helped us setting the preliminary categories of the codes. Nevertheless, we had to induce and develop the codes based on what we find within the data. Therefore, in our study a code is: a word, phrase, sentence, action, activity, a difference, similarity, opinion etc. Sometimes, this is influenced by identifying patterns in the data such as repetition, surprise or an interviewee explicitly states that it is important. The interviews were conducted in French which is participants' native language. We coded all interviews in their original language to avoid losing the meaning in the translation and stay close to the data as recommended by (Bogusia Temple & Alys Young, 2004) (van Nes et al., 2010). Translation with great accuracy of some interviewees quotations will be present in the results chapter which are considered to contribute to trustworthiness in qualitative research as recommended by (Both et al., 2003) (van Nes et al., 2010).

5.4.4 after the 1st cycle coding

This is rather a short phase, where a basic code mapping is done. In other word, organizing codes and landscaping these codes in a visual manner bringing several codes together (categories, themes), deciding if there is a need for hierarchy among categories. Also, dropping some initial irrelevant codes if necessary.

5.4.5 2nd Cycle coding

This phase starts by examining the initial codes to identify the trends, patterns, relationships and if one code or group of codes come before or after the other then assigning labels (categories or themes). To keep track of the codes emerging from the data, we used a codebook. This codebook contains description or an illustrative example which offers a guidance regarding its application (Saldaña, 2013). The codebook is refined throughout the coding process so that the codes can be assessed and to improve the coding scheme's reproducibility

As explained earlier, our data analysis process is an iterative process especially between the 1st and 2nd coding cycles. First cycle coding produces initial codes that help in reducing a considerable amount of data into small meaningful segments. Then comes the second coding cycle, the initial codes are assessed to check if we could bring several codes together based on the relationship between codes. (For example, the “Alignment of the collaboration’s objectives” codes were emerged under two groups “the industry objectives and the university objectives”). This is done for all initial codes. This iteration has improved the codes organization, where the codes are separated if they are overlap in terms of their categories (themes). Furthermore, this helped in assessing if there are themes within a theme (subthemes). For example, in “Alignment of collaboration’s objectives” theme, the interviewees highlighted how the two different organizations (university/industry) have different objectives. The interviewees insisted on the

importance of carefully choosing the potential partners. The interviewees gave some selection criteria to choose their partners. With this, we introduced a new sub-theme “Partners selection criteria”. This to show how we organized and reorganized (through the iteration process) our codes under themes and subthemes.

NVivo does not give an analytical approach for the data, but at this stage of data analysis NVivo provides different features to visualize and explore the possible concepts and ideas around the data. NVivo ‘Explore’ function is an excellent tool to explore potential relationship between the dominant codes and other codes and to put the codes into their respective clusters.

The figure 24 below, shows an example how we can explore and visualize our data. This shows some examples of the outcomes of the collaboration projects.

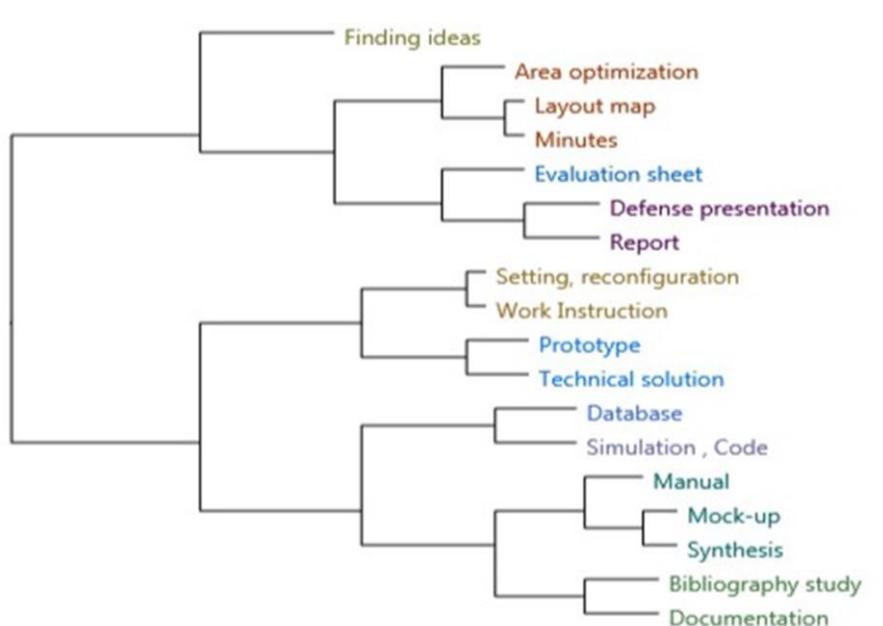


Figure 24 - Exploring data

This helped us at early stage of data analysis to develop and improve our coding. Either by breaking an existing code into new codes (Splitting a code into codes) or by developing broader code, that encompasses other codes (combining codes into a code). Although this visualization is helpful for developing ideas and concepts from the data but it is still far from

perfect. As it is clearly shown in the figure 24, some of the similar codes are not mapped together appropriately. For example, mockup is mapped with other documentations and report is not mapped with the documentations. This shows a limitation on using computer-assisted tool for Qualitative Data Analysis. To minimize the effect of this limitation, we firstly increased the familiarity to the data by repetitive reading the raw data to know the data well. Secondly is the iteration process between the 2nd and 1st coding cycles.

In summary, the methodology started as early as conducting the systematic literature review which was discussed in chapter 3 section 3.1. The result of this systematic review was identifying the themes and the factors that lead to initiate to university-industry collaboration in the context of the open innovation. These themes were considered as the predetermined topics for conducting semi-structure interview to describe the collaboration in depth at the early stage. Data collection was in four different engineering schools and eleven companies based on collaboration of industrial projects at the early stage development. The collected data was processed using NVIVO through two coding cycles. Next chapter will present the results and findings.

Results & Discussion

In this chapter, the results of the study are presented and discussed

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6 Results & Discussion

This chapter is intended to present the results and discuss the findings. The findings of this study are related to three main parts: Characterizing UIC, UIC framework and Evaluating UIC. The chapter starts with a global view of the results at a glance. Second part, presents the characterization of the university-industry early stage development collaboration. This part presents and discusses details the themes and aspects related to the collaboration. Third part is dedicated to the developed framework of the collaboration, which was developed based on the collaboration characterization. Evaluating UIC at the early stage is presented in the fourth part of this chapter.

6.1 Results at a glance

The main results could be divided into three parts. First part is the characterization of the UIC based on the data collected on the themes that we identified in literature review analysis (chapter 4, subsection 4.2.1). In terms of the collaboration's objectives, the difference in terms of objectives is that, the industry is focused on objectives related to the problematic of the collaboration (finding a solution, access to workforce and resources etc.). While the university is focused more on the objectives that related to students (training for student, professional experience etc.). Another Key finding with regard to the organizational dimension of university-industry relation is that the collaboration can take a place at two different levels:

- At the institutional level: in which the collaboration is more institutional and formal. At this level, the engagement duration is longer which could be couple of years. At this level also, industry does not only engage on collaboration projects but also in the strategic orientation of the university regarding educational programs and specialization and the university's relation with the industry.

- At the project level: which has more flexible organizational aspects. It is still formalized and framed through contracts but the industry engagement is limited to the project. To initiate this kind of collaboration, it could be started through informal interaction.

Over two third of the industrialists that we interviewed have initiated their collaboration with the university through personal contacts. At the early stage development collaboration, NO intermediaries are involved. The industry relation unit (structure within the university that manages the industry relation) is a sufficient structure to support the collaboration especially with regard to administrative activities such as initiating and establishing the collaboration. In our findings, in these collaborations and at this stage of development no major difficulties with regard to the IP policy, which facilitates knowledge exchange between university and industry as the result is owned by industry. However, confidentiality raises some concerns by the professors as well as the industrialists. Further details on these findings is in section 6.2.

In the second part of the main results of this study, we developed an UIC framework based on three stages: “before the collaboration”, “during the collaboration” and “after the collaboration”. The characterization of the collaboration through the detailed analysis of the themes in the overall collaboration (1st part of the results) have helped us to construct and expand a framework of the collaboration encompassing different aspects of the collaboration at different stages. Further details on UIC framework is provided in section 6.3. Third part of the results, we developed a measurement system that evaluates the progress as well as the success of the collaboration. This measurement system is based on three sets of KPIs, each set corresponds to a stage of the collaboration (2nd part of the results). The sets are a combination of quantitative and qualitative KPIs. The KPIs were defined from the components of the UIC framework that was built based on the characterization of the UIC. The measurement system

and the KPIs sets were validated through two projects. Further details provided in sections 6.4 and 6.5.

Table 7 presents our findings and their connections at a glance (Saldaña, 2013).

Summary table provides a brief description of the theme, and then the possible sub-themes resulted from each theme. The table shows also, in how many interviews the subtheme brought up and how many times it was mentioned (reference).

Alignment of collaboration's objectives				Interviews	Reference
Description: The objectives and motivations of the potential partners to be engaged in a collaboration, what influence the choice of partners?	Objectives /Motivations	Industry	Finding good profiles for recruitment	11	13
			Access to workforce and resources	9	9
			Discovering new approaches	11	14
			Finding solutions for problems	11	13
			Networking	4	6
			Preparing students for the profession	9	12
	University	University	Identify research issues and industrial cases	5	5
			Networking	5	5
			Practical training for students	19	25
			Recruitment opportunity	6	6
			To have projects	7	7
	Partners selection criteria	Geographical distance		21	23
		Means to collaborate		7	8
		Concrete collaboration problem		12	15
		Partner quality , reputation		8	10
		No criteria		3	3
Relationships				Interviews	Reference
Description: How the collaboration is initiated? Who starts the initiation? What are the types of relationships	Finding projects	Initiated by the company	Contacting industry relations unit (at the university)	8	8
			Forum/events	6	7
			Online platform	4	4

between the university-industry?		Initiated by industry relations unit (at the university)	11	13
		Initiated by students	3	3
		Personal contact	11	12
	Relationships types	Partnership	10	12
		Personal	17	18
		Sponsorship	5	5
	Structure		Interviews	Reference
	Structure :	Administrative, clerk (university, industry)	13	15
	Describing the basic structure of people/units involved in the collaboration	Responsible of Relations unit (university)	6	6
		Engineer (industry)	4	4
		Pedagogical team (university)	6	6
		Professor (university)	21	23
		Student (university)	26	29
		Technical manager (industry)	12	16
Description: knowledge creation & transfer, The geographical distance importance in facilitating knowledge exchange.	Knowledge		Interviews	Reference
	Types of problem partners try to solve	Improvement of existing product, service	17	18
		Finding new solutions /new ideas	20	23
	Geographical distance	Important	20	22
		Not important	6	6
	Partners satisfaction of the collaboration	No	0	0
		Not always	5	5
		Yes	21	21
	Intellectual property policy		Interviews	Reference
Intellectual property policy: To facilitate knowledge transfer between university and industry, who is the owner of the results?	Owner of the results	Company	26	27
	Confidentiality	No, it is not an issue	17	17
		Yes, it is an issue	9	10
Description: Openness/culture of the organizations for collaboration, what influence the openness towards the collaboration and integration of external knowledge?	Organizational culture		Interviews	Reference
	Factors for openness	Acquiring new ideas	5	8
		Networking	9	9
		Search for results	11	11
		Trust in partners	7	8
	Communication and mobility with partners	Depends on the distance	4	4
		No	1	1
		Yes	21	21
	Resistance to integrate external knowledge	Little	5	5
		No	17	17
		Yes	4	4

Outcomes			Interviews	Reference
Outcomes: Different types of obtained results from the collaboration 5	Industry University	Documentation	Layout map	1
			Manual	5
			Minutes	1
			Synthesis	3
			Work Instruction	1
		Technical solution	Area optimization	3
			Simulation/Code	6
			Mock-up	4
			Prototype	12
			Setting, reconfiguration	1
			Database	1
		Finding ideas		11
		University	Bibliography study	8
			Defense presentation	21
			Evaluation sheet	9
			Report	20
Success factors			Interviews	Reference
Success factors: The main success factors of collaboration 6		Access to resources		5
		Organizational culture		8
		Clear objectives		13
		Commitment		13
		Communication quality		11
		Geographical proximity		12
		Interpersonal relationship		12
		Sharing common objectives		3
		Trust between partners		11

Table 7 - Results at a glance

This table shows our coding at a glance, where it summarizes parent codes and child codes. Our objective here, is not to quantify the qualitative data, the table presents only the main themes of our findings. This summary does not include descriptive themes such as “collaboration process” “intermediaries” etc. since these themes need to be described qualitatively. For example, “collaboration process” which describes in detail the collaboration activities, tasks and steps. All themes will be discussed in the next sections.

6.2 Characterization of early stage development University-Industry Collaboration

In this section, each theme will be briefly described. Then, we will systematically present and discuss the findings supported with evidence from the data on the respective theme. Comparing the views of the two groups of participants (university and industry) to highlight the similarities and differences in each theme. We will discuss and compare our findings to other researches based on the literature review conducted in chapter 3 and discuss what our findings contradict or agree with in the literature. Some quotations will be included when necessary as evidence and to support our interpretations and explanations (Corden & Sainsbury, 2006; Kline, 2008; Wingrave, 2018). We will use pseudonyms for the participants to preserve anonymity (Kaiser, 2009; Saunders et al., 2015). (UPx for University Professor, UASx University Administrative Staff and Ix for Industrialist). This section will conclude with summary and main takeaways.

6.2.1 Alignment of collaboration's objectives

This theme discusses the objectives of the potential partners to be engaged in a collaboration. The theme also highlights the differences and similarities between university and industry in terms of objectives in their collaboration. Furthermore, the importance of the alignment of the objectives to minimize the difference. This theme also discusses the selection criteria to choose the potential partners.

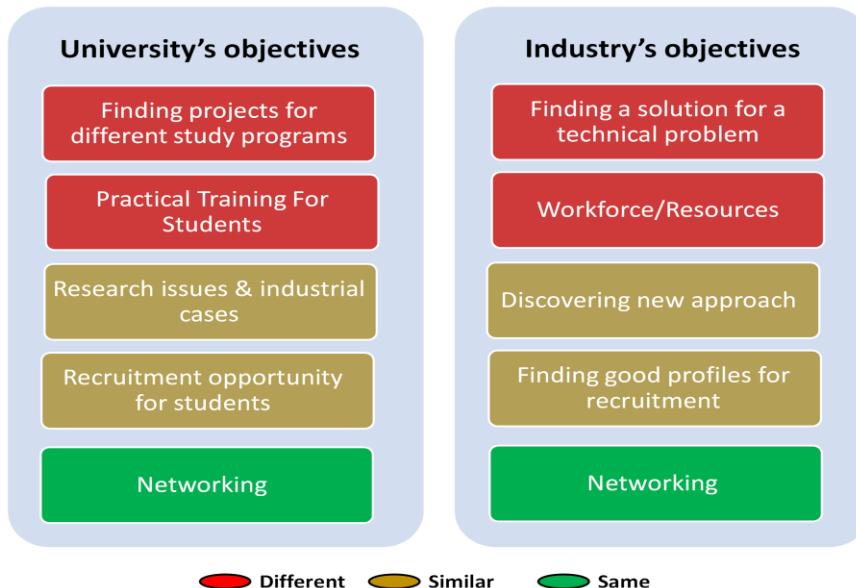


Figure 25 - Collaboration' objectives

Objectives

The collaborators from the two organizations (industry/university) try to achieve the objectives of their organizations. Figure 25, shows that the collaboration's objectives are divided into two groups: industry's objectives and university's objectives. For the university, the objectives are centered around the “**students**”. Students' training is one major collaboration's objective for the university. Students work collectively (in groups) and individually in these collaboration projects to gain their first industrial experience. They apply what they learn in the classroom in practical situations. In these collaborations, they learn how to work in teams by building a team, dividing tasks among them, respecting deadlines and using project management techniques & methods. Another aspect where students learn during these collaborations is to deal with clients. In the presence of their professors, students attend meetings, discussions with industrialists (clients). These meetings are conducted to discuss the progress status, adjusting the specifications or requirements etc. As part of the preparation for the future professional activities, at the university also, they believe that these projects bring a

good recruitment opportunity for students. Students will have the chance to prove themselves through various operational activities. Depending on where the students are in their curriculum, they will establish a contact with the industry to explore recruitment opportunities when they graduate.

UP7

“At the university, our motivation is educational. The goal is to have students go from an academic attitude to a professional attitude.”

UP2

“What is important is that our students know what they are being prepared for and that they learn about behavioral patterns, corporate cultures and know-how”

As quotes above indicate, the university mainly value the collaboration with the industry is to train students who are directly involved in the operational activities. Student involvement in collaboration allows them to have a first experience with the industry by working on a concrete problem, with the real pace of companies.

For the industry, the objectives are centered around the “**Problem**” of the project. Industry brings a problem for the collaboration to work on (or agree on a suggested problem by the university). The industry main objective is to find a solution for this problem or progress in developing its solution. Based on the duration of the project, this objective for industry is realized through different levels, which could be the analysis of what solutions already exist and what are other possible solutions. Then comes design, development, testing, demonstration and technical documentation (Different types of outcomes will be discussed later in a specific theme “**collaboration’s outcomes**” theme). Also, with regard to the project problem, collaboration is a good occasion for industry to discover a new way of approaching problems, new ideas, new methods from the university and scientific techniques.

19

“The motivation for the company is to solve a problem”

10

“In these collaborations, the company's goal is to get help on a topic that's important to us”

The quotations above indicate that, the industry seeks finding a solution for the collaboration problematic with the help of scientific expertise.

Looking at the two lists of objectives, university and industry have some common objectives. One of the common objectives is “**networking**”. Both organizations, find the collaboration as an opportunity to expand their professional network on the institutional and personal level. For university, they add the companies on their dissemination list/database for collaboration in the following years. Same for companies, where they have reference of the programs and specializations in the university that interest the companies as well as the timeline/calendar of the university (when to send topics to university, start and end of the projects etc. “**Recruitment opportunity**” is an important common objective between university and industry. Although, they both share this objective for the collaboration, there is a slight difference on their perceptions. University, view the collaboration as a recruitment opportunity for the students in general, companies try to find “**good profiles**” for future recruitment.

One important objective for the industry is to have “**workforce and resources**” to find a solution for the problematic of the collaboration. These resources could be the project team. Group of enthusiastic students guided by the supervision of their professors who are experts in their fields. Also, with the possibility (sometimes), to use the university premises.

“**Identifying research issues and industrial cases**” is an objective desired by the professor. These collaborations, give professors the opportunity to explore and identify

unexploited issues for research or simply new issues and cases to update their teaching materials.

Objectives alignment is very important aspect at this stage. The alignment is achieved by proper positioning and adjustment of the differences in the objectives. Setting reasonable and achievable objectives that fall within students' field, capability to work on and time dedicated. Objectives should not be too ambitious and difficult to reach for the students.

Partners' selection criteria

Figure 26 below, shows the selection criteria which the stakeholders consider before choosing a potential partner. Both industry (82% of industry participants) and university (80% of university participants) give an equal importance to the geographical proximity. They believe that the proximity facilitates the collaboration for everyone in the project.

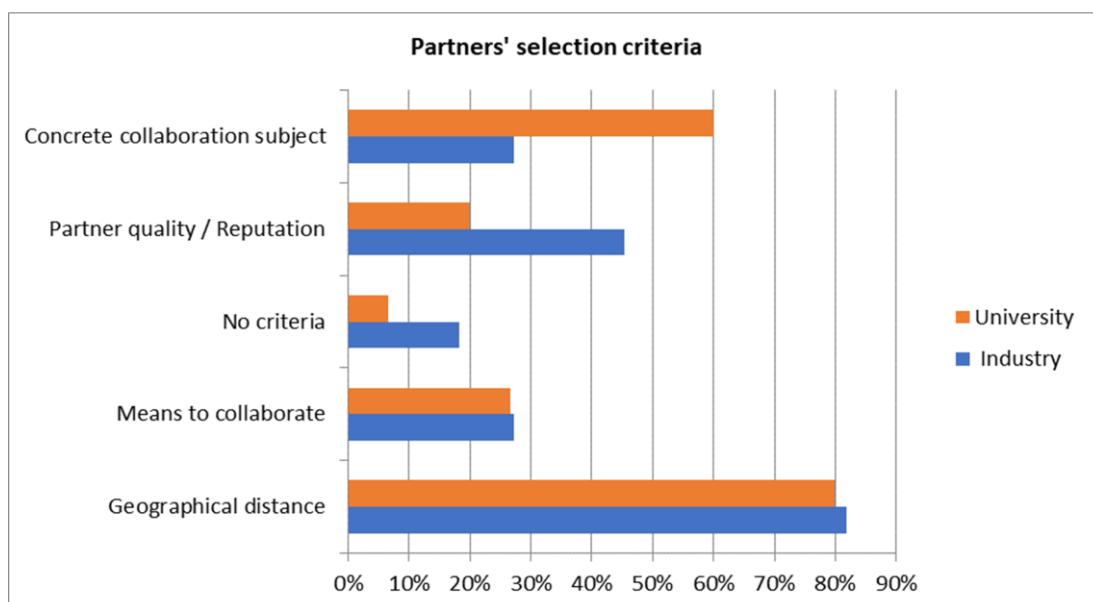


Figure 26 - Potential partners' selection criteria

Students would have flexible mobility between the university and on-site visits. When the collaboration is in the same city, students will not have financial burden in terms of accommodation. Industrialists are more open and willing to participate in students' evaluation and attend students' defense if the distance between the university and the company is

reasonably short. The covid-19 has pushed for more flexibility with regard to working remotely. However, an essential element here is that, it is very crucial for students to have some hands-on experience through on-site visits during the collaboration's operational activities. It is important to mention that the distance aspect depends on the types of collaboration and the mechanisms used.

Over 45% of the industry participants consider the prestigious universities/engineering schools are always potential partners. Compared to the industry, university participants find this criterion is less important. It is good to collaborate with prestigious and well-established industry partner, however being big company, SME or startup is not a barrier for the collaboration as long as the collaboration project is relevant and beneficial for students. The means to collaborate is a criterion that is equally important for both industry and university. For the industry, these means or resources include the workforce (students, tutors) to carry out the project's activities. Also accessing the university's facilities (labs, platforms, workshops). For university, the relevance of the project to the students' educational program. The thematic of the projects must be precise and fall within the main field of the students' specialty program (i.e. industrial engineering, mechanical, electrical, IT, environmental etc.).

“Concrete collaboration problem” is the second important criteria for university to choose their partners. For university, a specific problematic which corresponds to company' need is essential element for a collaboration. This will help in defining clear objectives and ensure the industry engagement in the collaboration.

12

“Geographical distance is important for students, but also for us as industrialists to be willing to attend students' defense and participate in their evaluation”

UP8

“The project thematic must be precise and fall within the main field of students' program”

Implications

In university-industry early stage development collaboration, the university and industry have multiple objectives. They share some of these objectives and differ in other objectives. One of the key findings, the difference in terms of objectives is that, the industry is focused on objectives related to the problematic of the collaboration (finding a solution, access to workforce and resources etc.). While the university is focused more on the objectives that related to students (training for student, professional experience). Objectives alignment plays an importance role for the establishment of the collaboration. The alignment is achieved by proper adjustment of the differences in objectives. In addition, considering students capacity, specialty and time constrain. Furthermore, we elaborated the criteria to choose a potential partner and it is very important to choose partners carefully early on to minimize difficulties in aligning the objectives.

6.2.2 Relationship before initiating the collaboration

Relationships is the broader theme that includes two important sub-themes: **Relationship types** and **Finding projects**. We will discuss the different the types of relationships between the university-industry to initiate a collaboration. There are three types of relationships: partnership, sponsorship and personal. Then, the mechanisms of the collaboration initiation to finding projects describing how the collaboration is initiated? Who starts the initiation?

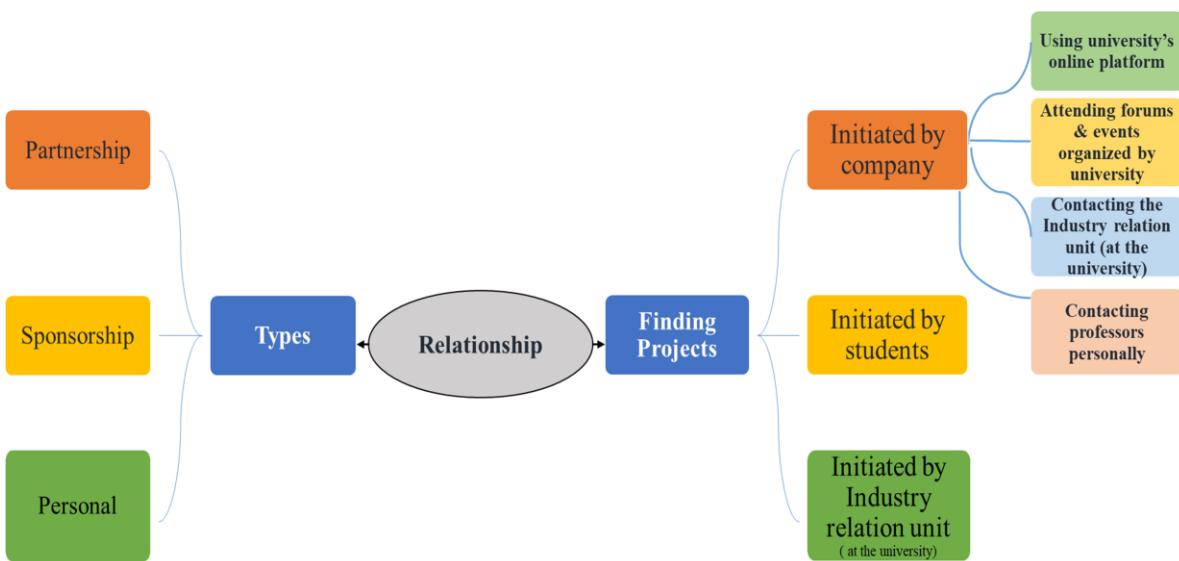


Figure 27 - Relationships in UIC

Relationships Types

The participants (interviewees) have pointed out two categories of relationships. Formal relations: where the collaboration could be initiated based on well-established relationship between organization. This type of formal relationship could be a partnership or sponsorship. Less formal relations: There are personal relations where the collaboration could be initiated in informal settings based on personal contacts but towards the collaboration, it is formalized through contracts. In the previous chapter (chapter 5) in describing different engineering schools of Grenoble INP, we presented in each school a dedicated structure to activate and manage its relation with industry, ecosystem actors and other entities. The objective of this structure is to make the industry present in the school's programs and activities. The structure has different names “Cellule Relations entreprises”, “Les Relations Industrielles” etc. For the sake of simplicity, we will call this structure “Industry Relation Unit” wherever it is relevant.

Partnership

The university tries to build active relationship with the industry through a partnership. In this partnership, partners will participate in university's industrial & educational activities. This includes developing collaboration projects, future engineer (students) recruitments as well as the strategic orientation of the university with regard to educational programs and specialization. As explained in the previous chapter, there are different mechanisms to organize the activities of the partners for example in Grenoble INP Génie Industriel, there is "Club des Industriels" and "cercle des industriels".

"Club des Industriels" which is a group of enterprises from Grenoble basin. This club of enterprises is composed of 10-15 members. The objective of the club is to discuss the strategic orientations of the school in term of educational and training programs. They also provide internship offers and often sponsorships. There is also the "cercle des industriels", these are companies who are primarily invited in the context of events at the school, for example, the forum of internships for students, there are events called "Wednesdays GI" or "job dating". In these events enterprises presents their activities and themes that interest them. These kinds of events are more oriented towards finding internships than collaboration projects, however this sometimes also allows the company to consider a further collaboration that ends up in a collaboration contract. The relationship is well established and the engagement is renewed every couple of years (2-3 years).

Sponsorship:

Companies can sponsor class/intake. The class/intake is named after the sponsor. The company follows this class over three years (the usual duration of an engineering program in engineering school). Sponsor will meet with the class once or twice a year for industrial events. This event varies between internships and recruitment opportunities as well as innovation challenges.

Personal:

Personal contact is another way to initiate the collaboration. Some industrialists have personal relations with professors inside the university (or vice versa). This personal relation could be established through previous collaboration, or the industrialist used to be a former student of the professors (Alumni) etc. They could start contacting each other for a potential collaboration. This also, includes the initiation of the contact between university researchers and the industrialists. Initiating the contact at this stage will mostly be based on informal interaction and personal contact since it has less formalities and more flexible organizational aspects.

Finding projects

The mission to find collaboration project is one of the early activities to initiate a collaboration. Depending on the type of collaboration, the search for a project begins 3-6 months before the expected start of the collaboration project. The start and ends are usually set by the university in accordance with the academic year.

The Industry Relation Unit, students, professors or the company, could initiate the collaboration. Over the years, the Industry Relation Unit has database of contacts in the industry. They use this database or contacts to initiate a collaboration. In addition, this structure invites companies for events & activities in the university. In these events companies have the opportunities to explore the university' facilities, programs and exchange with professors for the possibilities of collaborations.

Students also can initiate the idea of collaboration. Students contact companies when they conduct a study for a specific technology or product. If the company is open for the collaboration, they suggest concrete problematic, which then has to be validated by the pedagogical team.

It is important to recall here that our participants from the industry are coming from small to small-medium size companies. When companies initiate the collaboration, they can do it in different ways. One way to initiate the collaboration is using university's offers platforms. Depending on what companies are searching for, they post their detailed offers on the platform. These platforms are common for all companies; students will check and apply to the offers. Generally, the offers on these platforms are linked with internships. Another, way to initiate the collaboration by companies is attending university's industrial events. Companies come to present their profession, their internship possibilities and hiring. In these events, industrialists meet university's staff (management or professors) and they discuss the possibility of collaboration or even establishing a partnership relationship. As explained above in the personal relations between university and industry, informal interaction between both university staff (mostly professors) and industrialists is another way to initiate a collaboration. This is two-ways communication, so the industrialists might contact the professors or the professors contact the industrialist for the possibility of initiating a collaboration.

Implications

A Key finding with regard to the organizational dimension of university-industry relation is that the collaboration can take a place at two different levels:

- At the institutional level: in which the collaboration is more institutional and formal. At this level, the engagement duration is longer which could be couple of years. At this level also, industry does not only engage on collaboration projects but also in the strategic orientation of the university regarding educational programs and specialization and the university's relation with the industry.

- At the project level: which has more flexible organizational aspects. It is still formalized and framed through contracts but the industry engagement is limited to the project. To initiate this kind of collaboration, it could be started through informal interaction.

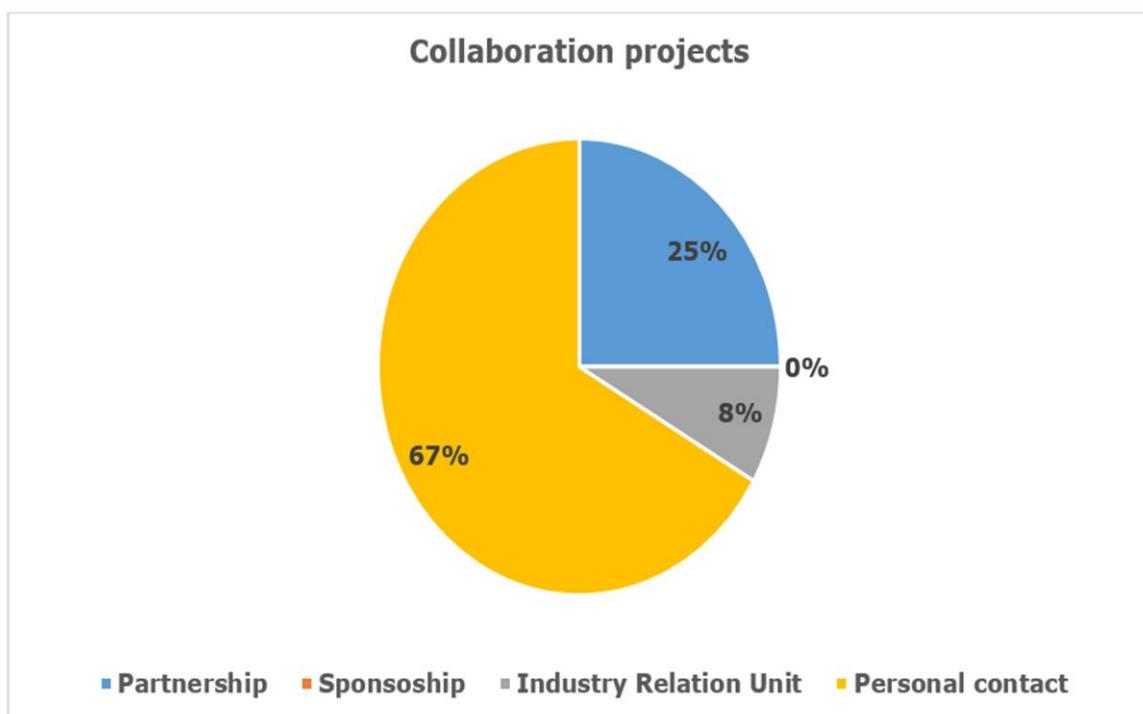


Figure 28 - Collaboration projects based on relationship types

The figure 28, highlights through which relationship type the industrialists established a collaboration project. Over two third of the industrialists that we interviewed have initiated their collaboration with the university through personal contacts. This is not only true for the industry, but also for the university. Professors find the personal interaction to initiate a collaboration more efficient.

UAS1

“For collaboration projects, we do not really contact companies formally, we depend on our personal relationship and personal contacts since it is faster”

UP1

"I think it's more effective to know the companies beforehand, through previous collaborations. If a former student works for one of these companies, it is also easier."

Another possible reason for this preference is the time constraint. For example, if the deadline to start a collaboration project is rapidly approaching and professors have not yet enough projects for all students. The professors might be in urgency to find collaboration projects for their students especially deadlines in the academic calendar are tight and announced beginning of the academic year. Therefore, they depend on their personal contacts. For industry, obviously not all companies are in partnership engagement with the university, hence, there is a big number of companies try to use the personal contact to initiate a collaboration.

The partnership relation is amount to 25% of the collaboration projects. This is still very important figure to secure collaboration projects. However, it is worth mentioning that there are other objectives of these institutional relations at the strategic level. This includes the continuous improvement of the educational programs to correspond for the industry needs as well as building the university's strategy for its relation with the industry. The presence of the industry relation unit at the university is crucial to attract partners from the industry. This is done through a continuous communication and interaction as well as organizing the industrial events and inviting companies.

6.2.3 Structure of the collaboration

In this theme, we will be describing the basic structure of people/units involved in the collaboration. As figure 29 shows, university engages more personnel than the industry to establish and conduct the collaboration. Furthermore, there are two categories of activities: The administrative activities and operational activities.

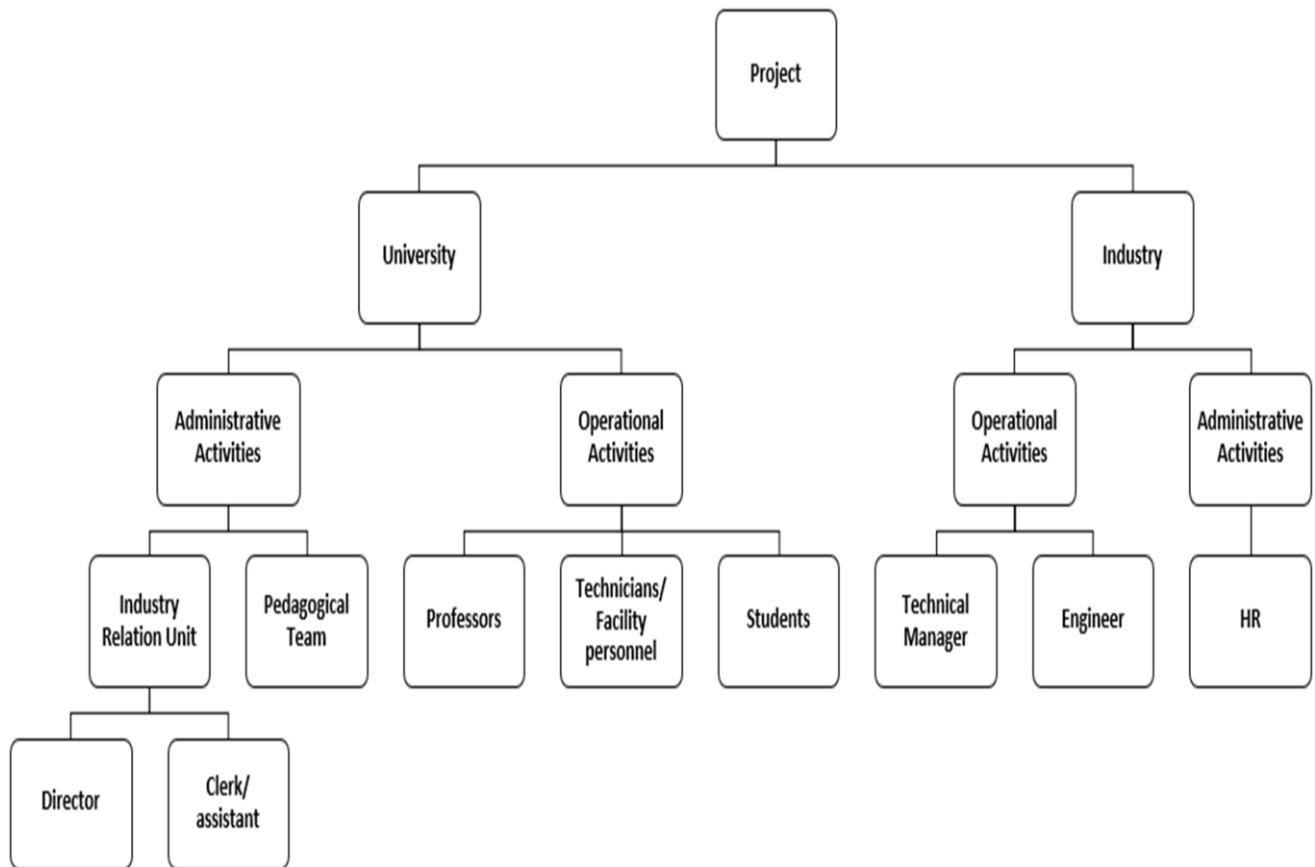


Figure 29 - Collaboration Structure

University

The director of the industry relation unit with the assistant handle all formal contacts with companies. Build database for the future contact and use this database to disseminate the information of the possibility of collaboration. The unit also help in organizing the industrial events and inviting companies for university's activities. The unit also prepares the charters and

contracts for partnership, sponsorship and collaborations. The industry relation unit works closely with the pedagogical team. The pedagogical team is composed of professors who validate the projects proposed by the industry. They make sure that the project topics are relevant to students' field and well defined. In addition, they verify if the suggested topics suits the students' level. They propose some adjustments to the topic if needed and discuss it with the industry.

Professors guide students throughout the project duration. They help students in performing the operational activities of the projects. In addition, they facilitate students' meetings with the industrialists so that students can communicate their progress and clarify their doubts for the blocking points. Together with the industrial tutors, professor evaluate students' performance in completing the projects. It is worth mentioning that, professors are not only involved in the operational activities but also the administrative activities (of the collaboration). In many cases professor initiate the collaborations with the industry especially through personal contact. At the university facilities, some university's personnel (e.g. technicians) are involved in the projects. They help students to use the equipment's and the tools available in the facilities. The students are one major element of the collaboration. They perform the operational activities. Furthermore, they communicate with their professors in performing the related tasks. They communicate with the industrialists (through their professors) for specifications, requirements and the progress.

Industry

At the industry, the number of involved people is less than those are involved at the university side for the collaboration. The technical manager is usually linked to the establishment of the relation with university especially for partnership or sponsorship relation. Depending of the company size and structure, establishing the relation with the university could be through the CEO instead of the technical manager. The industrial tutor for students could be

an engineer at the company. The engineer follows the operational activities of the projects and guide students. The company's engineer communicates with professors with regard to the project progress and they decide together in making the necessary adjustments if needed. In addition, the industrial tutor participates in evaluating students and attend their defense when possible. It is necessary to indicate that the engineer could initiate the collaboration when it is through personal contact. The Human Resource (HR) personnel at the industry is rarely engaged in the collaboration projects. Even if the HR personnel is taking part in the collaboration project they have very limited involvement related to administrative tasks for students at the company.

Implications

From the presented structure above in figure 29, at the university, there are more people and logistic involved. At the university, they need to manage and organize these activities for the whole intake students (multiple projects teams). Unlike the industry where they need to organize these activities just for their project (single project team, sometimes industrial partner collaborates on more than one project at the same time). Secondly, the operational activities are conducted at the university premises. This needs more logistic supports to ensure the completion of the project's tasks while respecting the time plan and deadlines.

There is no need for a major change at the industry side to accommodate the collaboration since these activities are related to the early stage development and knowledge management is at smaller scale. At later stage, commercialization phase, a change might be considered since other activities will be required such as managing and integrating Knowledge (at higher scale) as well as commercialization activities.

6.2.4 Collaboration's Process

This theme describes the steps and key activities of initiating and conducting the collaboration. In this theme, we will coverer the administrative and operational activities. The figure 30 shows the flow of these activities.

The collaboration process starts by initiating the contact, followed by establishing the collaboration conditions then only the operational activities can start. The first key activity or step is initiating the idea for the possibility of collaboration project. This step can be initiated by the university or the company depending on the type of relationship as well as the way of finding projects as explained in (6.2.2). At this step, the topic or the problem of the collaboration might not be well defined. Companies can propose to university the idea of the collaboration in terms of a “need” or a “skill” they believe it can be found at school or with the students under the supervision of their professors. University (administrative staff or professors) can propose the collaboration to company by presenting the educational programs and specialties as well as collaboration project timeline.

The second step presenting the topic and objectives of the collaboration. This meeting (or communicating by email) is dedicated to present concretely the topic of the collaboration. The objectives also are essential elements to discuss during this meeting. This meeting is conducted usually between professors from the university and engineer or project leader at the company. The company provides detail about their need, problematic, objectives as well as confidentiality restrictions (if any). In this meeting professors will present in details the program and specialty of the students who will conduct the project, the level of the student (which year) time plan of the project, the deadlines, possible and available facilities.

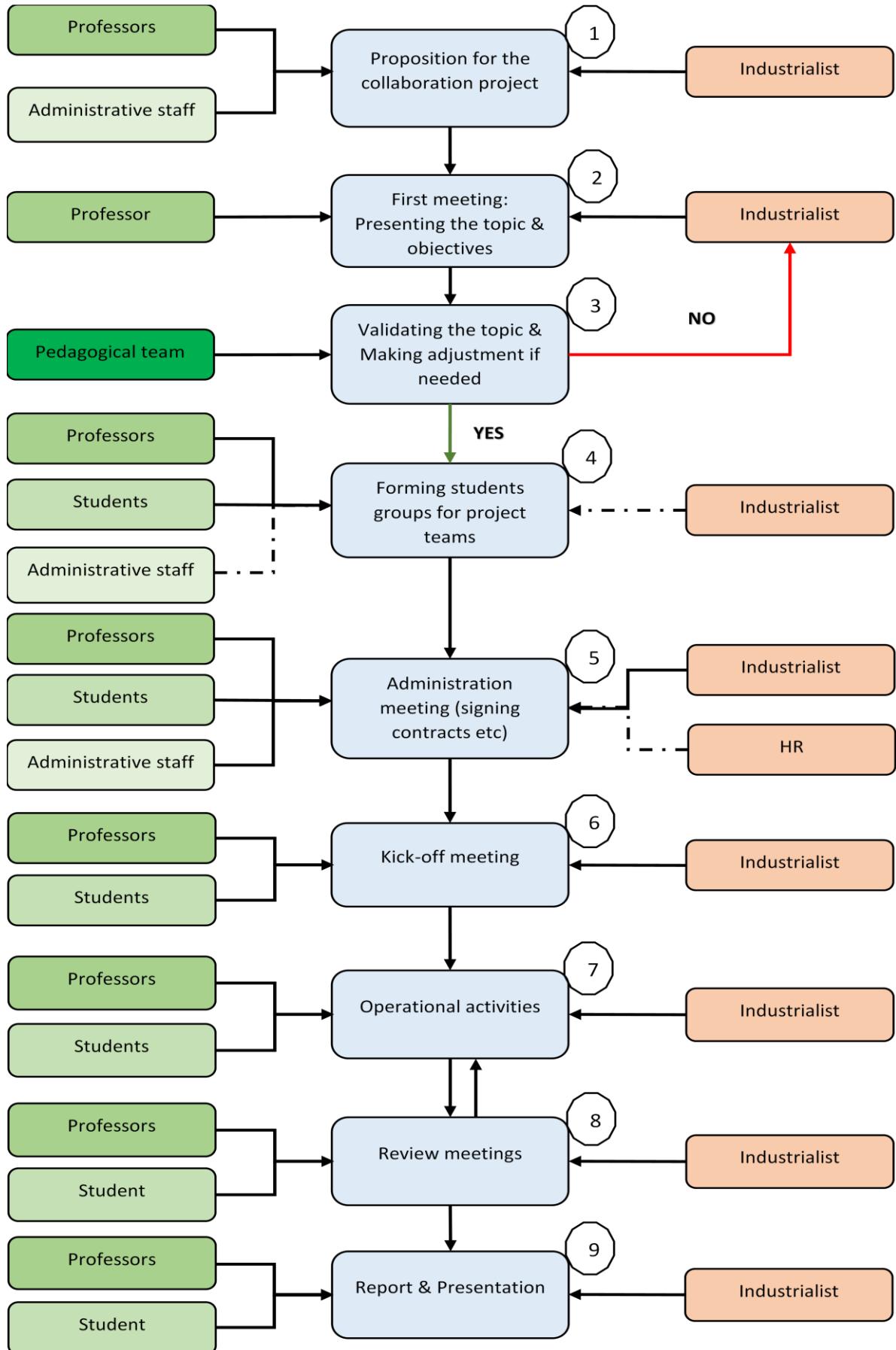


Figure 30 - Collaboration Process

Third step is validating the topic by the pedagogical team. As explained in (6.2.3), the pedagogical team validates the projects proposed by the industry. They validate the topics by analyzing if the problematics are well defined, relevant to students' field. The pedagogical team also verify if the objectives of the project are attainable or too ambitious for the students' capacity. The answer of this validation process could be YES or NO. When it is YES, the project can proceed to the next step, if the answer is NO, then the industry will try to accommodate the suggested modifications by the pedagogical team and come back with refined proposition.

Fourth step, once the problem of project is finalized, the projects are presented to the students. The professors start forming the projects teams. Generally, each project team will be composed of 3-5 students depending on the difficulty of the projects but also the number of students in the class and the number of available projects for the class. There are different ways to choose the students such as sending a survey to students to choose top 3 or 5 projects that interest them, then based on their answers, professors make the group. Another way is letting students discuss among themselves to form their groups with maximum and minimum students per group and choose the project based on a first-come, first-served basis. In addition, professors will identify researchers or professors' colleagues who can supervise the students and help them meet the demand of the industrialists. The professors might get some help in assigning students for the projects by a clerk or an administrative assistant from the **industry relation unit** at the university when the number of students is big. It is also possible that someone from the industry participate in forming the project groups but it is not mandatory (As shown in figure 30, step 4, dotted line).

Once the team is formed, the fifth step takes place which signing the contract. This involves professors as academic tutors, industrialist as industrial tutors and students who will be involved in conducting the operational activities of the project. If necessary, a confidentiality clause will be signed also during this step (confidentiality is discussed during the 2nd step). An

HR person from the industry could involve in this step as shown in figure 30, step 5, dotted line. This step marks the end of all necessary procedure to establish the collaboration before the start of the operational activities.

The sixth step is the launch of the project, where the project is presented in details. Specifying the problematic, the objectives, the specifications and the expected results. The tasks will be identified, the time plan will be discussed and the deadlines will be agreed. Students will be asked to assign a project leader to be the contact point. In addition, they will distribute the tasks between themselves. They will be asked to prepare full details on the plan, tasks, due dates and Gantt chart etc.

The seventh step is the core of the project, which is conducting the usual tasks, and activities of the project. Depending on the nature and duration of the project, this step goes through different phases. Some of these phases could be reviewing the state of the art, specifications, design, development, integration, testing and validation. As indicated in figure 30, this step is repetitive until all the project phases are completed. During this step, industrial tutor will help the students to understand the problem, the objectives and eliciting the requirements. The teaching team will guide students throughout the project, frame the team's activities, assist and check the project management process (tasks, milestones, decision-making, etc.). Furthermore, the teaching team will assist the students for the communication with the client (industrial partner) as well as with the school platform or laboratory. Throughout the project a dedicated technical and logistical resources are at the disposal of the project team. Generally, the activities are conducted at the school platforms or one of the associated laboratories. There will be some site-visits at the company premises when needed.

The eighth step is the review meetings. The number of review meetings depends on how frequent the industrialists communicate and exchange with the students and their professor. If

the communication is regular, (e.g. weekly or biweekly) hence the project team works closely with the industrialist then there will be only one mid-term project review meeting. If the communication is less frequent, then there might be up to three review meetings (Review 1, Review 2 and Review 3). The objective of these meeting is to discuss the progress and analyze the challenges or the difficulties to reach the objectives. The blocking points are discussed during these meeting and making the necessary adjustment. Decision-making process plays an important role in this step, if the decision to make adjustment is centralized or could be taken by people involved in the operational activities. As indicated in the figure 30, from this step there is a return loop to previous step to continue the operational activities.

After terminating all operational activities and all review meetings, the ninth and final step which is final meeting of the project. This meeting is for students to present the project results as a presentation “defense” as well as a report. One day is dedicated for all students to present the results of all projects, which takes place at the university. The industrial tutor, academic tutors and other invitees will be the member of the jury who will take part in the finale evaluation of student’s performance in the project.

Implications

The process of collaboration involves multiple actors and passes through multiple steps. In our findings, defining the problematic for the collaboration is quite lengthy process. This is a very crucial and important step for the collaboration. A concrete problem that represents a need from the industry should be well defined. Defining clear and reasonable objectives which fit and fall in the field and capacity of the students. Another important success factor is the involvement of the industrialist during the project. Sometimes this might take several meetings where the pedagogical team validate the topic and make sure that it corresponds to the education program and within the capacity of the students. This is a challenge for collaboration specially when communication is formal and institutional in which it would take longer time. This

explains why the personal contacts and relationships are preferable since the communication and feedback will be faster in order to conform the validation of the problem and avoid length process.

6.2.5 Intermediaries

This theme intends to describe the intermediaries that support the collaboration between university-industry. Their role in accelerating the collaboration. All participants in the interview have indicated that there is no intermediary in their collaborations. The contact is direct between the university and the companies. For them, it is time consuming for establishing the collaboration when there are more structures involved as the professors insists on verifying the relevance of the collaboration topics to students' fields. Furthermore, setting the limits of the expected results is important for professors based on the capacity and level of their students (which year) since the industry mostly comes with ambitious projects. Therefore, the exchanges between the professors and industrialists to address these aspects will be complicated. Again, as discussed in (6.2.2), they emphasized on their preference to initiate the collaboration through personal contacts since administrative structure acts as a barrier between industrialist and professors and their students (those who are involved in the operational activities).

Although, the contact is direct between the university and the industry (through the industry relations unit), there are some exceptional cases where the collaboration could be established through an intermediary such as:

- Incubator: Putting different start-ups in contact with university or with professors and researchers who can bring their expertise to collaborate in projects with these startups.
- Industrial chair “chaire industrielle”: The university creates chairs with consortium of industrial players (companies, union or network), these chairs facilitate the

communication between its members and the university for collaboration projects based on a specified thematic.

Implications

The industry relation unit, which is reasonably small structure within the university, supports the collaboration by promoting the school programs, specialties and industrial events in the regional and national ecosystems. This will help to diversify and increase the number of the industrial collaborators with the school. At the early stage of development collaboration. The industry relation unit is a sufficient structure to support the collaboration especially with regard to administrative activities such as initiating and establishing the collaboration. Apart from the two exceptions mentioned earlier, involving intermediaries at this stage is not ideal which might add a burden especially in procedures and communication. At later stage of the development, it is feasible that an intermediary structure could play a role in the collaboration. This includes commercialization activities, IP management, communication and conflicts management.

6.2.6 Knowledge Creation and Transfer

This theme is about the knowledge generated during the collaboration. In this theme we will not discuss the outcomes of the collaboration (outcomes will be presented in a separate theme where we discuss them in details) but rather we will discuss a high-level conceptual understanding of the knowledge creation and transfer.

We attended collaborations sessions, meetings and operational activities with professors, students and industrialists. We observed and analyzed how these activities were carried out. Attending these sessions and activities gave us in-depth and rich understanding of the collaboration's situations and the different settings.

In attempting to show how these collaboration sessions and settings generate and transfer knowledge between those who are involved in the activities, we used SECI model (socialization, externalization, combination, and internalization) of knowledge creation by (Nonaka & Takeuchi, 1995; Nonaka & Toyama, 2003). This is to provide a global picture of knowledge-related activities. Nonaka's and Takeuchi's SECI model is widely known and used to explain the dynamic process of knowledge creation and utilization. The model received some criticisms for its applicability including cultural issues, organizations adaptation and empirical shortcomings (Glisby & Holden, 2003; Weir & Hutchings, 2005; Gourlay, 2006; Andreeva & Ikhilchik, 2011). However, our purpose here is to conceptualize knowledge creation and transfer process by looking at key examples of knowledge-related activities with the help of SECI model for knowledge creation. Knowledge transfer definition as adopted by (de Wit-de Vries et al., 2019) in knowledge transfer review "the process by which knowledge concerning the making or doing of useful things contained within one organized setting is brought into use within another organizational context". These settings or ways of doing things take place during the operational activities. (Nonaka & Toyama, 2003) define the conversion modes generated by the switching process from one type of knowledge to another (tacit & explicit) as follow:

Socialization: Knowledge creation starts with Socialization, which is the process of converting new tacit knowledge through shared experiences in day-to-day social interaction. (e.g., working side-by-side or observing colleagues)

Some examples of what we observed:

- Brainstorming ideas: exchanging ideas between the industrialists, pedagogical team and students.
- Interactions between the team members
- Guidance of the supervisors: pedagogical team and industrial tutors guide students throughout the project by providing advices and answering questions.

- Interaction between the client and the project team.

Externalization: is the process of articulating tacit knowledge into explicit concepts.

Tacit knowledge is made explicit so that it can be shared by others to become the basis of new knowledge such as concepts, images, and written documents.

Some examples of what we observed:

- Team members discuss with the supervisors how to use methods and theories learned in the classroom in developing the solution
- Team members develop roadmap, rules, timeline to be implemented
- Team members formalize hypotheses, questionnaire etc.

Combination: Explicit knowledge is collected from inside or outside the organization and then combined, edited, or processed to form more complex and systematic explicit knowledge through the Combination process.

We observed:

- Team members combine documents, videos, images, (bibliographic study, reports etc.)
- Team members analyze models, questionnaire, data etc.
- Team members analyze the feasibility of specifications

Internalization: Explicit knowledge created and shared throughout an organization is then converted into tacit knowledge by individuals.

Some examples of what we observed:

- Team members discuss with the supervisors discuss simulations and experimentations
- Presentation and visualization.

Illustrated below Figure 31, is high-level interplay between tacit and explicit knowledge in the collaboration projects we observed.

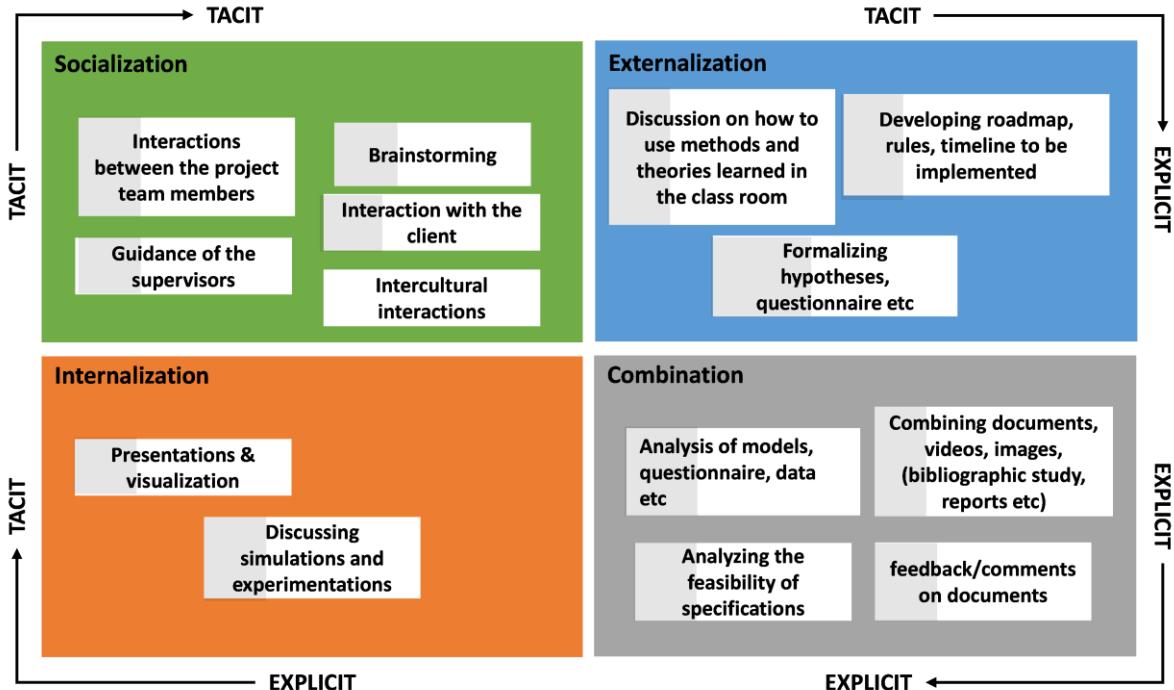


Figure 31 - Knowledge creation & transfer adapted from (Nonaka & Takeuchi, 1995; Nonaka & Toyama, 2003)

In order to characterize knowledge in the early stage development collaboration, we used SECI model to help us visualize knowledge creation and transfer. We will not go in details in the knowledge management aspect as it is not an issue to be addressed in this study, however other related topic such as outcomes, IP policy (sharing) and openness culture will be discussed in subsections 6.2.7, 6.2.9 and 6.2.11 respectively.

Implications

Figure 31 shows different situations to highlight some key examples of knowledge-related activities to conceptualize knowledge creation and transfer process used within different organized settings in the collaboration context. These settings represent practices/ways that facilitate knowledge creation and sharing/exchange. It is important to highlight here that, geographical advantage is an important element in facilitating knowledge exchange. Moreover,

it motivates all actors for collaboration. This will facilitate the mobility of industrialists, students and professors to perform the operational activities, but also the industrialists will be willing to attend students' defense and participate in their evaluation.

6.2.7 Collaboration's Outcomes

Different outcomes obtained from the collaboration. There are the different outcomes for the industry and the university.

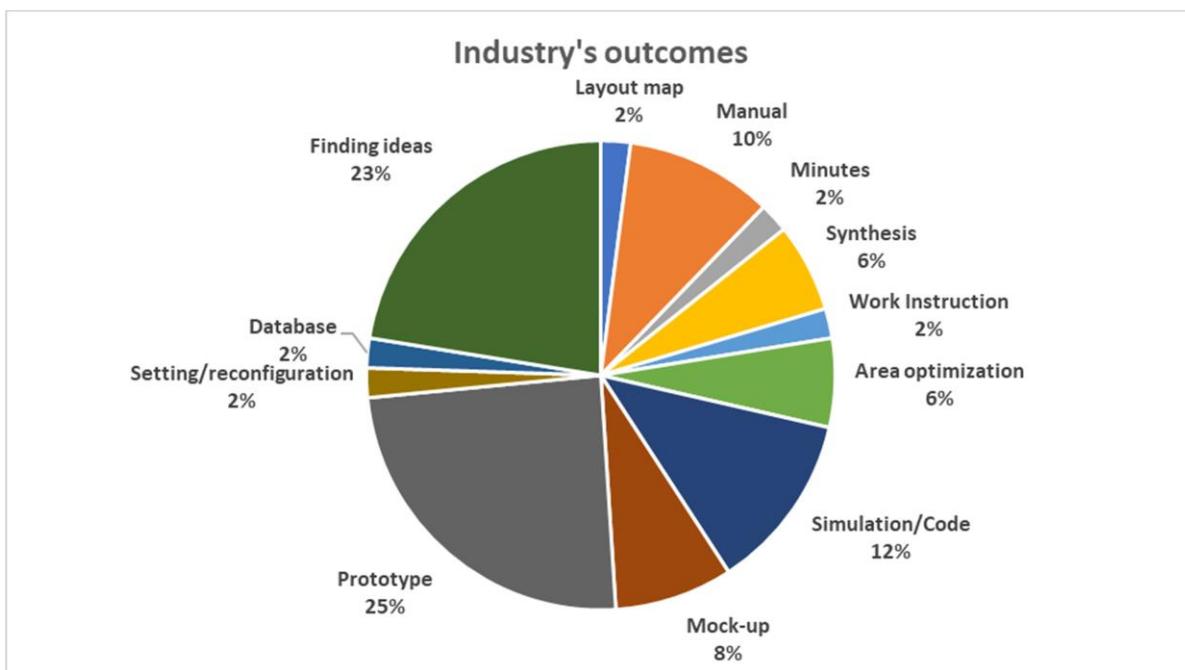


Figure 32 – Collaboration Industry Outcomes

As figure 32 shows, there are several industry's outcomes. These outcomes are property of the industrial partner. These outcomes could be divided into three groups: Technical solutions, Documentations and Finding ideas. To obtain these outcomes, the project team conduct different tasks starting by analyzing the client's needs, defining the specifications, eliciting and formalizing the requirements then elaborating and selecting the most appropriate solution by demonstrating a realized functional demonstrator. The fact that we conducted our study on four engineering schools, the technical solutions represents 55 % of the outcomes. The

technical outcomes include prototype, mock-up, simulation/code, reconfiguration, database and area optimization. These technical outcomes are related to different domains and specializations such as 3D Printing, Virtual reality, Mechanical parts, Embedded systems, Information Technology & Security, Automation, Electrical Engineering, Thermal and Hydraulic Engineering, Robotics, Water Conservation, Energy Efficiency, Production line and supply chain. Area optimization is related to a workshop where there is a need for incorporation of a new machine or new production line, improve production flows, set up a new process etc. The documentation outcomes represent 22%. Apart from the report required by the university, students might produce other documentations for the industry such as Manuals, Work instruction, Layout map, meetings' minutes and synthesis. The purpose of these documentations is to familiarize the user with the product/service, guide the user through a series of steps that lead to the completion of a task, give safety instructions, assembling of the various elements of a workshop into a single map (layout) as well as reporting and referencing discussions (minutes). For finding ideas is another important type of outcomes, which represents 23% of the total outcomes of the collaboration. These ideas have varied notions such

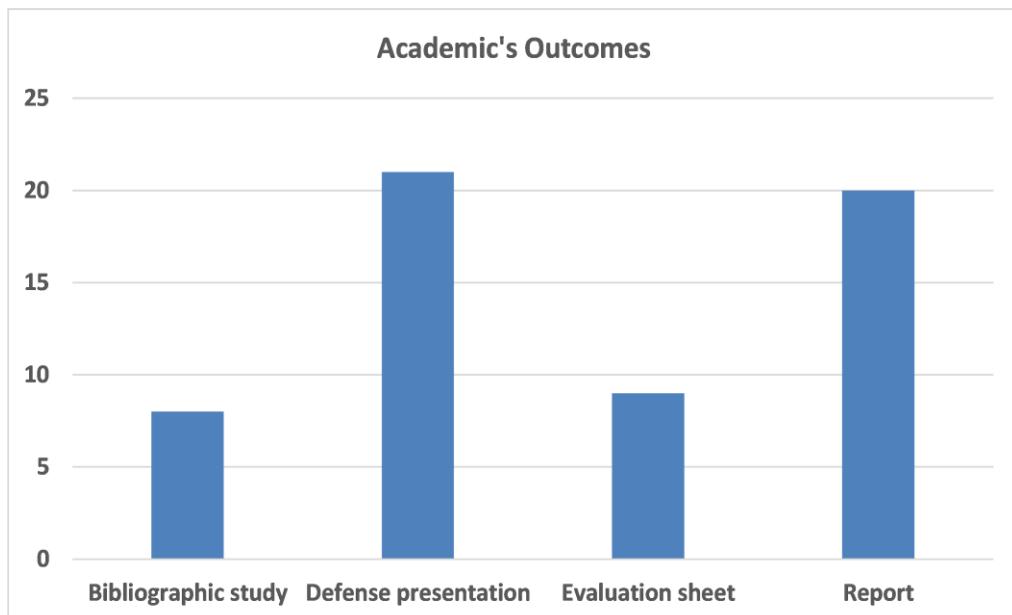


Figure 33 - Collaboration Academic Outcomes

as novel solution concepts, architectures to structure a solution, designs to create a feature,

mathematical model, solution framework etc. What these have in common is that, they might not have the exact technical specifications but will eventually contribute to the final product.

They still need to produce academic-related outcomes that are shown in figure 33. Students will have to write a report on a problem faced by the industrial partner analyzing the feasibility to tackle this problem. Final report will include the client's need analysis, the problematic description, state of the art, objectives, tasks and activities carried out, experimentations and the obtained results. It is worth mentioning that, in the report some elements might be omitted due to confidentiality issues. For the defense, students present the project results as a presentation. One day is dedicated for all students to present the results of all projects, which takes place at the university. The industrial tutor, academic tutors and other invitees will be the member of the jury who will take part in the final evaluation of student's performance in the project. The jury members will produce the evaluation sheet. Sometimes the industrial tutors evaluate students beforehand, based on their performance during the project. During the defense's day, industrial tutors submit the evaluation sheet to the professors and discuss the students' performance.

Intangible outcomes

There is an intangible outcome which is gained by the students during the project period. Students improve their knowledge of the industry and apply what they studied in the classroom to the in industrial reality. They also develop project management and teamwork competencies, as well as engineering competencies (problem understanding, modelling, decision-making, etc.) The guidance of the supervisors is another intangible asset for the students, where they have regular interaction with those experts (researchers, professors, industrialist). Through these interactions, the students and those who work in the project acquire interpersonal and soft skills.

For the industry, as discussed in subsection 6.2.1, discovering new approaches to tackle problems is one of their objectives. With the help of the researcher/professors, expertise on the state of the art of scientific methods and techniques, learning how to use these methods and techniques represent an intangible outcome that benefits the industry.

Implications

For the university, the objectives of the collaboration are centered around the “**students**”. Hence, the academic outcomes are related to Students’ training and learning achievement. Students report and present the activities performed, results obtained and lessons learned in the final report and defense presentation. For the industry, the objectives are centered around the “**problem**” of the project. The industry outcomes are related to “**finding a solution**” or progress in developing its solution such as testing an idea. However, industrialists have a clear conscience and respect for the students’ stakes. In addition, with regard to the project problem, there are different technical outcomes discussed above such as prototype, mock-up simulation code etc. It is important to indicate that the outcomes are directly related to the objectives. Before the collaboration starts, most of the objectives are set to be as outcomes.

6.2.8 Proof of concept through prototyping

In chapter 3, subsection 3.2.4, in the literature, the term proof of concept has several definitions and practices based on domains. We indicated that in the literature that, In engineering design, prototypes are used as proof of concept (Houde & Hill, 1997)(Pahl et al., 2007). We decided that we would focus on prototypes as PoC since it covers multiple purposes in the engineering design and development process. As discussed in the previous subsection (outcomes) one major outcome of these collaborations is prototypes, in this subsection will describe the activities and practices concerning the prototyping.

With regards to what the projects' problematic, figure 34 shows that, generally there are two types of the problem that the collaborations address:

- Improvement of an existing product/service
- Finding new ideas/ solution

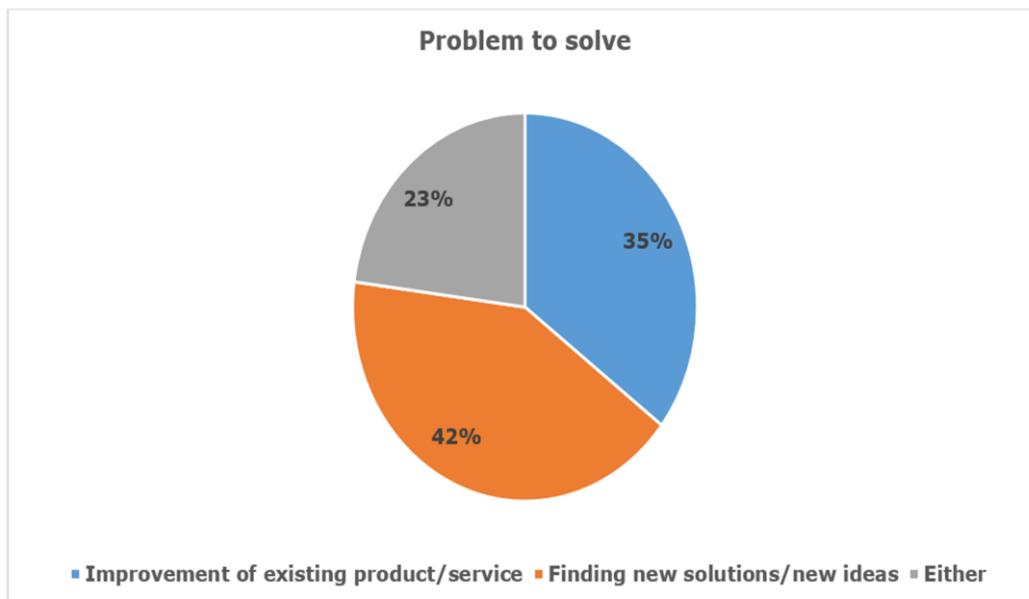


Figure 34 - Type of project problematic

For the existing product / service, the client (industry) seeks an improvement of their product/service by adding extra features or just simply adjusting & rectifying the features. In another word, exploring the possibilities with no radical changes. For finding new ideas/solutions, the client (industry) has an idea but does not have the means to experiment it (equipment, technology or time), they find the collaboration projects as opportunity to explore these ideas. In both cases, the industry will have a valuable external feedback.

The V-Model is a widely used process model in almost every systems development environment (Childs, 2013). The V-Model is an approach model that considers the entire lifecycle of a system fitting the line of thinking in systems engineering (Weilkiens, 2006). In this subsection, the objective is to analyze the activities and practices in prototyping during these collaboration projects and how they are mapped in the V model.

Since the study focuses on the early stage development collaboration projects, collaborations try to enhance an improvement or explore a new idea at the early stage. Generally, whether the problem that the collaborations addresses is an improvement for an existing product/service or finding a new ideas/ solution, they have same blocks as shown below.

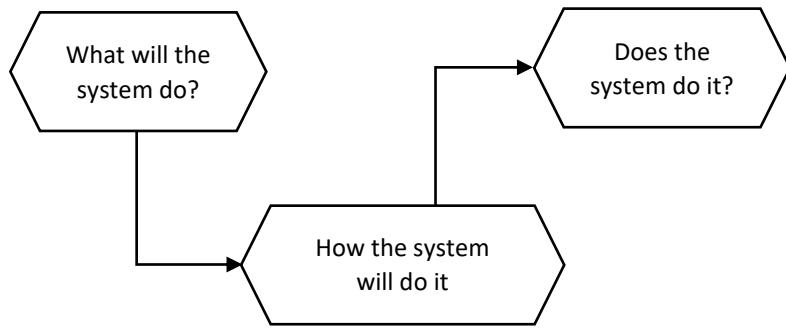


Figure 35 - Projects blocks

These blocks encompass different stages. Here is a brief description of systems development lifecycle in these projects through the observations collected during the collaboration sessions attended and the analysis of students' project reports:

- 1) Formalization of the need: Conducting a need analysis, understanding what the client needs, client's expectations, who are the users etc. eliciting the system requirements. At the end of this stage good understanding of the problem.
- 2) Feasibility: This stage is divided into two parts. Technical feasibility, analysis the state of the art, components' specification and material requirements. Then, economic feasibility (limited/basic) analysis mostly associated with the cost.
- 3) Design: System architecture, modeling and drafting to understand how the components will work together. This involves simulation, mathematical models, calculation for critical functions etc.

4) Prototyping: Building prototypes to verify to which degree the design ideas can be captured. This involves different test sets for the functions of the system's components. Then compiling these components together to build the complete system.

Although the structure of development cycle is simplified for students, but these stages could fit in the V-model of the systems engineering process. In the first stage, students' clients' needs are elicited then needs or expectations are transformed into a set of system requirements. Second stage is more focused on the technical specifications of the system's components. The third stage is repeated process to design and develop the system's components. Final stage is verifying to which degree the system functionality corresponded to the requirements.

In product lifecycle, verification and validation of engineering designs directly influence production performance and define product functionality and customer perception. (Maropoulos & Ceglarek, 2010) reviewed different definitions of verification and validation in the literature. Among these definitions, a generic definition by ISO 9000 Standard (ISO Standard 2015) which is for the product development context (Mejía-Gutiérrez & Carvajal-Arango, 2017) :

- Verification: Activities conducted to ensure that the design output meets the input requirements (associated with requirement and specifications).
- Validation: Activities conducted to ensure that the resulting products meet the requirements for the specified application or intended use (associated with customer needs).

Below figure 36, is a simplified V-model for the prototyping activities for the projects we observed.

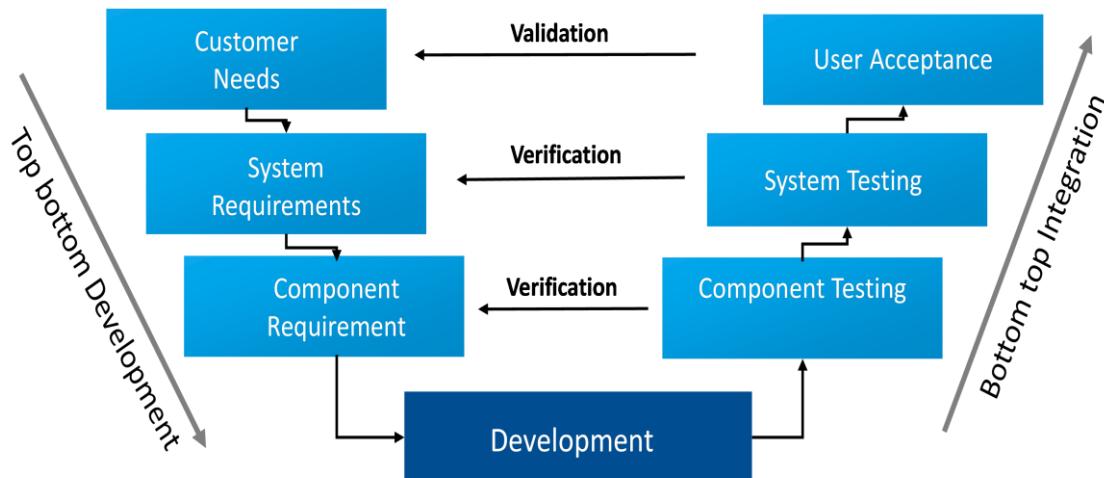


Figure 36 - Simplified V-Model for prototyping in projects

Requirements development and design occur top-down as shown on the left side of the “V” as shown in the figure. System integration, system verification and system validation occur bottom-up as shown on the right side of the “V”.

Implication

In our study, one important outcome of UIC at the early stage development is prototypes. Academically, the usefulness of prototyping is that it represents a wealth of knowledge and experience for the students since it covers a wide range of the engineering design and development process. Students have the opportunity to enhance their capabilities to build artifacts as part of their practical training. For the industry, prototyping simulates the real and future product in a cost-effective approach. Furthermore, prototyping increases the user involvement in the development and validation. In the collaborations we analyzed, development team uses prototyping as proof of concept to communicate their implementation of the requirements and specifications but also to demonstrate the functionality of the designed features.

6.2.9 Intellectual property policy

This theme discusses the Intellectual property policy in the collaboration to facilitate knowledge transfer between university and industry. We discuss two aspects in this theme: owner of the results and confidentiality.

Owner of the results

As discussed in subsection 6.2.7, there are several industry's outcomes and these outcomes are property of the industrial partner. The intellectual property is not a major issue in the collaboration between university and industry in such projects and at this stage. The university does not seek to own the results.

Confidentiality

In some of these projects, the final report, presentation prepared by students will be under confidentiality restrictions. Therefore, the industrial partner will choose to omit some elements of these documents. Professors indicated that, the confidentiality is a barrier as far as students' evaluation is concerned. Due to confidentiality, professors will not have detailed reports on students' results.

UP8

"Many companies want confidentiality, which at times is a barrier to assess students because we don't have detailed results. So, we have to judge the work in less detail"

The confidentiality issue is discussed before the start of the project (between step 2 and 3 as indicated in subsection 6.2.4 Figure 30). Then a confidentiality clause will be signed.

UAS7

"For confidentiality, we sign confidentiality clause when needed. For scientific publication which is very rare in these types of projects, we discuss with the company the elements to be published"

On the other hand, the confidentiality is also a barrier for industrial partners. This is related to the protection of proprietary information and customer information but also, if the university works with a competitor.

|11

"For a very long time, we did not collaborate with some universities because of confidentiality concerns, since they work with our competitors"

Implications

In our study, no major difficulties with regard to the IP policy, which facilitates knowledge exchange between university and industry as the result is owned by industry. However, confidentiality raises some concerns by the professors as well as the industrialist. Professors concerns are related to the omitted elements in the reports and presentations in which students are evaluated. Some elements of the results or details on the activities performed are omitted due to confidentiality issues. This is resolved by signing confidentiality agreement. For the industrialist, if the university works with a competitor this will be a barrier for the industry to engage in a collaboration. Building trust might take time before opening up in a collaboration.

6.2.10 Possibility of public funding

This theme discusses the possibility that the collaboration receives public funding. In these projects and at the stage of early development there is no public funding. At the university' facilities, the university covers almost all materials needed for the students. Although no financial contribution is requested from partner companies, through the apprenticeship tax, companies will be able to contribute to the school's revenue. In certain projects, a symbolic remuneration is paid by the industry for the students' mobility. For internships, alternated training and apprenticeship, the companies pay allowances for the students.

Implications

Some of these projects continue over the years where each year new group students continue working of the project from where previous year stopped. With the further development, the progressed project could be a pilot/use case for a bigger project under a bigger consortium. Projects that developed technological solution could be incubated in an incubation as a startup or spin off. During the creation of these startups, they will receive public funding. Sometimes, the company itself could further develop the project.

6.2.11 Organizational culture

This theme describes the openness of university and industry for collaboration. We will analyze the openness in two levels. First level, openness during the collaboration process. This includes the flexibility in communication and mobility (site visits and meetings) with partners. Second level, the openness towards the collaboration, in other word, what drives partners to be open towards the involvement in a collaboration.

Communication and mobility with partners

It was important to explore aspect of the openness in communication. We discussed with our participants their flexibility regarding communication and mobility in collaboration projects. The participants indicated that the exchange between the industry and university is easy and sufficient. As explained in alignment of the objectives (subsection 6.2.1), before the collaboration the communication is very crucial. This will help in defining clear objectives and ensure the industry engagement in the collaboration. Furthermore, the communication during the operational activities is an essential element to ensure the progress of the activities and obtaining the expected results. They used multiple ways of communications such as face-to-face meeting, Visio conference, email as well as telephone. There are specific factors will always influence the intensity and frequency of communication. Some of these factors are

project type, project duration, relationship types etc. Regarding the mobility, in the collaboration projects there are fixed number special meetings (kickoff meeting, review meeting, defense presentation etc.). Other meetings or site visits during the project whether to company sites or university's facilities, would take place when needed. At this level geographical proximity is the only barrier.

UAS4

"In certain projects, the professors visit the company with the students for a first contact with the industrial tutor and to ensure that the problem is clear"

I3

"Establishing good communication with the project team is essential. We communicate on weekly or bi-weekly basis and have some follow-up discussions when needed. We attend students' final presentations at the school and participate in their evaluation together with the professors"

Factors for openness

The participants pointed out some factors that influence the openness towards the collaboration. The two groups of participants seem to have similar view on the importance of "trust in the partners" and "the need for networking" with regard to the openness. With almost

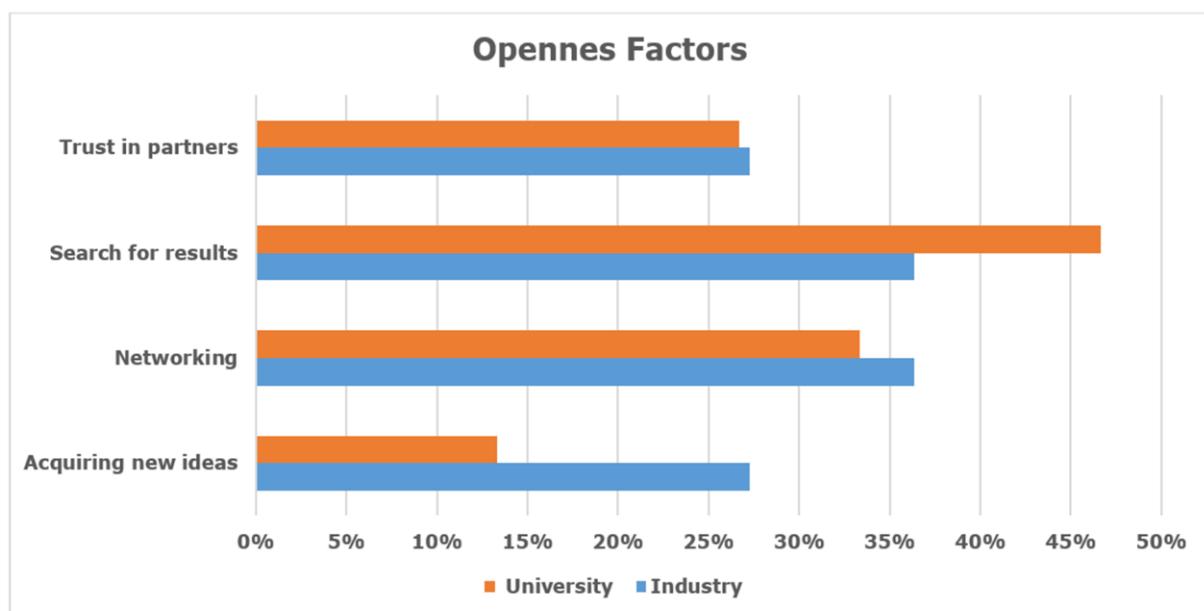


Figure 37 - Factors for initiating a collaboration

27% of each group of the participants, they indicated that “trust in partners” is a factor that will drive both sides for more openness in the collaboration. In addition, the recurrence of the collaboration helps in building trust between partners. Networking is another factor that can influence the openness of both industry and university. Expanding the network of partners or collaborators in the context of university-industry collaboration is sometimes made through exchanges in scientific conferences, industrial events. In these events, they exchange ideas and discuss the possibility to collaborate.

The industry participants believe that the need to find and acquire new ideas is a factor that will push them to be open towards the involvement in a collaboration with the university. These new ideas are very valuable in their fields and activities. The industrialists pointed out that even in technologies or solutions that they know very well, they will always have new ideas by collaboration with university. The university will provide in-depth research and analysis since they have scientific methods to perform the state of art in specific topics.

|11

“Even in the technologies that we master in-house, there are a lot of possible exploratory fields and it becomes very complicated to master everything internally. So, we have to open up to expertise, and seek it out from people who are doing more in-depth research, people who are doing things that we do not know how to do”

The university participants also think the “Search for Result” will make both sides more open towards collaboration. This includes different outcomes of the collaboration we discussed earlier subsection 6.2.7. The need to solve an issue faced by the industry will encourage the openness for collaboration.

UP6

“Finding a solution for the problematic of the project is an important factor for the openness”

Implications

Our findings discuss the openness at two levels. As for the openness in communication and mobility in the collaboration projects, the participants indicated that the exchange between the industry and university is easy and sufficient. Communication starts at the initiation stage where collaboration's idea, problem, objectives are discussed. Then establishing the collaboration where administrative procedures are communicated and finalized. The communication is then continued on regular basis during the operational activities. Sometimes, completing some administrative and operational activities require mobility (signing contracts, meetings, using facilities etc.) which both university and industry are open to do while taking into consideration the geographical distance. For the openness towards being involved in a collaboration, the openness is driven by the benefits or needs. As discussed in subsection 6.2.10, there is no financial incentives involved. However, university and industry still find other benefits/needs in these collaborations. For example, industry will benefit in finding solution/ideas or use workforce and resources and free facilities. The university needs to find collaboration projects for its students within timeframe scheduled in advance. These more urgent and pressing these needs the more they are open for collaboration. Furthermore, as discussed in subsection 6.2.9, the intellectual property is not a major issue in the collaboration between university and industry in such projects and at this stage. This has a positive impact on the openness on both levels.

6.2.12 Main Success factors

This subsection discusses the main success factors of collaboration. The figure 38, below shows set of factors that contributes to the success of a collaboration between university and industry. Although participants from both the industry and university share these factors but they have different degree of emphasis on these factors.

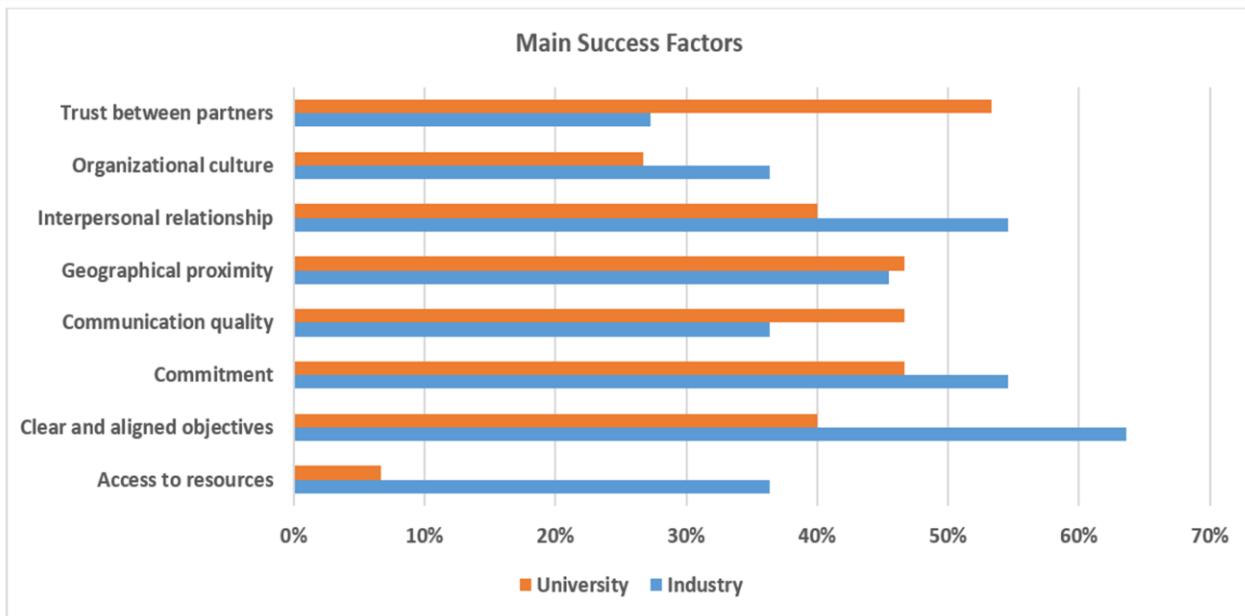


Figure 38 - Collaboration main success factors

Both, industry and university equally emphasize the following factors:

- **Geographical proximity**

Geographical distance is an aspect which contributes to the success of the collaboration according to the university's participants. University's participants emphasized slightly more than the industry's participants did on geographical distance as a success factor. When university and company are close to each other in terms of distance, that facilitates the mobility between them. For university, the collaboration with the industry represents an excellent opportunity for students to have practical training and some hands-on experience by using platforms, facilities and on-site visits. Furthermore, it will be easier for industry to participate in meetings at the university's facilities.

UP2

"To deal with complex situations, we meet or call. Sometimes it is necessary to have face-to-face meeting. On the other hand, we use email to ask for help or for a notification, but this limits the discussion. Personally, I use it to send documents and information"

Taking into consideration the fact that, covid-19 has pushed for digitalization with regard to working remotely, there might be new best practices for students' professional experience in the educational context. It is worth mentioning that, in subsection 6.2.1 (selection criteria) both groups of participants (university and industry) have almost identical view on geographical distance as selection criteria. This again the same geographical distance as success factor.

Factors that were emphasized more by the participants from University:

- **Trust between partners**
- **Communication**

Trust between the partners is factor that the university's participants believe it will lead to success of the collaboration project. As discussed in subsection 6.2.9 and 6.2.11, the trust is an important element in the confidentiality and the openness. University's participants are encountered with situations where the industrialists are reluctant to share information/data/details during the operational activities. This information is not communicated with the university or used by the student's due competition and confidentiality. This lack of trust has negative consequences of the development and expected results of the collaboration. Trust is built over the years through multiple collaborations and based on longer relationships. The partners will be familiar the collaboration process, structure, timing and the students' quality.

Communication is another factor that the university participants emphasized on for the success of the collaboration with the industry. For university it is important to communicate with the industry on regular basis. As highlighted in subsection 6.2.4, communication is crucial different phases of the collaboration process phases. The first phase is during the stage to define the problematic and the objective. The second phase where the communication is very

important is during the operational activities. At the development stage, students and professor will need to communicate regularly with the industry regarding the operational activities. This communication is to discuss the progress, the challenges and the mitigation plan if necessary. There are different ways to communicate based on the activities, which include face-to-face meeting and online communication.

UAS3

“Good communication and trust are key success factors.”

Factors that were emphasized more by the participants from Industry

- **Access to resources**
- **Clear objectives**
- **Interpersonal relationship**
- **Commitment**
- **Organizational culture**

It is important to recall here that our participants from the industry are coming from small to small-medium size companies. The Industrialists highlighted that in subsection 6.2.1, one of the objectives of the collaboration with the university is accessing workforce and resources. These resources include the work force “students and their professors” but also to use the university facilities to find a solution to the problematic of the collaboration. The industrialists consider accessing resources is a success factor for their collaboration with the university. Accessing university’s platform, labs or using its equipment’s is an aspect that the industrialist believe that the university should more flexible in granting such access.

I2

« Access to R&D platforms should be reviewed by improving the flexibility. Internally, we're having trouble making our prototypes on high temperature cast iron, and that's a shame”

17

"Internally we have the means to do prototyping of the projects, but in some cases, it may be interesting to use of the university's equipment and platforms"

For the industrialists, clear and aligned objectives is another success factor for the collaboration. As discussed in subsection 6.2.1, although university and industry share some objectives such as “networking” and “recruitment opportunity for students” but they have other different “specific” objectives. For example, industry main objective is “finding a solution for the problem” and university main objective is “practical training for students”. These different objectives need to be aligned as much as possible. This starts at the problem and objectives definition stage. Setting reasonable and achievable objectives in accordance with students’ field, capacity and time.

18

"I think, an ideal collaboration is to have a feasible project with achievable goal and a very relevant problem to students' capacity"

Human is one of the main elements of the collaboration. Having good interpersonal relationship helps in creating collaborative atmosphere throughout the collaboration. This starts at the initiation stage, where we saw how both industry and university prefer establishing the collaboration through personal contacts and relations (subsection 6.2.2). Then during the collaboration, in which communication is more fluid and easier. Furthermore, interpersonal relationship plays a positive role on trust, which facilitates the collaboration.

13

"The most important factor for a good collaboration is the human"

Commitment is another factor that contributes to the success of the collaboration. In the industry side, engagement in the collaboration shows the interest in the project and pursuing the results. Participating in the activities requires dedicating time for supervising and guiding students not only, they learn but also to make sure the needs and specifications are well understood to achieve the desired results. For university, pedagogical team must spend sufficient effort and time for the collaboration beside their teaching obligations. In addition, having an interest in the problematic from the research point of view is important.

I10

"For me there are two main success factors: good students and supervisors who give enough time to supervise the students"

As discuss in subsection 6.2.11, the organizational culture aspect is important. Our findings discuss the openness in the collaboration is essential to initiate the collaboration. Being involved in collaborations, recurrence collaborations will facilitate the collaboration. Mobility and communications are aspects related to the organizational culture.

Implications

Our findings show that there are multiple factors for successful collaboration. Trust between partners and communication are factors that emphasized more by the university participants. On the other hand, industry participants emphasized more on access to resources, clear and aligned objectives, interpersonal relationship, commitment and organizational culture. In addition, both equally emphasized on geographical distance.

6.2.13 Relation to other research

In this subsection, we will highlight the agreement and the contradictions between the literature and our key findings. We will also, discuss the possible explanation in case of contradiction.

In the literature, among the elements that make a collaborative project successful are understanding the motivations, interests, and the benefits of the partners as well as sharing common objectives (Bianchi et al, 2011; Padilla-Meléndez & Aguila-Obra, 2012; Valkokari et al, 2012). Our findings regarding the objectives is in line with these findings. However, we further explored the university and industry objectives to understand the differences and similarities. One key finding is that, the industry is focused on objectives related to the problematic of the collaboration (e.g. finding a solution). The university is focused more on the objectives that related to students (e.g. practical training for students).

In managing inter-organizational relationships, our findings agree with some researches and contradict with others. As discussed in the state of the art, the importance of creating an organizational structure to support innovation activities and its effects the decision of the partners to be involved in a collaboration (Petroni et al., 2012; Vega-Jurado et al., (2015). In which our findings partially agree with regard to the organizational structure to support strategic decisions with flexible hierarchical supervision and coordination of the collaboration activities. In our findings, this structure is the “Industry relation unit”. In subsection 6.2.2, we highlighted two level of collaborations. First level is the institutional level, where the industry does not only engage on collaboration projects but also in the strategic orientation of the university regarding educational programs and specialization and the university’s relation with the industry (Partnership and sponsorship relationship types). The other level is the project level. The project level is only concerned with the engagement on collaboration projects and it has more flexible

organizational aspects to accelerate establishing the collaboration. However, our findings contradict that the special organizational structure positively effects the decision of the partners to be involved in a collaboration since the majority of the collaborations is established through personal relationships as shown in figure 27 in 6.2.2. This is also in line what found by (Freitas et al., 2013) SMEs interact with universities through personal contractual arrangements, as indicated earlier, that our participants from the industry are coming from small to small-medium size companies who prefer personal relationship.

Our findings contradict (Buganza et al., 2011) regarding, some companies need some changes to accommodate knowledge activities in university-industry collaboration. In our findings, there is no need of change reported. As shown in figure 29 and discussed in subsection 6.2.3, this contradiction could be because the stage of the development in the collaboration. Our study focuses on early stage development collaboration and these collaborations require minimum personnel from the industry. At the later stage “commercialization”, a change might be considered since other activities (mainly commercialization activities) will be required.

Our findings regarding the collaboration process (subsection 6.2.4) gave us more insight on why the personal contacts and relationship is preferable (subsection 6.2.2). In collaboration process, an essential step is “validating the topic & Making adjustment if needed”. This to verify the collaboration problem is suitable and achievable for students’ level. This step will be length when communication is formal and institutional but will be faster when communication is through personal contacts. This does not imply any changes on the conditions to validate the topic. Our findings confirmed with (Liliana, 2013) the importance of flexibility in procedures and mechanisms of the collaboration. We emphasized on procedures and mechanisms to establish the collaboration (administrative activities), but (Liliana, 2013) went further on flexibility for completing activities tasks of the working groups. This is the contrary to (Muscio

& Vallanti, 2014) finding, centralization of tasks for the working groups is essential to resolve conflicts, facilitate communication and respect the deadlines.

Knowledge creation and transfer is one of the main parts of an effective university-industry collaboration. We used SECI model by (Nonaka & Takeuchi, 1995; Nonaka & Toyama, 2003). Knowledge characteristics will have an impact on the collaborations (Schofield, 2013). It is worth mentioning that our findings suggest that the geographical advantage is an important element in facilitating knowledge exchange and motivating actors for collaboration which agrees with the findings of (Myoken, 2013).

Concerning the openness in university-industry collaboration. Our findings (subsection 6.2.11) discuss openness in two levels: openness during the collaboration process and the openness towards the involvement in a collaboration. In the literature, most studies focus on openness during commercialization activities where there is financial incentives and technology control. The higher the financial incentive the more openness is required (Simeth & Raffo, 2013; Simeth & Raffo, 2013).

For themes such as Intermediaries, Intellectual property policy, Possibility of public funding, we had limited data since the collaborations projects in our study do not involve these aspects, nevertheless we could relate to some views. In the literature, the role of intermediaries is to support the university-industry collaboration in the commercialization phase. Intermediaries (such as technology transfer offices, Technology parks etc) support the collaboration during patenting, commercialization efforts, these (Shane, 2002; Sellenthin, 2011; Muscio & Vallanti, 2014; De Beer et al, 2017;). Involving intermediaries in the early stage which will cause a communication barrier and bureaucracy which confirms the findings of (Padilla-Meléndez & Aguila-Obra, 2012) for the later stage. Intellectual property policy is interconnected to other collaboration aspects such as strength of the relationship and the

openness in organizational culture (Padilla-Meléndez & Aguilera-Obra, 2012; Welsh et al., 2008). In our findings, the confidentiality is viewed as a barrier for both industry and university. Funding is an important factor that drives the patents and commercialization activities (Lopez et al, 2009; Hayter, 2013). This not the case for our study since it focuses on the early stage development collaborations.

6.2.14 Summary & takeaways

The aim of this part of the study was to have a comprehensive view of the early stage development UIC. In addition, to have a better understanding of the collaboration and systematically describe the relevant characteristics of each aspect of the collaboration. Themes discussed in 6.2, represent the collaboration's aspects in our study. Analyzing these themes separately gave us insights to characterize different aspects of the collaboration from initiation until the end.

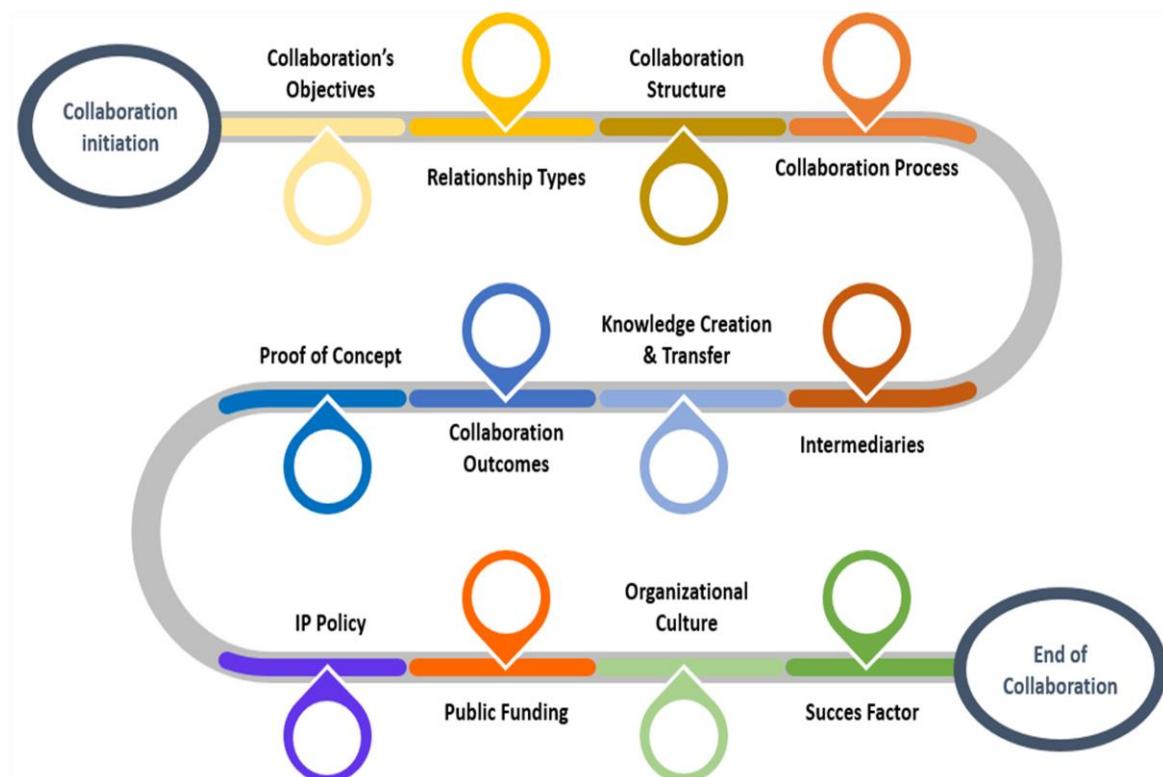


Figure 39 - Collaboration aspects

Through the data collected, we have analyzed the following themes: **Collaboration's objectives, Relationships, Structure, Process, Intermediaries, Knowledge, Outcomes, Proof of concept, IP policy, Public Funding, Organizational culture and Success factors.**

This gave us a comprehensive view of the early stage development UIC. Covering multiple aspects of the collaboration. Table 8, highlights the main key takeaways of characterizing UIC. This analysis and the comprehensive view will help us to develop a framework UIC at the early stage development in the next section.

Theme	Main Takeaways
Alignment of objectives	University's objectives are oriented towards students (training, professional experience)
	Industry's objectives are oriented towards the project's problem (finding solutions, ideas, progress in solving the problem)
	List of university's objectives in university-industry collaboration at the early stage development (Fig25)
	List of industry's objectives university-industry collaboration at the early stage development (Fig25)
	Importance of alignment of unshared objectives
	Importance of choosing the potential partners in order to align the objectives.
	Partner's selection criteria for university-industry collaboration (Fig26)
Relationships	Three types of relationships: partnership, sponsorship and personal
	The collaboration could take a place at two levels
	Collaboration at the institutional level includes (partnership, sponsorship)
	Collaboration at the project level includes (personal)
	Personal relationship is the preferable type by both (professors & industrialists)
	Personal relationship has more organizational flexibility at the initiation stage (contacts, defining concrete problematic and setting objectives of the collaboration)
	The collaboration initiated through personal relationship is eventually formalized by a contract before the start.
Collaboration Structure	The structure of the collaboration involves more people and logistic from the university than the industry (multiple collaboration projects, operational activities are conducted at the university premises)
	An internal structure at the university "industry relation unit" plays an important role in promoting the school programs, specialties and industrial events in the regional and national ecosystems. Also, will help to diversify and increase the number of the industrial collaborators with the school.
	No structure change is necessary at the industry side for early stage collaboration. Change might be considered at later stage of the development since other activities will be required such as managing and integrating Knowledge as well as commercialization activities.
Collaboration Process	Extensive flow of collaboration process in 9 steps (Fig30)
	The collaboration kick-off is STEP 6 (surprisingly late) due to topic validation
	Topic validation: defining the problematic, objectives and limits (To adapt for students' level) is time consuming task specially for communication at institutional level

	The collaboration initiation could be shortened through personal contacts, recurrence collaboration, former students. (<i>those who already know the mechanisms, procedures and conditions to establish the collaboration</i>)
Knowledge creation and Transfer	High level conceptualization of knowledge creation and transfer process in the collaboration by highlighting key examples of knowledge-related activities with the help of SECI model for knowledge creation (Fig31)
Outcomes	<p>List of industry's outcomes in university-industry collaboration at the early stage development (Fig32)</p> <p>List of academic's outcomes in university-industry collaboration at the early stage development (Fig33)</p> <p>New ideas include: novel solution concepts, architectures to structure a solution, designs to create a feature, mathematical model, solution Framework</p> <p>Intangible outcomes (interpersonal skills, learning new methods and techniques etc.)</p>
Proof of Concept	Project development three blocks (Fig35)
Organizational culture	<p>Openness at two levels: openness during the collaboration process, openness towards being involved in a collaboration</p> <p>Openness during the collaboration process is driven by trust and geographical proximity</p> <p>Openness towards being involved in a collaboration is driven by benefits/needs</p>
Success factors	List of main success factors (Fig38)
Others	<p>No intermediaries are involved in early stage development collaborations (it is time consuming to establish the collaboration when there are more structures involved) (preference to initiate the collaboration through personal contacts)</p> <p>No major difficulties with regard to the IP policy as the result is owned by industry</p> <p>Confidentiality raises some concerns for the professors regarding students' assessment since sometimes they might need to evaluate students with less detail due to confidentiality.</p> <p>Confidentiality raises some concerns for the industrialists, if the university work with a competitor this will be a barrier for the industry to engage in a collaboration</p>

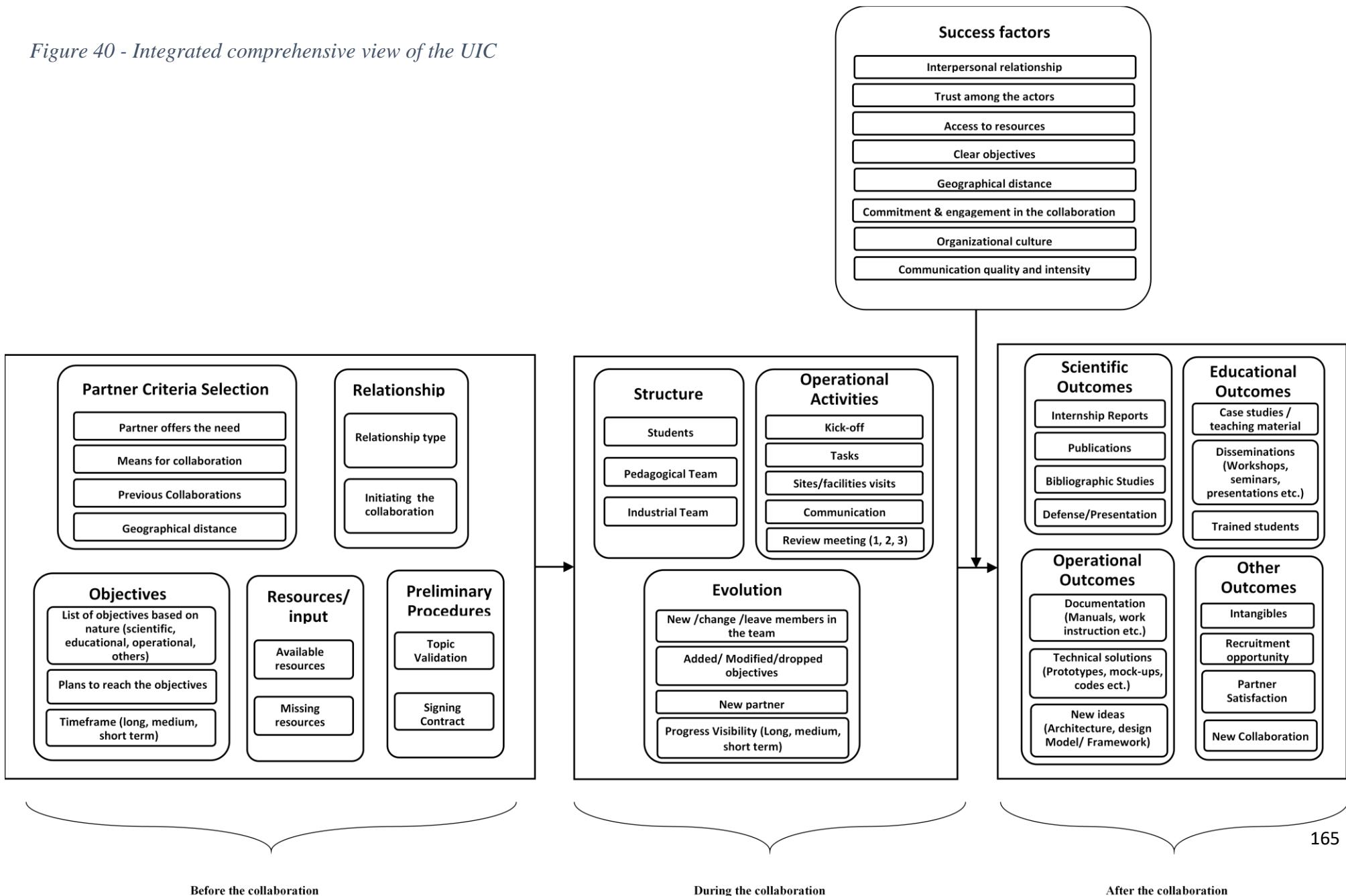
Table 8 - Main take away

6.3 UIC framework

We initially in (Haidar et al., 2019) divided the university-industry collaboration into three stages: “before the collaboration”, “during the collaboration” and “after the collaboration” (in subsection 4.1.2 figure 14). The characterization of the collaboration through the detailed analysis of the themes (section 6.2) in the overall collaboration have helped us to construct and expand a framework of the collaboration encompassing different aspects of the collaboration at different stages. In addition, success factors of the collaboration are included.

We compiled the various elements of the collaboration from initiating the contact to the outcomes. The “Before” stage is concerned by the initiation and establishing the collaboration. The “During” is related to the operational activities, where the project team work and perform collaboration activities. “After” stage is when the outcomes are delivered. We also, included set of success factors those, which will influence the success of the collaboration. Figure 40 below, shows an integrated comprehensive view of the UIC at the different stages incorporating the various elements. Next sections will address each stage separately and explain the sequential process.

Figure 40 - Integrated comprehensive view of the UIC



6.3.1 before the collaboration

The actual collaboration project starts during the operational activities where the team members from university and industry start collaborating/working on the development to find a solution for the problematic of the project. However, **before** the collaboration starts, it has to be initiated and established. Therefore, “**before**” stage is initiating and establishing the collaboration. This involves several administrative activities. Figure 41 shows the activities sequence at the “**Before**” stage.

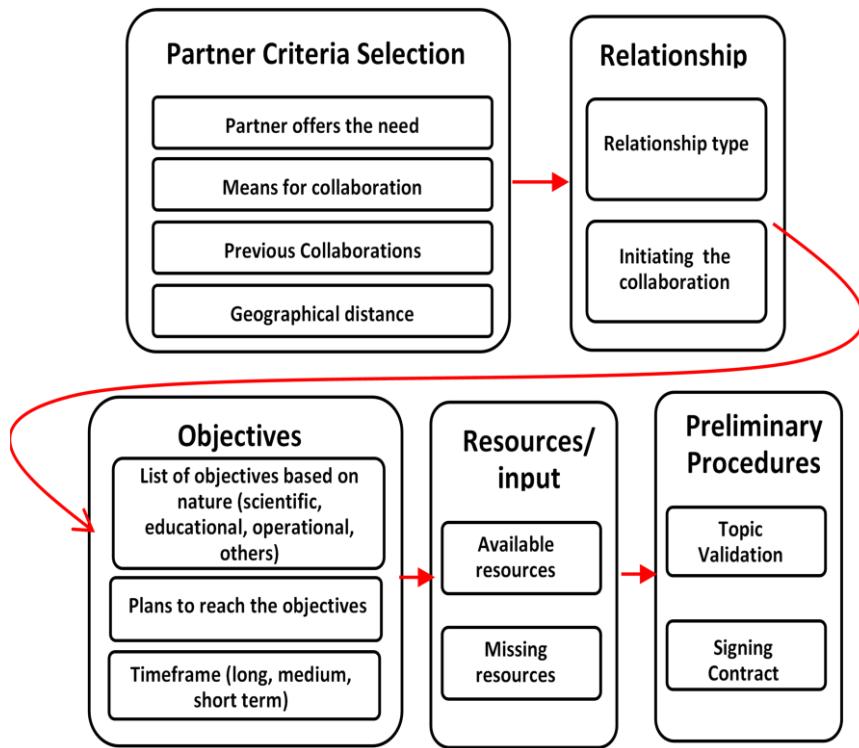


Figure 41 - Activities flow in "before" stage

University and industry start searching for potential partners. For the initiation of the collaboration, selecting partners and type of relationship are the main elements of the “initiation” of the collaboration. In our findings, a set of selection criteria was provided based on the point view of university staff and industrialists that they consider before initiating the idea of collaboration (contact). Difference of the relationship’s types (partnership, sponsorship,

personal) will influence how university staff or industrialist initiate the contact for the collaboration. This initiation will explore or inquire about the possibility of the collaboration. This does not necessarily need precise and detailed topic (problem to solve) of the collaboration. partners selection's criteria and relationship types are discussed in subsections 6.2.1 6.2.2 respectively

Once the possibility of the collaboration is confirmed, the collaboration needs to be established by agreeing on the topic, objectives, teams and eventually signing contracts when applicable. For the establishment of the collaboration there are three essential elements: Defining the problematic and its objectives, identifying the inputs/resources then administrative procedure (contract, confidentiality etc.). Our finding shows, defining and validating the problematic and objectives is crucial step where pedagogical team verify the relevance of the problematic to the students' field, and capacity. This step might be long specially when the communication is formal. Objectives need to be reasonable and achievable with clear plan. Adjusting and repositioning the objectives to minimize the differences in the objectives. Objectives nature (scientific, educational, operational, etc.) is related to the outcomes as explained in subsection 6.2.7 where most of the objectives are set to be as outcomes before the collaboration starts. In addition, these objectives/outcomes might have different timeframe (long, medium and short term) before it can be visible. Initial plan to reach this objective should be specified (tasks, deliverables etc.).

Another important element in establishing the collaboration is resources. In subsection 6.2.1 (objectives characterization), one of the industry objectives is to have access to resources. This includes workforce (professors, students etc.), facilities, equipment etc. These resources will be used to tackle the topic of the project. Sometimes not all resources are available. Furthermore, as indicated in subsection 6.2.12, accessing resources is one of the success factors. In the “Before” stage, the collaboration partners will start pooling their resources and identify

what is still needed as resource's. Therefore, the resources component is divided into two parts: the available resources and the missing/needed resources.

6.3.2 during the collaboration

The Figure 42 (whole) represents the collaboration structure. Describing all units, people involved in the collaboration process (from initiation until the end). At the “during” stage we are interested in the structure of people and units that are involved in the operational activities only (red dotted square). In subsection 6.2.4, figure 30, this stage is between STEP SIX “kick-off meeting” and STEP NINE “Report & presentation”. Conducting the operational activities is a repetitive action (a loop between the steps until the operational activities are

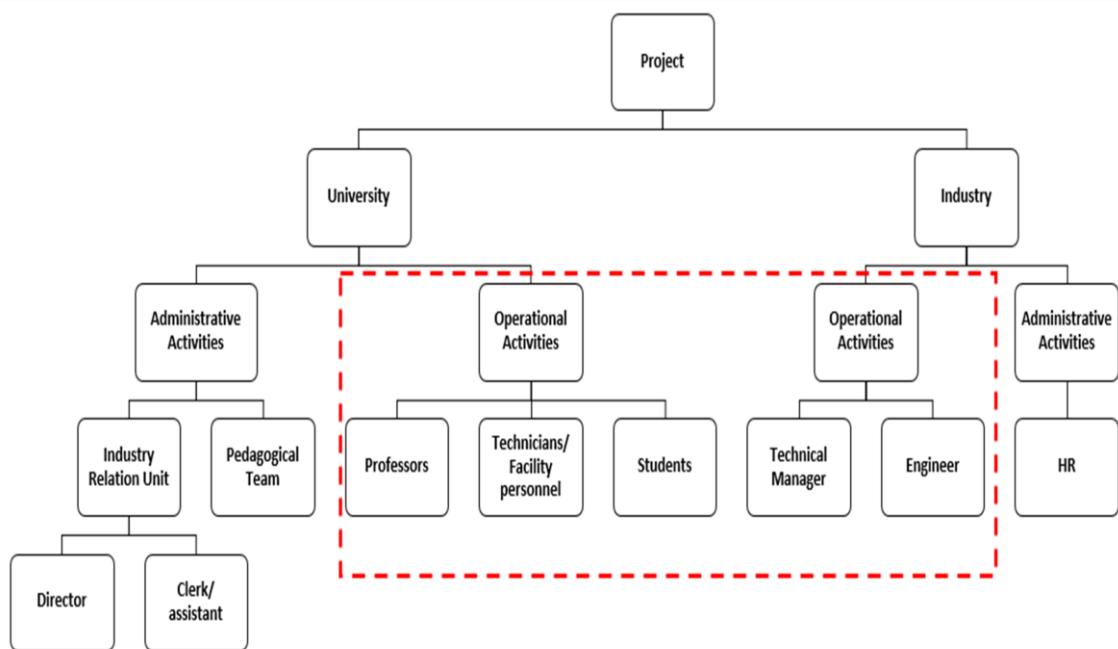


Figure 42 - Structure of people involved in the operational activities

completed).

Conducting the operational activities is the core component of this stage. These activities involve students, pedagogical team and industrial tutors (technical manager or an engineer). Kick-off meeting presents the project in details. This includes the problematic, the objectives, the specifications and the expected results. This will highlight the list of tasks and

deadlines. Regular meetings take place to review the progress of the work and address the needed adjustment. In these tasks, the team exchange and communicate the updates and review the progress of the work until all task are completed.

Figure 43 shows the three basic components of the “**During**” stage. Structure, which indicates the people involved in the operational activities. Another component is performing the operational activities. We added another component to this stage, which is the evolution of the collaboration. With the progress of the work, new objectives, plans, actions might need to be added or the predefined should be modified/changed. The team itself might have new member or changed members.

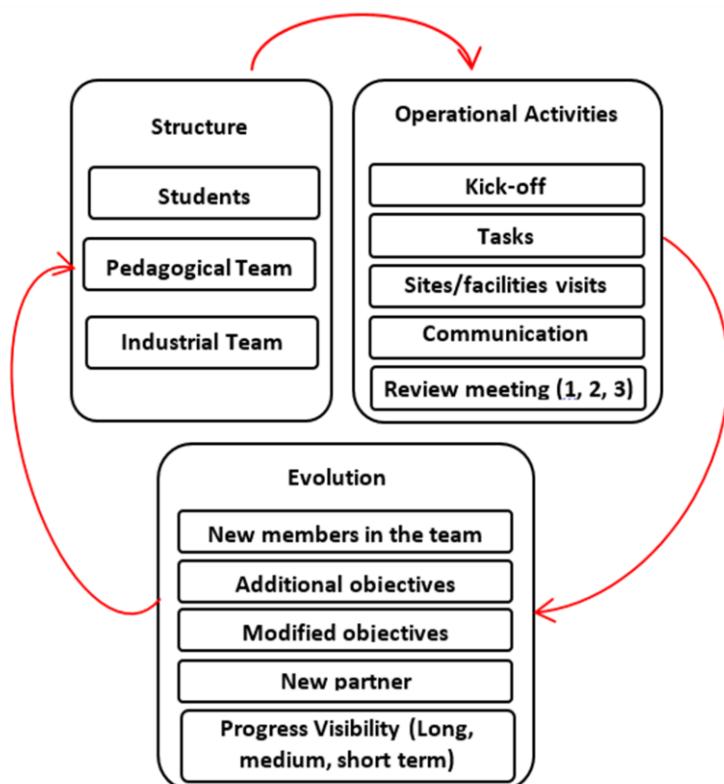


Figure 43 - Operational activities

There are other aspects that are embedded within these components at the “During” stage will have an impact (positive or negative) on the collaboration such as decision-making process concerning the operational activities (taken by people involved or centralized by the management of both organizations). In addition, collaboration culture (openness, secrecy,), access to resources and barriers such as IP, confidentiality, communication and mobility. In

subsection 6.2.10, our findings indicate that, these types of collaboration take years to be completed and these collaborations tend to be recurrent on the long term. As figure 43 shows, conducting the operational activities is a repetitive action until all tasks are completed.

6.3.3 after the collaboration

In “during” stage, teams collaborate to complete all operation activities and tasks to achieve the objectives. The “after” stage is when the teams completed the operational activities. This will conclude the collaboration by delivering the outcomes of the collaboration. These outcomes are the results of the operational activities to attempt finding a solution for the problematic was proposed. We discussed two types of “collaboration topic/problem”. The industrial partners need is either:

- Improvement of an existing product/service
- Finding new ideas/ solution

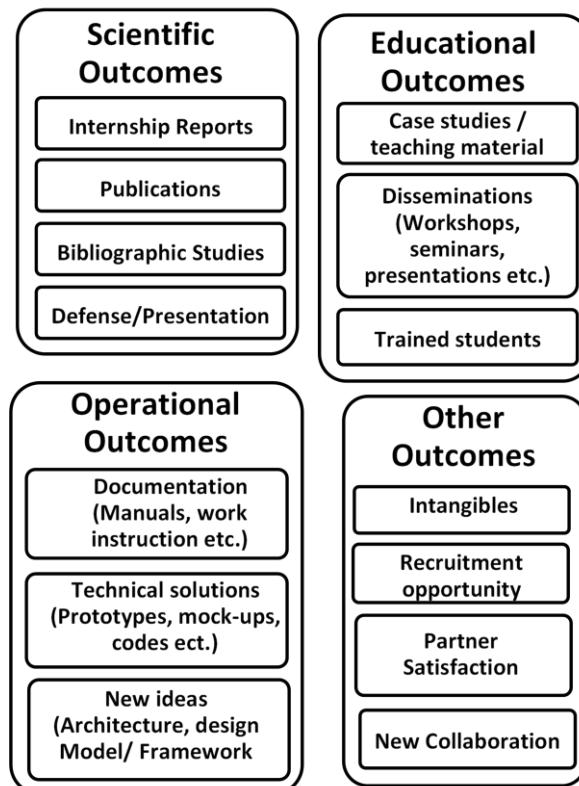


Figure 44 - Types of outcomes

Developing the solutions goes through phases to finally produce the different outcomes. As discussed in subsection 6.2.7, there are different types of outcomes. This include academic outcomes (scientific and educational), operational outcomes and others. Figure 44 shows the four types of the outcomes of the collaboration: scientific outcomes, educational outcomes, operational outcome and other outcomes.

Scientific outcomes include: internship reports, publications, bibliographic Studies and defense/presentation. Reports, bibliographic and presentations are usually part of the task to be completed during the collaboration project and students will be evaluated based on these documents (as well as performing the operational activities). However, scientific or technical publications are very rare in these types of projects (as indicated in subsection 6.2.9).

Educational outcomes: Case studies / teaching material, disseminations (Workshops, seminars, presentations etc.) and trained students. For university, these projects prepare students for their professional activities. Hence, this is a practical training opportunity for students to develop specific project competencies. **Operational outcomes:** technical documentation (Manuals, work instruction etc.), technical solutions (Prototypes, mock-ups, codes etc.), new ideas (Architecture, design Model/ Framework). The operational outcomes will depend on the domain of the collaboration. **Other outcomes:** Recruitment opportunities, partner satisfaction, new collaboration. Intangible outcomes should be considered, students acquire interpersonal and intercultural skills and industry learn applying scientific methods and techniques (subsection 6.2.7). Another outcome is the agreement on continuing the collaboration for further development of the current project or eventually new project.

6.3.4 Collaboration main success factors

During the interviews, professors insisted that the company must dedicate time to the project. Professors and industrialists have empathized that for successful collaboration, the problem must be well defined and objectives should be clear. One of the factors of good collaboration is the communication and interaction between the industrialists and the student and the pedagogical team. Industrialists think trust is built through an established relationship with university. This will help the industrialist (specially SMEs) to be granted the access to university resources and facilities. The personal contact will accelerate the process of



Figure 45 - Main success factors

establishing the collaboration. The geographical proximity, the presence of cultural barrier and lack of commitment will hinder the collaboration. These factors are discussed in details in our findings in subsection 6.2,12.

6.3.5 Conclusion

In this subsection, we developed an UIC framework based on three stages: “before”, “during” and “after”. We build the framework of the collaboration based on the characterization of the collaboration through the detailed analysis of the themes in the overall collaboration in section 6.2. The UIC model encompasses different aspects of the collaboration at different stages. We explained explain the sequential process of the activities. In next section we will develop sets of KPIs to evaluate the UIC.

6.4 Evaluating the collaboration at the early stage

As seen in the themes’ analysis section 6.2 and the collaboration framework section 6.3, the collaboration consists of multiple actors, several procedures and different components. This make university-industry collaboration evaluation very challenging. Furthermore, this study focuses on the early stage development collaboration, which makes following the collaboration’s progress even harder since the results could take several years before being visible. This is a challenge for universities and the industry alike. This subsection presents our proposition to evaluate the UIC.

6.4.1 Related work

In addition to the difficulties mentioned earlier in evaluating university-industry collaboration is that, in the literature different researchers approached the issue with different perspectives. For example, (Mora-Valentin et al., 2004) considered that success of a cooperative agreement is determined by the achievement of the pursued objectives, arguing that every cooperative relationship is born with the aim of achieving specific objectives. (Iqbal et al., 2011) developed an evaluation model based on constraints and success criteria that are related to collaboration relationship. (Piva & Rossi-Lamastra, 2013), indicated that, for an effective evaluation system should monitor the development and the achievement of the collaboration

goals and outputs (tangible & intangible) should also consider the critical problems that might affect achieving the results.

6.4.2 Defining Performance Indicators the measurement system

(Perkmann et al., 2011) suggested that performance measures provide a way of assessing the progress over time of specific activities, should encompasses the different stages in a process from initial conditions to eventual outcomes.

In his study, a success map was developed Figure 46, representing the collaboration stages based on the existing literature on university–industry relationships. According to the study, to measure the success, indicators should be defined for each stage of the collaboration. This is adopted by multiple studies including (Seppo & Lilles, 2012) (Piva & Rossi-Lamastra, 2013)(Ankrah & AL-Tabbaa, 2015)(Galan-Muros & Davey, 2019). Rather than only focusing on objectives or outcomes (which are extremely important), splitting the collaboration into stages helps in identifying elements or components associated with the respective stage.

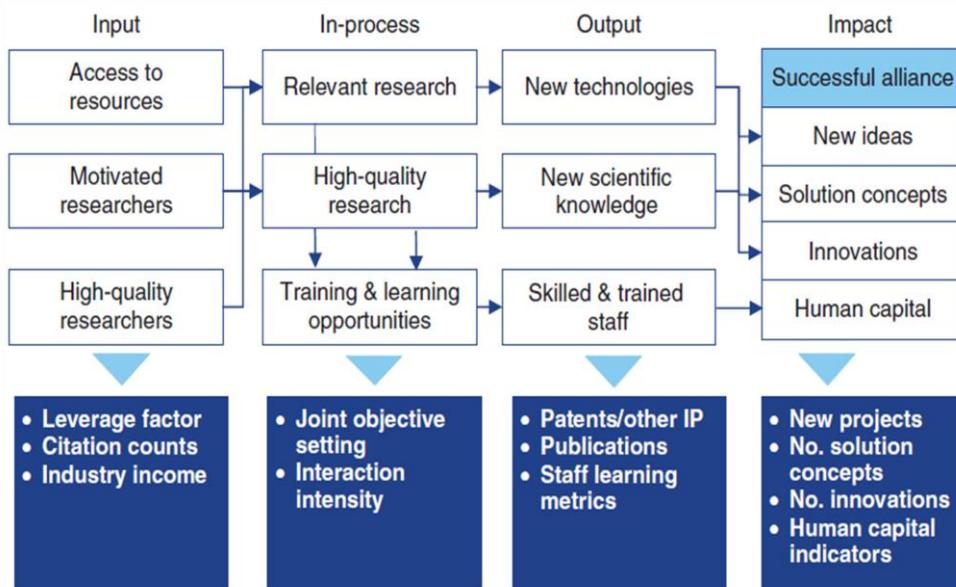


Figure 46 - Success map based on multiple stages (Perkmann et al., 2011)

Following (Perkmann et al., 2011), to define the KPIs , we will use our framework developed in section 6.3 figure 40. The framework divides the collaboration into three stages (before the collaboration, during the collaboration and after the collaboration). In each stage, we have multiple components. These components were developed based on the extensive characterization (section 6.2) of the university-industry collaboration at the early stage development. Below is steps' sequence how the KPIs were developed.

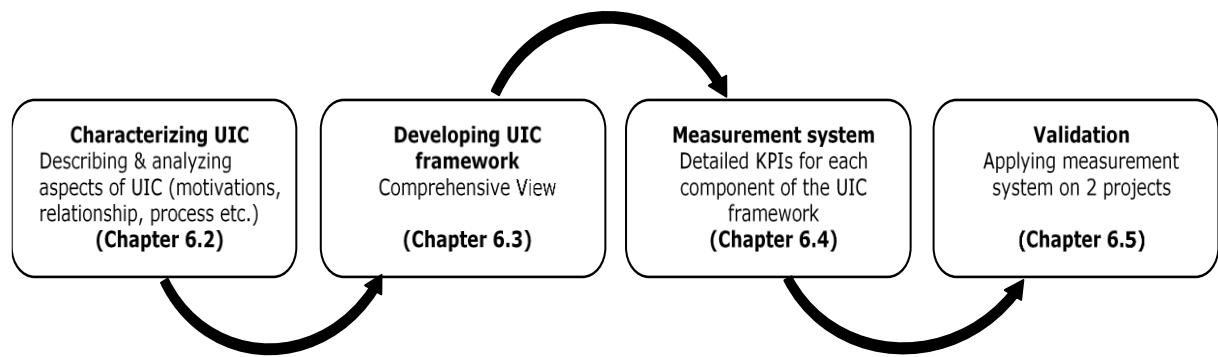


Figure 47 - Steps to develop measurement system for UIC

As shown in figure 47, we used the data collected in the interviews and observation to characterize the UIC at the early stage. The analysis conducted in subsection 6.2 helped us to build up a comprehensive view of the UIC detailing various aspects at different stage as discussed in subsection 6.3. Then, we define indicators for each components of the framework by considering the identified aspects (tasks, responsibilities, elements etc.) associated to this particular component at each stage. The KPIs will be mix of quantitative and qualitative types to ensure we cover the maximum tangible, intangible, codified, uncodified, visible and invisible aspects. These KPIs will serve as metrics to evaluate the collaboration at each stage (before moving to the next one).

According to (Perkmann et al., 2011) for a system of measurement for university–industry alliances, to be useful, needs to address the following challenges:

Challenge	Details	Description
Multiple objectives	Objectives differ across partners and may have different time horizons	Use measures that provide a combined picture of participants' interests
Intangibles	Project outputs and outcomes are often intangible	Identify realistic proxies (indirect) for intangible outputs and outcomes
Long-term nature	Benefits may only be realized in the medium and long term	Identify leading (prospective) Indicators
Measurement norms	What should measures be compared against?	Provide a framework for the interpretation of measures

Table 9 - UIC evaluation challenges Perkmann et al., 2011

Below how we address these challenges in table 9 for our case:

Measurement norms

As shown in the figure 47, our starting point is understanding in depth the collaboration section 6.2 (Characterizing the collaboration). Then, the framework was developed in section 6.3. The framework encompasses the collaboration in three stages in the collaboration covering different components and activities from the initiation through the operation to the outcomes. The framework will help us to define what to measure and allows us to identify measures for each stage component and facilitate the interpretation of measures.

Multiple objectives

Objectives differ across partners and may have different time horizons. As we discussed in characterizing the objectives of the collaboration, subsection 6.2.1, the collaborators from the two organizations (industry/university) try to achieve the objectives of their organizations. The figure 25 shows that the collaboration objectives are divided into two group: industry's objectives and university's objectives. Therefore, in defining the performance indicators we will address this issue by considering the different multiple objectives of the university and the industry that listed and discussed in subsection 6.2.1.

Intangibles

This challenge is very relevant to our study since the study focuses on the early stage development collaboration. In characterizing the outcomes of these collaborations, we highlighted the different type of the outcomes, which includes technical solutions, documentation, academic outcomes and intangible outcomes. In subsection 6.2.7 (collaboration outcomes), we highlighted examples of the intangible outcomes. In addition, with regards to the framework third stage (after the collaboration) subsection 6.2.3, we emphasized on the intangible outcomes as part of the success of the collaboration. Furthermore, we will add qualitative measures in each component of each stage.

Long-term nature

In the early stage development university-industry collaboration, conducting research tasks is a time-consuming, hence sometimes the results might not be visible in short time. In developing the framework, in subsection 6.3.1 we considered the time aspects in objectives' nature (scientific, educational, and operational) in which these objectives have different timeline. In subsection 6.3.2 and progress visibility (long, medium, and short term).

“Before” Stage KPI

Our findings (subsection 6.3.1) show that, the “**Before**” stage is initiating and establishing the collaboration, in other word at this stage NO operational activities will take a place yet. In subsection 6.3.1, figure 41, we explained the sequential view of the activities at the “**Before**” stage. Therefore, to initiate and establish the collaboration the following elements should be addressed: potential partner selection, relationship types, objective definition, resources/inputs for the collaboration and preliminary procedures (topic validation, signing contracts).

To initiate the contact, potential partners should be identified beforehand. Identification of potential partners is not straightforward task. This will involve several aspects and decisions. Collecting data is essential, however some data might be already available over the years from previous collaboration such as database, contacts etc. Then decision on setting the criteria for the selection (educational, technical, strategic, geographical etc.). In addition, making the contact to check the possibility of the collaboration. Our findings (subsection 6.2.1) indicated that if the relationship is already established with the potential collaboration project partner (partnership, sponsorship, personal) this task is not necessary, in other word it is only applicable for new potential partners (which we consider). For this task, we suggest a quantitative/qualitative indicator "**No. of potential partners**" to evaluate achieving this task qualitatively (**whether through the selection criteria or if it was not needed**). This indicator will not only indicate the completion of the task, but also gives valuable information about the characteristics of new partners. Our findings show that there is a direct relation between the choice of partners and the success of the collaboration.

The relationship type also influences initiating the collaboration. In subsection 6.2.2, in characterizing "relationship", we found that informal relationship (personal contact, previous collaboration, former student) is more flexible and faster than institutional relationships (partnership and sponsorship) in terms of communication. This has a positive impact on the initiation process (specially topic & objectives validation). We take in consideration the fact that, a new partner (selected from the previous task) will not be familiar with procedures, mechanisms and condition. This will influence the performance at this stage. For this task, we suggest a qualitative indicator "**Initiation mechanism**" to evaluate qualitatively the initiation of the collaboration based on relationship type (institutional or personal). Then describe if there was previous collaboration or a former student was involved in the collaboration. These elements will be taken into consideration, partner being familiar with the procedures;

mechanism will positively influence the performance of this task (initiation, topic and objectives validation).

List of objectives at this stage need to be defined. As we discussed in subsection 6.3.1, for each objective nature (scientific, educational, operational, others), plan (task, deliverables) and timeframe (long, medium and short term) should be defined. Therefore, firstly, we suggest a quantitative indicator “**No. of defined/clear objectives based on nature and timeframe**” for the defined objective. Then another qualitative indicator “**Objectives’ plan difficulty level**” to evaluate the completion of the “initial plan” to achieve the objectives and the difficulties level of these objectives, as discussed in subsection 6.3.1, this initial plan could be adjusted and modified in the next stage accordingly. This indicator is very important and useful for the “after” collaboration stage, this will be considered for evaluating the achieved objective at the end of the collaboration.

Resources/inputs as an important component for the collaboration establishment. The main resources will include workforce (professors, students etc.), facilities, equipment and materials. As discussed in subsection 6.3.1, when partners start pooling the resources/inputs for the collaboration some of these resources won’t be available. Therefore, we will take this into consideration. For the team members, we suggested three separate quantitative indicators to distinguish between the different capabilities. “**No. of experts to be involved**”: to indicate the number Professors, Researchers, Engineers etc. who will take part in the project. “**No. of students to be involved**” for the workforce. “**No. of other personnel (if any)**” to indicate facilities technicians, equipment’s handlers etc. Budget is an important input indicator, however as our findings indicate in subsection 6.2.10 there is no funding for early stage development collaboration project. Thus, we suggest quantitative indicator for budget: “**Budget (if applicable, materials, transport, etc.)**” for expenditures and finances. Another resource is TIME we suggest quantitative indicator “**Project duration**”, time to conduct all tasks and

activities. We also, suggest a qualitative indicator “**More Resources**” to evaluate if all needed resources are available, the workspace settings etc.

Final task at this level is preliminary steps. This to validate the topic and sign the contract when applicable. We suggest a quantitative/qualitative indicator “**No. of meetings/exchanges before the topic is validated**”. The preliminary steps will depend on problem and objective definition, and Familiarity with the mechanisms and procedures. Completing these tasks and responsibilities will conclude the stage “before”.

KPIs “During” Stage

We emphasized, in the “Before” stage NO operational activities will take a place, the “During” stage is mainly about the operational activities. In subsection 6.3.2, figure 43, we explained the loop of the operational activities process until all tasks are completed at the “**During**” stage. Therefore, to conduct the operational activities of the collaboration the following elements should be addressed: Structure of people involved in the operational activities, performing the activities and evolution of the collaboration itself in terms of objectives, team etc.

The structure of people and units that involve in the operational activities. In the “Before” stage we addressed the team members as resources/input and identified three KPIs (**No.of students, experts and facilities personnel**). However, at this stage we must address other aspects that effects conducting the operational activities as discussed in subsection 6.3.2.

Therefore, we suggest the following qualitative indicators: “**Structure of the collaboration**” to evaluate how people involved are organized (students, pedagogical team, industrial team etc.), Decision process concerning the operational activities (taken by people involved or centralized by the management of both organizations), Collaboration culture (openness, secrecy etc.) etc. As we highlighted in subsection 6.2.4 (collaboration process) and subsection 6.2.12 (success factors), these elements or factors influence the performance of the

team and consequently affect the completion of the tasks. Another qualitative indicator we suggest is “**communication intensity**” to evaluate the difficulties, intensity, and availability in communication. Also, to consider communication and cultural barriers. In our findings, in subsection 6.2.9 (IP policy) and subsection 6.2.12 (success factors), we discussed how confidentiality negatively influences the collaboration especially when some result or data is not communicated or shared. In “before” stage we analyzed the indicators for resources/inputs, here we suggest another qualitative indicator “**resources accessibility**” to evaluate the access to facilities and equipment’s, if the access is granted etc. As part of the evolution of the collaboration we suggest the following quantitative indicators, “**No. of added/modified objectives (if any)**” to evaluate if in the progress of the development activities, new objectives are added or the defined objectives are modified. “**No. of added/changed team members (if any)**” to evaluate if in the progress of the development activities, new or changed team members. The output of the stage will be the outcomes of the collaboration.

KPIs “After” Stage

This stage is “after” the completion of all operational activities. In stage “before” and “during”, we defined indicators for all components and elements which will influence the performance and consequently the success. What is left is now to evaluate the collaboration outcomes. Therefore, the indicators for this stage are simply concerned with the outcomes.

In subsection 6.3.3, figure 44, our findings indicate that there are four types of outcomes (scientific, educational, operational and others). Furthermore, in subsection 6.3.3, we highlighted that two important aspects need to be considered in evaluating the outcomes of the collaboration, which are: intangible outcomes and the visibility of the results. Therefore, we suggest indicators to evaluate the achieved objectives based on nature (educational, scientific and operational). These types of objective were defined in “before” stage. For the educational objectives, we suggest three quantitative: “**No. of achieved educational objectives**”, “**No. of**

trained students” and “**No. of workshops/seminars**” to indicate respectively, how many of the predefined educational objectives were achieved, how many students participated in the collaboration (as it is their practical training) how many workshops or seminars to communicate or disseminate educational material.

For the scientific objectives, we suggest two quantitative indicators: “**No. of achieved scientific objectives**” to measure how many of the predefined scientific objective were achieved. Second indicator is “**No. of scientific documents produced**”, this is not limited to “publication” but also, reports, bibliographic studies, case studies etc.

For the operational objectives, we suggest the following quantitative indicators: “**No. of achieved operational objectives**”, “**No. of functional demonstrators**”, “**No. of functional simulations**”, these indicators will respectively measure how many of the predefined operational objective were achieved, how many specific operational outcomes (prototypes, codes etc.). In subsection 6.2.7, our findings suggest that, 23% of the total outcomes of the collaboration is “Finding ideas”. These ideas could be novel solution concepts, architectures to structure a solution, designs to create a feature, mathematical model, solution Framework etc. Therefore, we suggest quantitative/qualitative indicator: “**No. of new Ideas or concepts**” to measure quantitatively or qualitatively how many ideas were developed.

We added one more category in the UIC framework “others” (subsection 6.3.3). This category will include other outcomes such as recruitments, new collaboration opportunities, and the intangible outcomes and satisfaction of the results. For this category we suggest the following indicator: “**No. of proposals/ prospective for new collaboration**”, “**Number of hired students/ Hiring rate**”, and “**Rate of partner’s satisfaction**” to measure the possibility of new collaboration, hiring rate and satisfactory level of partners. One interesting element we discussed in 6.3.2, 6.3.3 and 6.3.4 is the visibility of the results, in which some of the results might take years (some of the collaboration projects continue working several years with

different students). We suggest a qualitative indicator: “**Problem solution progress**” to qualitatively measure the progress of finding a solution taking into consideration, level of difficulties of achieved objectives (Uncaptured progress), New “best practice” learned/developed etc.

Figure 48 below, is a simplified view of the measurement system and the KPIs, followed by a detailed table 10 summarizes the indicators for each stage, indicating the indicator’s type as well as a description

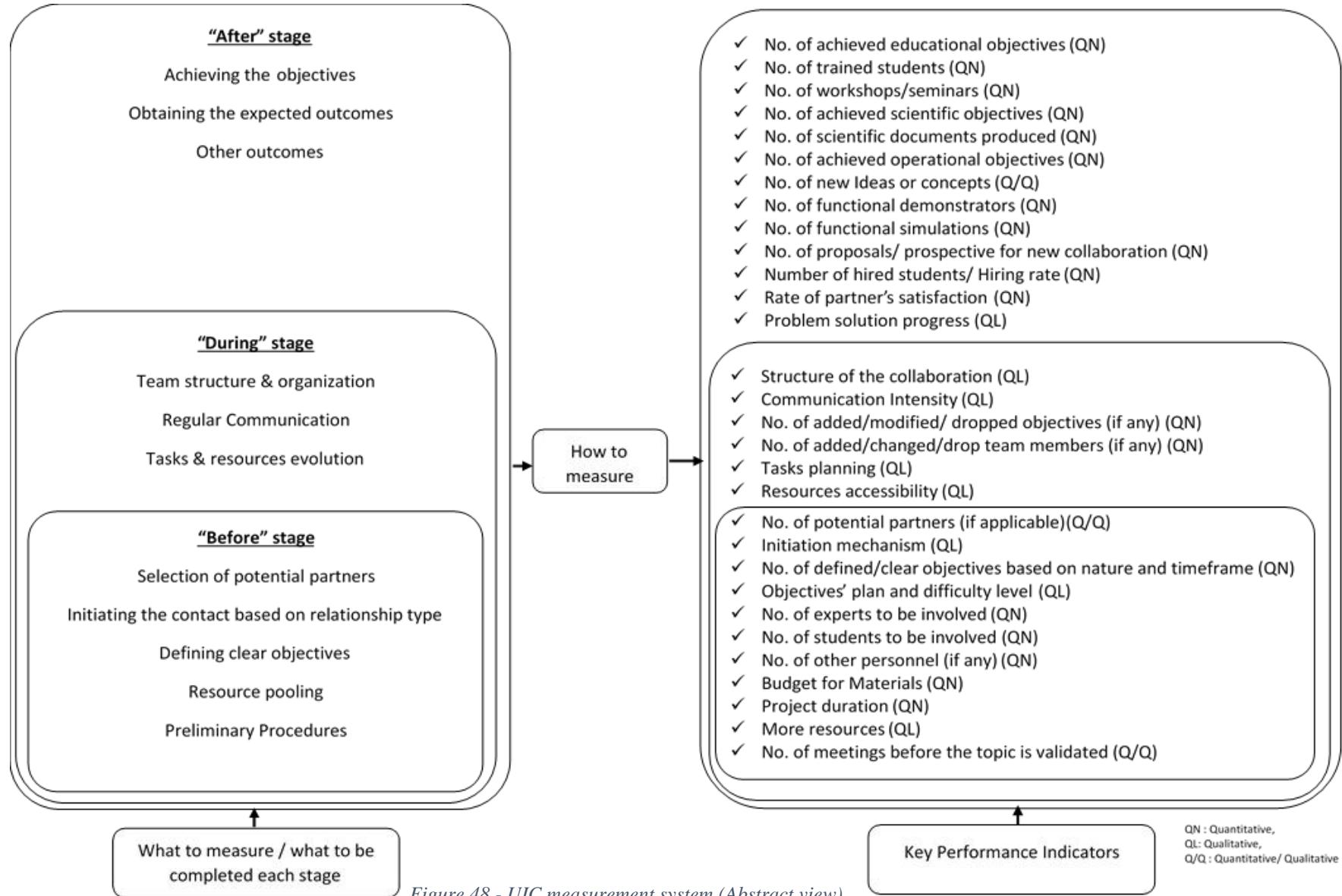


Figure 48 - UIC measurement system (Abstract view)

Stage	Component	Indicator	Type	Description
Before evaluating the intent of a desired output, but do not guarantee (Drivers) Initiation establishing	potential partner selection	No. of potential partners (if applicable)	Quantitative/Qualitative	Points to consider: how the partners were selected (whether through the steps/selection criteria or if it was not needed since the partner has an established relationship) (This gives valuable information about the characteristics of new partners)
	Relationships	Initiation mechanism	Qualitative	Points to consider: Relationship type (institutional or personal), if there was previous collaboration, former student. These elements should be taken into consideration, partner being familiar with the procedures; mechanism will positively influence the performance of this task (initiation)
	Objectives	No. of defined/clear objectives based on nature and timeframe	Quantitative	List of clear objectives
				Nature: Scientific, Educational and Operational objectives
				Timeframe: Long, Medium and Short term
		Objectives' plan and difficulty level	Qualitative	Points to consider: Objectives' plan (tasks and deliverables) and level of difficulty of the objectives (This will be considered for evaluating the achieved objective at the end)
	Resources/Inputs	No. of experts to be involved	Quantitative	Professors, Researchers, Engineers etc.
		No. of students to be involved	Quantitative	Workforce
		No. of other personnel (if any)	Quantitative	Facilities technicians, equipment's handlers etc.
		Budget for Materials	Quantitative	For expenditures and finances
		Project duration	Quantitative	Time to conduct all tasks and activities
		More resources	Qualitative	Points to consider: if all needed resources are available, the workspace settings etc
	Preliminary Procedures	No. of meetings before the topic is validated	Quantitative/Qualitative	Points to consider: Problem definition
				Points to consider: Objectives definition
				Points to consider: Familiarity with the mechanisms and procedures

During	Structure evaluating the intent of a desired output, but do not guarantee Drivers	Structure of the collaboration	Qualitative	Point to consider: how people involved are organized (students, pedagogical team, industrial team etc.)			
				Point to consider: Decision process concerning the operational activities (taken by people involved or centralized by the management of both organizations)			
				Point to consider: Collaboration culture (openness, secrecy etc.)			
Operational activities				Point to consider: the difficulties, intensity, availability in communication,			
				Point to consider: Barriers such as IP, confidentiality etc.			
				Point to consider: Mobility (site visits, facilities visit etc.)			
Evolution		No. of added/modified/ dropped objectives (if any)	Quantitative	If in the progress of the development activities, new objectives are added or the defined objectives are modified			
		No. of added/changed/drop team members (if any)	Quantitative	If in the progress of the development activities, new, changed or dropped team members			
		Tasks planning	Qualitative	Executing tasks according to plan			
		Resources accessibility	Qualitative	Points to consider: the access to facilities and equipment's			

After	Educational outcomes	No. of achieved educational objectives	Quantitative	From the previously defined educational objectives (Before stage)
		No. of trained students	Quantitative	Performed the collaboration activities
		No. of workshops/seminars	Quantitative	Educational and dissemination activities
	Scientific outcomes	No. of achieved scientific objectives	Quantitative	From the previously defined scientific objectives (Before stage)
		No. of scientific documents produced	Quantitative	This is not limited to "publication" but also, reports, bibliographic studies, case studies, surveys
	Operational outcomes	No. of achieved operational objectives	Quantitative	From the previously defined operational objectives (Before stage)
		No. of new Ideas or concepts	Quantitative/Qualitative	Novel solution concepts
				Architecture to structure a solution
				Designs to create a feature
				Architecture Designs Model/ Framework
		No. of functional demonstrators	Quantitative	Mathematical model
		No. of functional simulations	Quantitative	Prototype, mock-up etc.
	Others	No. of proposals/ prospective for new collaboration	Quantitative	Initiative to collaborate (continue and further develop the current collaboration or start new collaboration)
		Number of hired students/ Hiring rate	Quantitative	Students hired / taken for new project if not graduated
		Rate of partner's satisfaction	Quantitative	Collaboration results satisfaction
		Problem solution progress	Qualitative	Points to consider: the progress of the development to solve the problem, level of difficulties of achieved objectives etc (Uncaptured progress)
				New "best practice" learned/developed
				New partner who from now onwards became familiar with collaboration

Table 10 - UIC measurement system (Detailed)

Remarks & considerations on the KPIs

- For “Before and “During” stages, the indicators **DO NOT** guarantee the outcomes of the collaboration

For example, in the “Before” stage, we defined indicators such as “No. of defined/clear objectives”, “No. of experts, students etc.” and other resources indicators, however, having a well-defined objective or access to resources do not guarantee the outcome. Nevertheless, for us these indicators measure, “the intention/ promise” “what causes / influences the success”. This is in line with(Langford et al., 2006; Seppo & Lilles, 2012) , inputs indicators are used to measure the intent of collaboration but not the outcome. Also, (Iqbal et al., 2011; Piva & Rossi-Lamastra, 2013) in developing an evaluation model based on constraints and challenges effecting achieving the goals or the outcomes.

- We did not consider “**Bibliographic metrics**” to evaluate capabilities

Bibliographic metrics is widely used in the literature such as number of publications or citations (Perkmann et al., 2011)(Seppo & Lilles, 2012). Despite indicating, we distinguish between the different capabilities using three separate indicators (one for students, one for experts: professors and industrialist, one for facilities personnel). Evaluating capabilities is very complicated since not all students have the same capabilities nor the experts. In subsection 6.2.7, our participants indicated that, publication is not an objective in these collaborations, therefore we decided to NOT consider it.

Next subsection will be validating the proposed performance measurement.

6.5 Validation

In subsection 6.4.2 and figure 47, we indicated that the performance measurement development used the data collected in the interviews to characterize the UIC at the early stage. The characterization was used to develop the UIC framework, which is then used to develop the measurement system and its KPIs. These steps were based on eleven collaboration projects hence the measurement system was deduced from these cases. We decided to further attempt a broader applicability of this measurement system beyond the analyzed eleven cases (induced). We will apply the performance measurement and the KPIs sets on two pilot cases.

The pilot evaluation

The objective of testing proposed performance measurement system is to assess the feasibility of the developed evaluation process (based on the three stages) as well as to validate the KPIs. We performed this with two projects of the Plateaux Projets (product industrialization) at Grenoble INP - Génie Industriel. We accessed the database of the Plateaux Projets and chose two projects with a condition that, the two projects were recurrent projects where the collaboration is extended over 2-3 years (NOT one-time collaboration). This characteristic is important since we need to analyze the progress of the collaboration and access rich data over the years.

The data was collected from two sources for each project, first an interview with academic tutor who has in-depth knowledge and experience of the collaboration process, organization and other aspects. This gives depth on the data collected from the interview for the validation of the KPIs. The interviews were structured around the KPIs presented table 10. The second source is the projects reports and documentation available on the database. The project team prepared these documents. The validation will be conducted stage by stage. A KPI will be validated if it is validated by both projects, if one project does not validate the KPI then the KPI will be rejected.

Validation of the “Before” stage KPIs

This stage is linked to the initiating and establishing the collaboration. The academic tutors emphasized on definition of the collaboration’s objectives as an indicator for the success. In addition, before agreeing on the collaboration, they explained the plans and the time line for the industrialist to highlight the constraints. These discussions, allow the partners to formulate and structure the collaboration around in a way to produce reasonable results for the industry while leaving enough time and autonomy and for the students to do the apprenticeships. Therefore, planning is an important indicator during the phase of defining the collaboration problem. However, Number of potential partners or number of meetings to define and plan the objectives are irrelevant to both tutors since the type of relationship has a direct impact on this phase. Recurring collaboration makes this stage easier and faster. Industrial partners become familiar with university’s procedures and mechanism and they know what to expect for the students. Combining resources is an important element to boost the success of the collaboration. In the projects reports, resources used are elaborated in terms of workforce (team members, supervisors and facilities personnel) or budget. **Table 11** below shows the KPIs validated and rejected KPIs at the “Before” stage

KPI	KPI Type	Project 1	Project 2
No. of potential partners (if applicable)	Q/Q	✗	✗
Initiation mechanism	QL	✓	✓
No. of defined/clear objectives based on nature and timeframe	QN	✓	✓
Objectives’ plan and difficulty level	QL	✓	✓
No. of experts to be involved	QN	✓	✓
No. of students to be involved	QN	✓	✓
No. of other personnel (if any)	QN	✓	✓
Budget for Materials	QN	✓	✓
Project duration	QN	✓	✓
More resources	QL	✓	✓
No. of meetings before the topic is validated	Q/Q	✗	✗

✗: Rejected ✓: Validated QN : Quantitative, QL : Qualitative, Q/Q : Quantitative/ Qualitative

Table 11 - Stage "Before" Validation

Validation of the “During” stage KPIs

This stage is the heart of the collaboration which is conducting the operational activities.

These activities involve students, pedagogical team and industrial tutors. The interviewees insisted on two main points at this stage, communication and decision-making process. In project 2, the collaboration on the 1st year was not efficient and the results did not achieve a satisfactory level. Pedagogical team and industrialists held a special meeting to discuss and analyze the reasons for such a performance. Both agreed that the quality of the communication must be improved in terms of responsiveness and commitment. Furthermore, the interviewees pointed out some other factors for poor communication such as collaboration culture (openness, secrecy,), barriers such as IP, confidentiality and mobility. Both tutors need to visit sites, facilities and attend collaboration sessions and presentations with students. On the decision process with regard to the technical aspects of the collaboration, normally a horizontal process involves only those who are involved in the operational activities. On the evolution of the objectives and the team, both projects rejected that as an indicator since evolution is part of any project when trying to find a new solution. The general objective of the project does not change. Details of the specifications may change depending on the feasibility, benchmarks and materials used. **Table 12** below shows the KPIs validated and rejected KPIs at the “During” stage

KPI	KPI Type	Project 1	Project 2
Structure of the collaboration	QL	✓	✓
Communication Intensity	QL	✓	✓
No. of added/modified/ dropped objectives (if any)	QN	✗	✗
No. of added/changed/drop team members (if any)	QN	✗	✗
Tasks planning	QL	✓	✓
Resources accessibility	QL	✓	✓

✗: Rejected ✓: Validated QN : Quantitative, QL : Qualitative, Q/Q : Quantitative/ Qualitative

Table 12 - Stage "During" Validation

Validation of the “After” stage KPIs

This stage is “after” the completion of all operational activities. There are four types of outcomes (scientific, educational, operational and others). These outcomes are related to the objectives that were defined before the start of the collaboration. For both projects, achieving these objectives are essential indicators of the success of the collaboration. With regards to the dissemination activities, both projects indicated that they do not conduct such activities however, they believe it is an important indicator for the success since the results or the feedback will be communicated to wider audience. They both, raised the question of confidentiality to communicate the results where the communication might be limited. For the possibility of further/extending collaboration and the satisfaction of the industrial partners, project 2 and 1 respectively proposed qualitative indicators. Hiring students after the collaboration project is an important indicator since it shows the success and quality of a team member in conducting the collaboration activities but also the satisfaction of the partners. **Table 13** below shows the KPIs validated and rejected KPIs at the “During” stage

KPI	KPI Type	Project 1	Project 2
No. of achieved educational objectives	QN	✓	✓
No. of trained students	QN	✓	✓
No. of workshops/seminars	QN	✓	✓
No. of achieved scientific objectives	QN	✓	✓
No. of scientific documents produced	QN	✓	✓
No. of achieved operational objectives	QN	✓	✓
No. of new Ideas or concepts	Q/Q	✓	✓
No. of functional demonstrators	QN	✓	✓
No. of functional simulations	QN	✓	✓
No. of proposals/ prospective for new collaboration	QN	✓	✓*
Number of hired students/ Hiring rate	QN	✓	✓
Rate of partner’s satisfaction	QN	✓*	✓
Problem solution progress	QL	✓	✓

x: Rejected **✓:** Validated **✓* :** Modified **QN :** Quantitative, **QL:** Qualitative, **Q/Q :** Quantitative/ Qualitative

Table 13 - Stage "After" Validation

In summary, four indicators were rejected “No. of potential partners (if applicable)”, “No. of meetings before the topic is validated”, “No. of added/modified/ dropped objectives (if any)”, “No. of added/changed/drop team members (if any)”. Two modification were proposed for two indicators: “No. of proposals/ prospective for new collaboration”, “Rate of partner’s satisfaction” to be qualitative rather than quantitative indicators.

Both projects suggested new indicators:

New KPI	Description
Students’ evaluation	As the main objective is educational, evaluating what students learn is crucial
Student’s satisfaction	To evaluate “openly” students disappointment, satisfaction, difficulties etc
Frequency of exchange with industrialists	This reflects the engagement and satisfaction level

6.6 Conclusion

Evaluating the performance and success of UIC is a challenge that we address in this study. As indicated in the related work in the literature (subsection 6.4.1), UIC’s evaluation is major challenge not just for universities and industry, but also for researchers investigating evaluating early stage development collaboration (Perkmann et al., 2013).

We developed a measurement system that evaluates the progress as well as the success of the collaboration. As shown in figure 48, we defined 30 KPIs. The idea is not to apply these KPIs at once but rather a stage by a stage as the collaboration progresses. There are three sets of KPIs each set corresponds to one stage of the collaboration. Sets will be 11 KPIs for the “before” stage, 6 KPIs will be for “during” stage and 13 KPIs for “after” stage. They are a combination of quantitative and qualitative KPIs. In the validation, 4 KPIs were rejected, 2 modified and 3 new KPIs were suggested. In the next chapter, the limitations of the study will be discussed.

General Conclusion & Future research

The aim of this chapter is to close this thesis with a brief recap of the main findings & contribution of the study then the relevant future research and limitations.

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7 Conclusion

In chapter two (section 2.1), figure 2, the global view of university-industry collaboration was presented as two main concepts, academic engagement (knowledge-related activities, upstream) and commercialization (IP creation and licensing activities, downstream). In the literature, most studies focus on describing the downstream processes associated with technology transfer and commercialization. The upstream part of the process which is associated with knowledge-related activities, is under-researched. This study focuses on upstream part of the university-industry collaboration, that involves the operational activities such as generating, consolidating and testing ideas. However, before the start of operational activities there are also administrative activities. This includes the initiation and establishment of the collaboration. This chapter will recall the main contributions of the study, suggest future research directions then highlight the limitations of the study.

7.1 Study Contributions

The purpose of this study is to investigate and systematically describe the relevant characteristics of multiple aspect of the UIC at the early stage development from initial conditions to eventual outcomes. The in-depth analysis of multiple collaboration aspects is used to develop a framework as a comprehensive view of the UIC encompassing the various aspects at different stage. This is framed by the research question:

Broad Question: How academic engagement influences the university-industry collaboration?

Sub-questions

- What are the characteristics of the early stage collaboration between universities and SMEs?

- What are the key performance indicators that evaluate university-industry collaboration at the early stage?

In tackling these questions, the study's contribution is divided into three main parts:

- UIC characterization: Describing and analyzing different aspects of UIC
- UIC framework: integrated comprehensive view
- Performance measurement system and KPIs to evaluate the UIC

7.1.1 Collaboration's Characterization

The aim of this part of the study is to characterize the early stage development UIC. Section 6.2, we analyzed and discussed the collected data about twelve themes: **Collaboration's objectives, Relationships, Structure, Process, Intermediaries, Knowledge, Outcomes, Proof of concept, IP policy, Public Funding, Organizational culture and Success factors.** Performing this analysis, gave us a better understanding of the collaboration as an entire process from the initial conditions to the eventual outcomes. In addition, this allowed us to systematically describe the relevant characteristics of each aspect of the collaboration. In subsections 6.2.1 to 6.2.12, the different aspects (themes) are described at different levels (individual & organization) with different characteristics.

7.1.2 UIC framework

The aim of this part of the study was to have an integrated comprehensive view of the early stage development UIC. From section 6.2, we used the detailed description of the various components of the UIC. We developed the framework on three stages section 6.3:

- ***Before the collaboration:***

Before teams from university and industry collaborate, the collaboration idea, objectives, resources, mechanism etc., have to be agreed upon. This takes place at what we call initiating and establishing the collaboration. Initiating the collaboration is simply the initial contact to enquire about the possibility of the collaboration. Establishing the collaboration is the process of validating the topic, setting the objectives, resources pooling and contracts. These are mostly collaboration administrative activities.

- ***During the collaboration***

Conducting the operational activities to develop the desired solution/outcome is the core component of this stage. This includes Kick-off meeting to present the project in details. Performing tasks and activities on regular basis and following a precise schedule. Regular meetings take place to review the progress of the work and address the needed adjustment. Communication is an important element at this stage, where team communicate regularly. The elements that have been decided in the previous stage (such as objectives, plans, resources etc.) could evolve according to the progress of the work.

- ***After the collaboration***

This stage concludes the collaboration. It is when the teams completed the operational activities. Delivering the outcomes of the collaboration. These outcomes are a combination of different types of outcomes (educational, scientific, operational and other outcomes) as discussed in subsections 6.2.7 and 6.3.3. One important element to recall here is the possibility of new collaboration or continue the work on the project.

We also incorporated in the framework a set of success factors that will influence the collaboration. The framework helped us in developing the measurement system and defining the KPIs to evaluate the UIC.

7.1.3 Measurement system and KPIs

Using the UIC framework developed in section 6.3, we developed a measurement system that evaluates the progress as well as the success of the collaboration. In subsection 6.4.2, figure 48 provides an abstract view of the measurement system, a detailed description of the KPIs is provided in table 10. We defined a set of quantitative and qualitative KPIs for each component of each stage. We considered different issues raised by the literature as well as our participants regarding the KPIs. These issues include the difficulty to evaluate the academic engagement, visibility of the results, intangible knowledge etc. Figure 49 below, provides an overview of the sequence of the study.

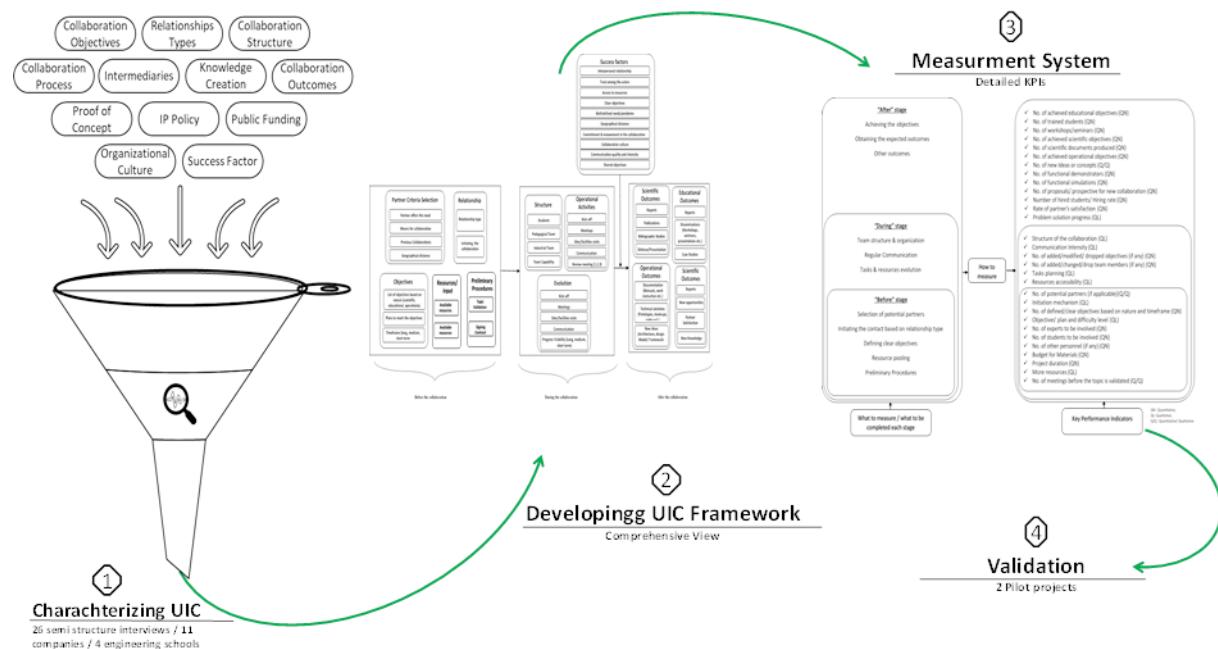


Figure 49 - The sequence of the study

Despite the broader applicability of the proposed tool (framework and performance measurement), however the purpose of this tool in this study is to improve the effectiveness of UIC. It is a twofold purpose:

- The framework will help to guide the building of university-industry collaboration through guiding the actors at different stages while considering various elements in each stage.
- Evaluating the progress as well as the success of the collaboration taking into considerations different factors that impact on the collaboration positively and negatively.

7.2 Limitation & Future research

While noting the important contributions made by this study, we recognize a number of limitations. These limitations open some directions for future research:

- One limitation is that, the data collection was limited to data on the collaboration process (from initiation until end) including the administrative activities to initiate and establish the collaboration, then the operational activities to complete the collaboration tasks. In order to better understand the role of education programs on the collaboration it would eventually be necessary to collect information on student's courses prior to the collaboration. The courses could be related to innovation process, design thinking, business development, Proof of Concept, Agility, project management etc. Analyzing these aspects might give some insight on the impact and role of education programs.

- Although the study compared different perceptions of practitioners, researchers and funding programs on the PoC, Lack of characteristics and practices of PoC by the relevant stakeholders needs to be addressed in the future research.
- External validation, a future research should attempt a broader applicability of the measurement system beyond the analyzed cases (induced) and the two pilots used for validation. It would be enriching to see what types of KPIs suitable for practitioners and for the university staff. Furthermore, evolution and improvement of the KPI.
- Limited exploration of Open Innovation in this study, OI is not only trending in the research literature but also in the industrial practices. In this study we explored slightly OI link to UIC (subsection 3.2.2.2) as the knowledge flowing from one organization to another and the university's role as a knowledge source.
- Other interesting questions could be: To which limit the partners can be open? Who should apply the evaluation mechanism to evaluate the collaboration? (people involved or external)

7.3 Application of the research results

Despite the broader applicability of the proposed tool (framework and performance measurement), however the purpose of this tool in this study is to improve the effectiveness of UIC. It is a twofold purpose:

- The framework will help in building university-industry relation by guiding the actors at different stages while considering various elements in each stage.
- Evaluating the progress as well as the success of the collaboration taking into considerations the different factors that might have positive or negative impact on the collaboration.

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Annexes

Annex 1: Interviews' guide

Contents

1. Introduction: introduce myself and make a short presentation on the aim of the research
2. Validate the interview condition (length, recording, confidentiality ...)
3. First question : Invite interviewee to briefly introduce him/her self
4. Main questions: questions of themes that will be discussed
5. Closing the interview

Introduction

I'm a researcher from *GSCOP* and I'm working on project called (OIPPEC) Open innovation Platform for University-Enterprise Collaboration, which is a research and collaboration project funded by the Erasmus+ Program of the European Union

This study attempts to gain insight and explore in depth the perceptions, perspectives of open innovation collaboration between universities and enterprises in the French context.

We intend to study the collaboration [before it starts, during and after it ends] to characterize the university enterprise relationship through industrial projects which involves company / school (dept) / students, Our investigation includes also:

- ✓ Identifying the models/tools/ practices.
 - How enterprises find universities projects that involve students?
 - What are the basic structures of the people / units involved in the collaboration? (Professors, researchers, students, administrators, etc. laboratory, platform, cell relations companies, etc.) (model structure)?
- ✓ Describing in-depth the innovation activities of the collaboration.
- ✓ Understanding the respective benefits of the collaborators.
- ✓ What are the main factors of good collaboration?

What changes are likely to promote more effective UE collaboration?

We selected your project for this discussion since it fits with the object of our research because it characterize the university-enterprise relationship through industrial projects that involve entreprise / school (dept) / student.

Validate conditions of the interview

Do you agree to discuss these topics with me?

I suggest a 45 minutes long discussion? Is it ok for you?

Do you mind if I record our conversation? The recordings are only for internal communication within the project. The recordings won't be published and there will be no direct citation of your words without your explicit permission for which we would ask you first. If you want so, we can also anonymize the interview, so your name don't appear.

[start the audio recorder only after the person agreed with the conditions]

First question

Invite interviewee to briefly tell me about him/herself? General information about background his/function?

Main questions

Strive to ask:

- Unbiased questions
- Focus on open-ended questions
- Avoid "why", prefer "what"
- Avoid ended questions.
- Vague terms or jargon
- Assumed knowledge

Closing the interview

Conclusion question "Is there anything else you'd like to add?".

Turning off the recorder.

Then ask if it is possible to contact the interviewee later in case of additional details or clarifications are needed.

Finally thanking the interviewee for their time and accepting to do the interview

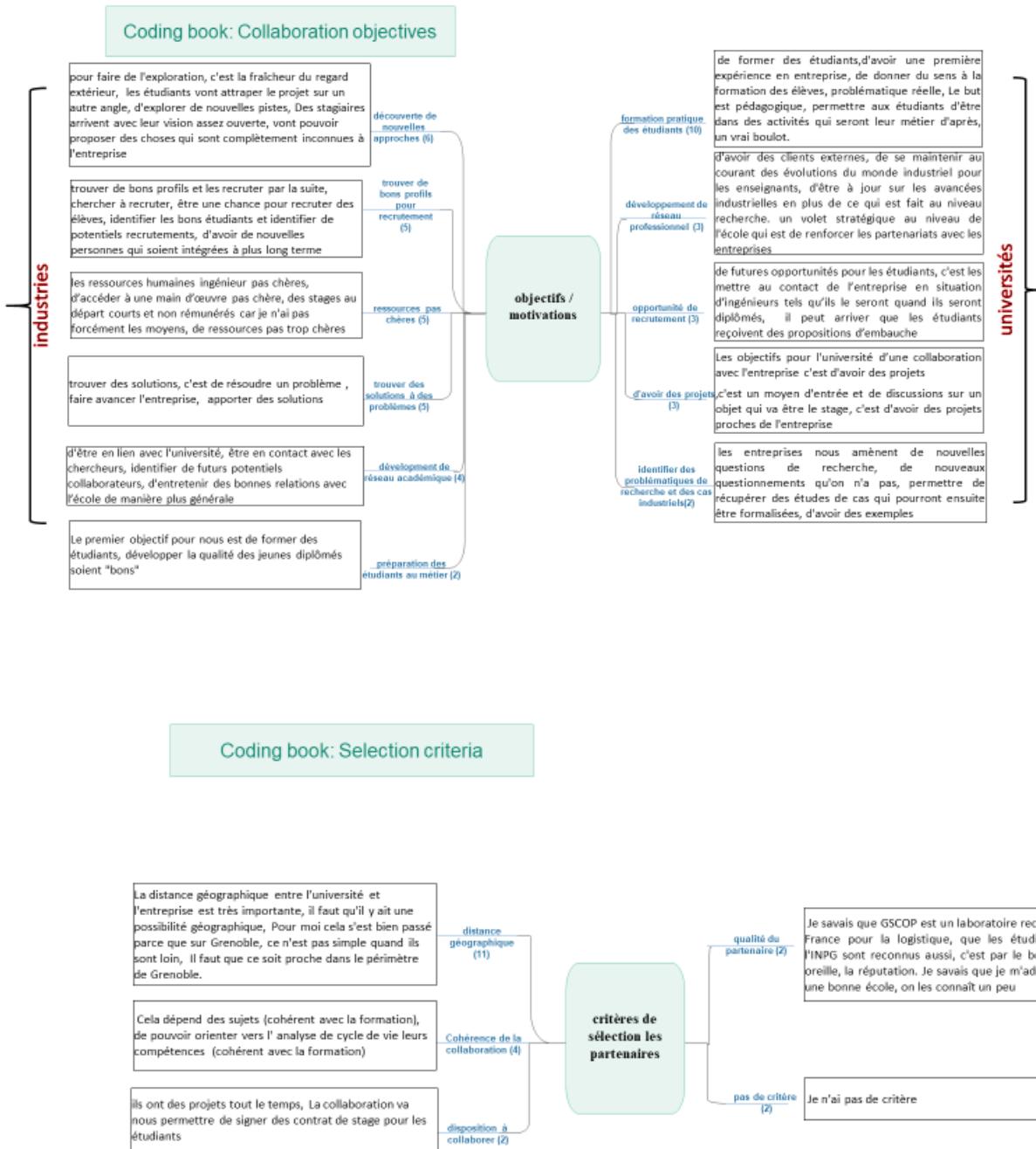
Interview Card



Date	
Time	
Place	

Organization	Name	Position	Field of expertise

Annex 2: Examples of the coding book



Annex 3: Systematic literature review main analysis

Categories	Sub-categories	Frequency			
External Resources	Profitability	4			
External Resources	Human Capital	12			
External Resources	Knowledge	21	ER		113
External Resources	Reducing The Risk	6	PM		24
External Resources	State Policy	10	OS		152
External Resources	Intermediaries	19	PX		9
External Resources	Alignement of goals	16			298
External Resources	Fund	17			
External Resources	Facilities	3			
External Resources	Cost Reduction	5			
Performance Measurement	Effectiveness	4			
Performance Measurement	Number of Patents/Proc	13			
Performance Measurement	Environment impact	1			
Performance Measurement	Number of Projects	1			
Performance Measurement	Number of Publications	5			
Organizational Structure	Structure	32			
Organizational Structure	Process	34			
Organizational Structure	Relationship Type	45			
Organizational Structure	IP policy	19			
Organizational Structure	Openness/Culture	17			
Organizational Structure	Changes in the organizat	5			
Proximity	Geographical	5			
Proximity	Industry	3			
Proximity	Social	1			
		298			

