MASTER

Educational cooperation in the European automotive sector

towards an integrated approach to strengthen innovation in the European automotive sector

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Towards an integrated approach to strengthen innovation in the European automotive sector

Master's Thesis

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“Competition has been shown to be useful up to a certain point and no further, but cooperation, which is the thing we must strive for today, begins where competition leaves off.”

Franklin D. Roosevelt

PREFACE

The European year of creativity and innovation, 2009, was dominated by the financial crisis. Many key players argued that more creativity and innovation is the right answer to the financial crisis and the way to go forward for Europe. The president of the European Commission (EC), Jose Manuel Barroso, presented the EU 2020 strategy at the end of 2009 underlining this view. Creativity and innovation are very important for the automotive sector as well, as one of the sectors that was most severely hit by the crisis. In 2011, only two years after the financial crisis, there are signs that the economy is double dipping, and that the automotive sector will be hit hard again. A traditionally strong sector for Europe that faces a technological revolution (electrification) and a financial crisis at the same time. Creativity and innovation will be needed to face the challenges ahead. But how do you support the emergence of more innovation?

At the time of asking myself the question how we can support the emergence of innovation, I was working for the Netherlands house for Education and Research (Neth-ER) at the heart of the European Union: Brussels. And in that time, the earlier mentioned president of the European Commission, Barroso, proposed the foundation of the European Institute of Innovation and Technology, to bring together education, research and innovation (the policy areas constituting the working field of Neth-ER) to boost innovation. A bold and innovative idea, which led me to write the thesis lying before you in which I research the question: when looking to support the emergence of more innovation, in particular in the automotive sector as shaped by EU policy, could education and educational cooperation play a role?

This thesis can be useful for everyone wondering the same thing I did: how to come to more innovation using education(al cooperation)? It can be of particular interest to those, mainly policy makers at universities, companies (small and big) and governments (from local to a European level), that need a better insight in the possible value of investments in the development of educational (cooperation) programme's when wanting to stimulate innovation. It will be especially useful for those involved in the automotive sector so beloved by me, but also to the educational institutions wishing to educate future innovators. And, hopefully, it will also be useful for someone that can take this research further and explore whether or not education(al cooperation), ten years from now, really has contributed to innovation.

For me, personally, this is a thesis that combines the knowledge and experiences that I gained during the past 15 years of my life. It all started with my love for automobiles that made it logical to study automotive engineering. But this did not give me the satisfaction that I was looking for. So after I got my bachelor's degree, I decided to continue studying innovation sciences with the specialisation in Technology & Policy. With the finishing of this thesis, I conclude my Master Innovation Sciences at the Eindhoven University of Technology, and go back to normal life. I wrote this document while holding a full time job, and thus a lot of spare evenings, weekends and vacations were invested into this project.

It has not been a quick, nor an easy, exercise and the completion of this thesis would not have been possible without the assistance and support of some people. I would like to conclude this preface by thanking two of them in particular. Firstly, I would like to thank my girlfriend Nynke for all her support and understanding. I could not have done this without her. Secondly, I thank Professor Schot for his patience and his supervision that helped me in developing the methodology and discouraged me from writing desirabilities. Finally I would like to thank my former colleagues at Neth-ER; Frans, Fried and David for all their support over the years.

SUMMARY

This thesis was inspired by the setting up of the European Institute of Innovation and Technology, which was proposed by the president of the European Commission, Jose Manuel Barroso, in 2006. It was meant to strengthen the knowledge triangle – of education, research and innovation – which is a central concept in European policy, believed to be a key for stimulating innovation and strengthening the growth and competitiveness of the European Union. Little is known however about the link between education(al cooperation) and innovation that is part of this knowledge triangle. That is a blind spot in innovation literature that this thesis aims to reduce, by providing an answer to the question if education(al cooperation) can contribute to innovation, according to theory, and in current practice. Since it is a blind spot in literature, the research needed to be exploratory, searching theories for what is known. Case studies were then performed to collect information from everyday situations to learn about education(al cooperation) in practice

Exploring innovation theories for what is known about the link between (elements of) education and educational cooperation and innovation, led to a model of six factors that can be met by education(al cooperation) for it to be able to contribute to innovation: the presence of Open Innovation in the sector; the presence of the educational institute in a cluster; the facilitation of interaction by students with other students (mainly via exchange programs); the presence of innovation theory in the educational programme; the offering of lessons by part time teachers that also work for the industry; and the attention in the program for the development of personal skills of students such as creativity, initiative and self-confidence.

When researching practice, an analyses of related European policy showed that the European Union recognises the importance of education(al cooperation) for innovation and stimulates some of the factors. Not all, since a lot is up to the member states or the institutes. And the policy stimulating the factors is also still very young. The student exchange programs (Erasmus Mundus and Joint Degrees) have been around longer, but the European Institute for Innovation and Technology, which is the most important EU-instrument to stimulate interaction between education and innovation, is just a few years old and still being developed.

Practice was examined further when looking into two case studies, concerning educational cooperation within the automotive sector as shaped by the EU. An examination of the sector learned that the factor of Open Innovation is present in the sector and that the presence of all five other factors are important for innovation in the automotive sector as well. The actual case studies were executed by using the method of Yin, and concerned two joint degrees relating to automotive engineering on Master's level involving three EU countries. The results showed that current educational cooperation in the EU is still very young and developing, but that it already contains some of the factors indicated by theory to be of importance to be able to contribute to innovation. Especially the factors of facilitating the exchange of students and providing lessons by teachers form the industry (both stimulated by EU policy) are already very much in place. The potential to contribute to innovation is there, but the implementation in practice of some of the factors could be improved and some factors still need to be incorporated since they are not at the moment. It is mainly education on innovation theory that needs attention, as well as the development of entrepreneurial skills of students. The emergence of clusters will be important as well.

According to innovation theory educational cooperation can contribute to innovation when meeting one or more of six factors, and with the stimulation of EU policy, educational cooperation in

practice already meets some of the factors and thus has the potential to contribute to innovation. If theory is right and meeting the six factors really does give educational cooperation the potential to contribute to innovation, can be researched further when policy and practice have developed further and the programmes have delivered a significant number of graduates that have found their place in society and/or the innovation system. This research can be a basis for that research proving theory right or wrong. In the meantime it has given policy makers and educators a guide to use the room for improvement and improve policy and programs in such a way that education(al cooperation) can potentially contribute to innovation in the future. And by doing that, this thesis may have contributed to what Jose Manuel Barroso had in mind in 2007: stimulating innovation, increasing the competitiveness of the EU, changing the world.

Persbericht

Onderwijs(samenwerking) kan bijdragen aan innovatie

Met een scriptie over de bijdrage die onderwijs(samenwerking) kan leveren aan innovatie, heeft Marc Smits onlangs de Master 'Innovation Sciences' afgerond aan de TU/Eindhoven. Hij deed dat onder begeleiding van Professor dr. Johan Schot.

José Manuel Barroso

De scriptie is geïnspireerd op een idee van Jose Manuel Barroso, voorzitter van de Europese Commissie. Die stelde in 2007 de oprichting voor van het Europees Instituut voor Innovatie en Technologie, dat de interactie binnen de zogeheten kennisdriehoek – van onderwijs, onderzoek en innovatie – moest verbeteren. Het idee van de kennisdriehoek is recentelijk uitgegroeid tot een centraal begrip in het Europees beleid dat Europa uit de crisis moet halen, groei moet bevorderen en competitie met de rest van de wereld mogelijk moet maken.

Witte vlek

Hoewel veel bekend is over bijvoorbeeld het belang van interactie tussen de werelden van onderzoek en innovatie, bestaat er een witte vlek in de innovatieliteratuur als het gaat om de relatie tussen onderwijs en onderwijssamenwerking enerzijds en innovatie anderzijds. De scriptie poogt deze witte vlek te verkleinen. Uit het verkennende onderzoek blijkt dat uit bestaande innovatietheorieën kan worden opgemaakt dat onderwijs(samenwerking) een bijdrage kan leveren aan innovatie. Daarvoor moet aan een of meerdere van zes factoren worden voldaan.

Op de goede weg

Uit een uitgevoerde beleidsanalyse en casestudies blijkt dat deze zes factoren gedeeltelijk gestimuleerd worden door de EU en ook al herkenbaar zijn in bestaande onderwijssamenwerking. Onderwijssamenwerking heeft in theorie én praktijk dus het potentieel om bij te dragen aan innovatie, maar er blijkt ook nog veel ruimte te zijn voor verbetering. Met deze thesis kan toekomstig onderzoek uitgevoerd worden naar de daadwerkelijke bijdrage aan innovatie van de onderwijssamenwerking, waarmee de witte vlek in de innovatieliteratuur nog verder verkleind kan worden. Ook biedt dit onderzoek houvast voor beleidsmakers, zoals die er al zijn in de EU, en onderwijsinstellingen die onderwijs(samenwerking) optimaal willen inrichten om innovatie te bevorderen. Zodat Europa uit de crisis kan klimmen, groei wordt bevorderd en competitie met de rest van de wereld mogelijk wordt. Zoals Jose Manuel Barroso in 2007 al voor ogen had.

REPORT OUTLINE

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CHAPTER 1 INTRODUCTION

1.1. Research motive

In 2006, the president of the European Commission (EC), Jose Manuel Barroso, proposed the setting up of the European Institute of Innovation and Technology[1] (EIT) to address Europe's “innovation gap” and to enable Europe to more effectively face the challenges of a globalising, knowledge-based world economy. There was a big difference in the innovation performance between Europe on the one side and leading innovation nations like the United States of America (USA) and Japan on the other side[Fagerberg et al 1999: 2]. The EIT should rapidly emerge as a key driver of sustainable growth and competitiveness in the European Union (EU) by stimulating world-leading innovation through the strengthening of the ‘knowledge triangle’[2]. Education and its role in the process of innovation is a cornerstone of the EIT's strategy to enhance the innovation performance of Europe.

In 2007, the European Parliament (EP) initiated four pilot projects for cooperation between European institutes of innovation and technology, in order to get a better understanding of cooperation in the knowledge triangle and thus the best way of shaping a possible EIT [EC2007a]. The goal of these projects was to

> “…..facilitate knowledge-sharing and technology transfer by building up the capacity of European networks in strategic interdisciplinary fields....”

The results of these projects should lead to a new, more integrated form of partnership that could be institutionalised in the EIT.

One of the pilot projects of the European Parliament was Green and Safe Road Transportation (GAST)[3], in which I was personally involved. This project was designed to significantly enhance the integration of education, research and innovation in the European automotive sector in order to make road transportation greener and safer. The pilot project finished in November 2009 and recommended, among other things, that further research be carried out into educational cooperation in European automotive clusters [GAST 2009]. GAST expected that the outcome of this research would be that educational cooperation in automotive clusters would be beneficial for innovation.

GAST's recommendation, and the setting up of the EIT before this pilot project was finished, made me curious. Can cross border educational cooperation really benefit innovation and thus help the EIT in its aim of stimulating innovation in Europe? Since educational cooperation was set up only recently, it is not possible for me to research - as GAST recommended - if educational cooperation in automotive clusters is beneficial for innovation. I can however explore whether or not educational cooperation has the potential to be beneficial for innovation.

1 More information on the EIT can be found in paragraph 5.2.2.
2 The knowledge triangle visualises the inter-relatedness between research, education and innovation, and with that research and education as key drivers for innovation. More information on the knowledge triangle can be found in paragraph 5.2.2.
3 More information on the GAST pilot project can be found in Annex II.

1.2. Research problem

As explained in paragraph 1, in this master's thesis I will research if educational cooperation can contribute to innovation. As will become clear from this paragraph, something similar has not been done before and little is known about the contribution of education(al cooperation) to innovation.

Knowledge has been at the heart of economic growth and the gradual rise in levels of social well-being since societies started arising. Inventing, innovating to create new knowledge and new ideas that are then embodied in products, processes and organizations, has always served to fuel development. From the medieval guilds through to the large business corporations of the early twentieth century, from the Cistercian abbeys to the royal academies of science that began to emerge in the seventeenth century. They have all been part of knowledge creation to fuel economic growth. It is now widely accepted that the creation, dissemination, and application of knowledge have become a major engine of economic growth [Shapiro et al 2007: 15]. Innovation drives economic growth because,

> “..........Through innovation processes leading to the creation of new knowledge and its application in new or better products, services, processes, and modes of organisation, or application of existing knowledge and/or technologies to new contexts.........” [Shapiro et al 2007: 10]

Innovation, knowledge, and technology are such powerful drivers of economic growth because unlike capital and labour, they do not suffer from diminishing returns [Shapiro et al 2007:11]. In other words, the creation of knowledge and technological innovation can actually increase the return to further knowledge and innovation, thus creating a powerful growth mechanism.

Europe is in the middle of developing into a knowledge-based economy. It is involved in an active transition from an economy based on traditional factors of production (land, labour, capital) towards an economy in which the major components are information and knowledge. The objective of this transition is to build a modern and effective economy that not only produces and applies relevant knowledge and information, but also makes these available to the largest number of individuals and organisations in order to allow them to profit from and contribute to the knowledge-based economy. The importance of knowledge for economic productivity has been rising because of this transition and it is expected to rise further with the further transition into a knowledge-based society.

The relation between knowledge and productivity basically consists of two 'pillars' [Shapiro et al 2007:10]:

1 research and innovation processes leading to the creation of new knowledge and its application in new (or better) products and services. See figure 1

2 education and training leading to a skilled labour force better able to produce and apply knowledge and information. See figure 2

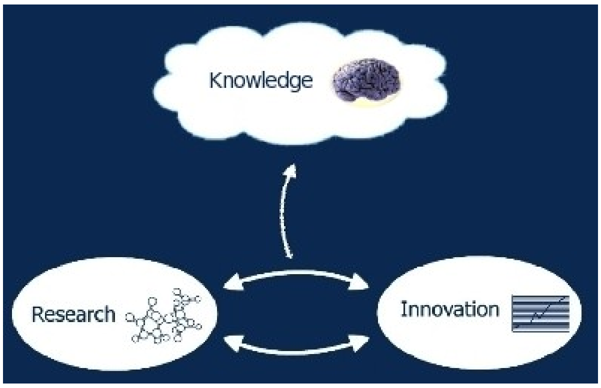


Figure 1: Pillar 1, relationship between knowledge and productivity

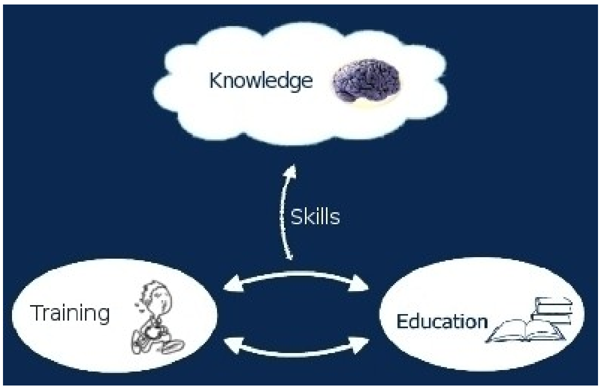


Figure 2: Pillar 2, relationship between knowledge and productivity

Much is known about the effect on innovation of the research-knowledge dimension that is portrayed in 1, but very little is known about the effect on innovation of the education-knowledge dimension portrayed in 2. As explained in paragraph 1.1, in this thesis I will focus on educational cooperation in particular. GAST perceived educational cooperation to be a means to improve the knowledge triangle – the EU policy concept that is similar to the second pillar and will be introduced in detail in paragraph 5.2.2.

According to the vision of the EU better interaction – a more 'integrated approach' - between the three dimensions of the knowledge triangle (innovation, research and education) will have a positive effect on innovation, and improved innovation will have positive effects on productivity. As mentioned, little is known about the influence of education on innovation; this is basically a blind spot (see figure 3). It is a dimension of the knowledge triangle that seems to be largely neglected by researchers, like the second pillar of the relationship between knowledge and productivity.

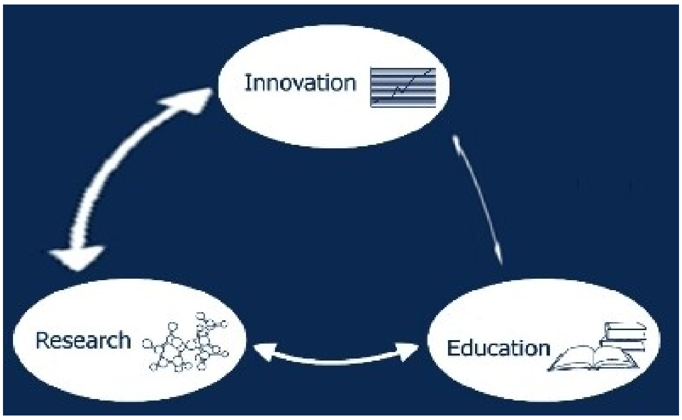


Figure 3 Graphical presentation of the research available on interaction within the knowledge triangle.
Note: *the figure shows that little research on the interaction between education & innovation and education & research is known*

This research aims to contribute to research that opens up this blind spot by researching whether educational cooperation can boost innovation in Europe. Educational cooperation not only improves education but also contributes to more interaction within the knowledge triangle; a more integrated approach. The potential influence of educational cooperation on innovation cannot fully be separated from the influence of education on innovation. An educational institution cooperating with one or more other educational institutions may strengthen that cooperation by offering a joint programme and educational institutions that do not cooperate yet may enrich their education by offering student mobility programmes. Because of this interrelationship between education and educational cooperation I will broaden this research to the influence of education, while focussing on educational cooperation.

1.3. Research objectives

In this section the research goal, research question, scope and hypothesis are addressed. The research questions consist of a main question and related sub questions.

Research goal:
To investigate whether (existing) education(al cooperation), as shaped by the EU, can contribute to innovation, in the European automotive sector.

Research question:

Can education and educational cooperation contribute to innovation?

Research sub-questions:

1. What are the definitions of innovation, education and educational cooperation?
2. According to innovation literature, what is the relation between education(al cooperation) and innovation,
   a) Can education(al cooperation), theoretically, contribute to innovation? And if so, how?
3. Is this theory applied in practice in the EU; Can education and educational cooperation in the automotive sector, as shaped by EU policy, contribute to innovation according to innovation literature?
   a) What is the EU policy for education(al cooperation) in relation to innovation and does it resemble innovation literature?
   b) What are the specifics (of innovation) in the European automotive sector? Is the automotive sector able to absorb education(al cooperation)?
   c) What does EU policy for education(al cooperation) in relation to innovation look like in practice in the automotive sector? Does it resemble innovation literature?

Scope:
The scope of this research will be the European automotive sector. By focusing on this sector the research framework is limited. However, the theoretical research done for this thesis is of a general nature and, although limited to the European policy area, the conclusions on the match between theory and European practice is also of a more general nature, so more general applicable conclusions can be drawn and the research can be useful for a bigger audience.

Hypothesis
Education and educational cooperation have the potential to contribute to innovation in theory and in practice.

1.4. Research design

As to the research design of this thesis, it is important to note two aspects of the research: it is exploratory and it will make use of a case study.

As became clear from the sub-questions as posed in the previous paragraph, in order for me to be able to answer my research question, I will need to find literature on the importance of education(al cooperation) for innovation. An idea which is seemingly accepted in European policy, given the ideas for EIT and GAST. However, when starting my literature study, I quickly discovered that these policy believes are not rooted in fundamental research on innovation. The possible role education(al cooperation) plays in the emergence of innovation is a blind spot that needs further research in the future. Due to this situation, my research had to be exploratory. I will use whatever is available on education in the literature on innovation and draw my own conclusions about the way in which education(al cooperation) might contribute to innovation according to innovation literature.

As to testing this theory in practice, I will use a case study for in-depth research: the education(al cooperation) as it was shaped by EU policy in the automotive sector. By using a case study, I will be able to give a possible answer to the question whether or not education(al cooperation) in practice lives up to the theory and has the potential to contribute to innovation. I will look into EU policy, since the GAST project and the EU policy concept of the EIT were the starting point for this research. I have selected the automotive sector, which was the domain of the GAST project and is very familiar to me, to study in-depth: I will fully analyse the education(al cooperation) in this sector, as it was shaped by EU policy, by researching the available written information and by interviewing key players.

1.5. Outline of the report

In order to answer the research question, this research is divided into three parts. Part A will be a literature study, defining the most important concepts for this research and aiming to present an overview of what is known about the influence of education, and educational cooperation in particular, on innovation. Part A will provide me with an answer to my first sub questions and the theory, a model of elements of education(al cooperation) that may contribute to innovation, with which practice can be compared. The next questions concern the practical side of this research and will be addressed in part B. First, EU education and innovation policy will be addressed and then the automotive sector. This will require an extensive study of (mainly policy) documents issued through the years. Following that, I will carry out a case study into the automotive sector to research what EU policy for education(al cooperation) in relation to innovation looks like in practice and if that resembles innovation literature. This will be done through a study of documents and by interviewing those who ultimately determine the education(al cooperation) programmes. In Part C the results of part A and B are put together to be able to conclude whether or not education(al cooperation) can contribute to innovation and to make recommendations to those who can influence that.

1.6. Added value of the research

The added value of this research is threefold and concerns different target groups. It is of added value to policy makers wanting to improve innovation with education(al cooperation), mainly, of course, the EIT with which this research started. This research may also be of added value to educators wanting to achieve the same thing and improve their programmes to better contribute to innovation. Finally, this thesis may be of value to researchers, since it researches a blind spot in research on innovation and because it is an exploratory thesis that may be the starting point for more research.

First of all, the outcome of this research is relevant for policy makers and the development of the EIT in particular. The EIT was set up before the GAST pilot project, exploring how to best shape the institute for it to reach its goals, was finished. So, the EIT just started and gradually needs to discover what it should do in order to strengthen the knowledge triangle and achieve what president Barroso envisioned in 2007. The mission of the EIT is to capitalise on the innovation capacity and capability of actors from higher education, research, business and entrepreneurship from the EU and beyond through the creation of Knowledge and Innovation Communities (KICs). This research will perform part of the research recommended by GAST and may thus provide the EIT with ideas to further shape its projects for the strengthening of the knowledge triangle and the enhancement of Europe. The shape and activities of a KIC is not set in stone and can be adjusted, and new KICs are being developed. When shaping the KICs, the outcomes of this research may be helpful in determining what to do with the education component of the KIC when aiming to capitalize on its influence on innovation. The department of Industrial Engineering & Innovation Sciences of the TU/e is, among others, one of the players involved in developing a KIC and can thus benefit from this thesis.

With this research I intend to give those involved in the KICs, such as the Dutch KIC participants and members of Neth-ER, The Netherlands Organisation for Applied Scientific Research (TNO) and the Eindhoven University of Technology (TU/e), information on if and how educational cooperation can strengthen innovation processes. In automotive research, but possibly also other sectors. The results of this research may be useful for other industrial sectors like the Information and Communication Technology (ICT) or energy sector as well, since the literature study and the policy study carried out concern education(al cooperation) and innovation, and their interaction, in general. Of course, it is not just those involved in the EIT that aim to shape education(al cooperation) in such a way that it optimally contributes to innovation. Everyone who can (or wants to) influence this contribution may be interested in the answer to the questions if education(al) cooperation can contribute to innovation (more). Policy makers, local, national or European. But also, an educational institution.

Any educational institution will want to deliver graduates that can contribute to innovation. The TU/e, for instance, aims to be a university "whose top quality education and research contributes to the progress of the engineering sciences, to the development of technological innovations and, therefore, to the growth of prosperity and welfare" [TU/e 2009:3] This research may help the educational institution that wants to improve its educational programmes in such a way that its students in the future may contribute to innovation even more. Especially those involved in the automotive sector, but also those in other sectors, may find this thesis helpful.

From a research point of view this thesis will contribute to what is known, but also to what may be researched in the future. The Master Innovation Sciences is focused on the analysis of technological change and innovation and the ways in which public and private actors attempt to influence the speed and direction of technological change in society. The scientific relevance of this research is its contribution to what is known about the influence of education(al cooperation) on innovation. This research is also relevant for innovation sciences because of its contribution to the research on the impact of education(al cooperation) to both economy and society. It will contribute in various ways to what is known on effective education(al cooperation) and its relationship to innovation processes.

Finally, as described in this introduction, this master's thesis is exploratory and can therefore be a starting point for anyone wanting to fully research the recommendation made by the GAST project or wanting to perform related research. At the time of writing, insufficient information is available to be able to research whether or not education, and educational cooperation, in particular, really prove to be beneficial for innovation. Future research could concern this question, which is the one following my sub research question if theory is brought into practice, namely: if practice proves the theory right. But, one can also build on this research when for example wanting to look into national policy related to education(al cooperation) and innovation, when wanting to research different sectors, etcetera.

This research may be helpful to policy makers, educators and researchers alike and therefore have added value in multiple ways.

PART A THEORETICAL RESEARCH

CHAPTER 2 INTRODUCTION TO INNOVATION AND EDUCATIONAL COOPERATION

The theoretical part A of this thesis is about the theoretical link between innovation and education, in particular educational cooperation. After introducing the concepts in chapter 2, I will explore how the influence of education(al cooperation) on innovation is perceived in literature about innovation (chapter 3). I will conclude this part of the research by, in chapter 4, distilled a model with factors from chapter 3 that form the theoretical relation between education(al cooperation) and innovation, according to innovation literature. This model can then be used, in part B of this research, to analyse EU policy, the European automotive sector and existing educational cooperations in practice. By doing this I will be able to answer the question whether education, and educational cooperation in particular, can contribute to innovation.

This first chapter of part A will introduce the most important concepts for this research: innovation, education and educational cooperation. These concepts can be interpreted in various ways and therefore I need to make clear what interpretation is used for this research. After I have done that I will be able to look for literature about innovation and education and educational cooperation therein.

2.1 Innovation

The word innovation dates back to the Middle Ages at the least, and possibly even earlier. It comes from the Latin *innovationem*, noun of action from innovare. The etymology dictionary further explains innovare as dating back to 1540 and stemming from the Latin *innovatus,* meaning renewal.

When looking for the current definition of innovation, several interpretations can be found. The most common definition is that innovation is “something new” [Van Dale, 1999][4]. Rogers [Rogers 1995] narrows that down somewhat by defining innovation while taking the perception of the individual: innovation then is "an idea, practice or object perceived as new by an individual or other entity of adoption”. However, in these general definitions no distinction is made between innovation and invention. In order to find a definition of innovation that does differ from invention, we need to look to some newer innovation literature. Than we will find that innovation can be seen as “the successful application of an invention” [De Wilde, 2000]. This means an invention in itself does not contribute to productivity, but an innovation does [Tidd et al, 2001, Den Hertog & Smits, 2004]. So, an innovation is “the successful application of something new“. Understanding that this is what innovation is, makes clear that there are several factors that influence the emergence of an innovation. In chapter 3 I will study innovation theories to see what factors influence innovation and if educational cooperation is one of these.

4 The definitions from the Van Dale dictionary in this chapter were translated from Dutch to English by the author of this thesis.

2.2 Education and educational cooperation

In order to be able to study if education, and more specific educational cooperation, is a factor that can influence the emergence of innovation, in chapter 3, it is necessary to define what these concepts hold. Education can be clearly defined and is comprehensibly described in the dictionary as 'the act or process of imparting or acquiring particular knowledge or skills through schools' [van Dale 1999][4]. The concept of educational cooperation cannot be found in a dictionary and there is no accepted scientific theory that substantiates the term educational cooperation, since it concerns a concept that has not yet been researched scientifically. This is also why educational cooperation as such is not mentioned in any of the innovation theories introduced in chapter 3. Therefore, the use of the concept of educational cooperation in this research will need to make use of the combination of the two separate elements of the concept of educational cooperation and their effects on innovation: education and cooperation.

As mentioned, education is defined as 'the act or process of imparting or acquiring particular knowledge or skills through schools' [van Dale 1999][4]. Cooperation is 'the process of working and (inter)acting together' [van Dale 1999][4] . In this way, educational cooperation is 'working and interacting together in the process of imparting or acquiring particular knowledge or skills through schools'.

Therefore, when studying if educational cooperation (and education in a broader sense) is a factor that can influence the emergence of innovation, chapter 3 will focus on the question if the importance of education (imparting/acquiring particular knowledge/ skills through schools) and the importance of cooperation (working and interacting together) is mentioned as a factor affecting innovation.

CHAPTER 3 INNOVATION THEORIES

In chapter 2 it became clear that innovation is “the successful application of something new“ and that therefore the emergence of innovation is influenced by several factors. In this chapter, innovation theories will be studied to see if education, in particular educational cooperation, as defined in paragraph 2.2, is among those factors and if so, how. By defining the 'how', in the conclusion of this chapter, I will be able to come to a scientific framework that indicates what criteria should be met by education(al cooperation) for it to positively contribute to innovation. This framework of criteria will be assembled in chapter 4 and used for the comparison with practice, addressed in part B of this thesis.

This chapter introduces some of the best known and some of the most relevant innovation theories for this research: the classical theory, open innovation, triple helix, innovation systems, theory on clusters and entrepreneurship theory.

3.1 The classical theory

The first theory introduced here is the classical theory. This is a somewhat older theory on innovation that has been, and in some cases still is, very influential. The classical model defines innovation as a vertical model in which innovation processes take place within firm/institute boundaries. Internal firm Research & Development (R&D) activities lead to internally developed products that are then distributed by the firm and sold. In this model innovation is driven by large companies and their often secret and locked laboratories. The classical theory thus defines innovation with the following basic model, within company boundaries:

Basic research → Applied research → Development → (Production and) Diffusion

This model limits interaction to people that work within the boundaries of company departments. But, in fact this model shows that there is no interaction. The arrows namely point in just one direction, while interaction is a two way process. There might be some limited interaction between company departments, but that's the most interaction that is possible. In this theory interaction with people from outside the company is often even seen as a threat to innovation, since it is important to keep knowledge behind closed doors, within the company. Because of the company limits to innovation, this model also limits education to what happens within the boundaries of the company. The existing knowledge within the company is transferred to colleagues within that same company.

This innovation theory does not allow a big role for education, let alone educational cooperation, in the process of innovation. Education as well as cooperation/interaction need to occur within the limits of the company. The only room the model leaves for education to contribute to innovation is that the knowledge that exists within the company is transferred to colleagues within the company. Education and interaction outside the company is very limited. From this it can be concluded that this classical theory on innovation does not recognize educational cooperation as a true factor influencing innovation.

Godin [Godin 2006] researched the model thoroughly and concluded that it has been very influential. Academic organisations have used the model to get research funds, and economists that advise policy-makers, disseminated the model widely and have justified government support to science by using this model. But, nowadays very few people defend this understanding of innovation, because it is too simplistic. According to Godin however, government policies are still based on this old model because statistical evidence in support of the model can still be found. According to him it can be found, because the model is so simplistic.

3.2 Open innovation

The classical model describes innovation as a closed process that takes place within firm/institute boundaries. Today's reality is, however, that innovation is being done everywhere and is not only driven in-house; companies are increasingly collaborating with external parties for research. The research is being done by smaller companies that then tie up with larger companies. Some important companies have even totally abandoned R&D simply because the shorter economic life cycles make it very difficult for their large organizations to constantly be on the cutting edge of the transforming technologies. The open innovation theory better describes this new, rapidly changing development that innovation is being done everywhere.

The open innovation theory is the antithesis of the classical theory that described innovation as a vertical process [Chesbrough 2003]. In recent years this concept of open innovation (OI) has gained growing attention by educational institutions as well as in businesses. OI is a term coined and promoted by Henry Chesbrough, a professor and executive director at the Center for Open Innovation at the University of California in Berkeley.[5] Chesbrough describes in his book "*Open Innovation: The New Imperative for Creating and Profiting from Technology*" how companies have shifted from so-called closed innovation processes, as shown in figure 4, towards a more open way of innovating. [Chesbrough 2003].

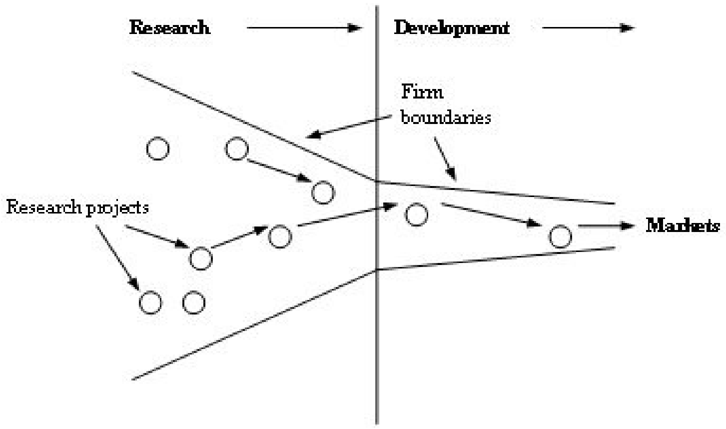


Figure 4: Closed innovation [Chesbrough 2003: XXII]

According to Chesbrough the closed, vertical model is subject to erosion, for several reasons. First of all, the mobility and availability of highly educated people has increased over the years, which has resulted in large amounts of knowledge existing outside the research laboratories of large companies. Secondly, the availability of venture capital has increased recently, which makes it possible for good and promising ideas and technologies to be further developed outside a firm, for instance as entrepreneurial firm or spin-off. Finally, other companies in the supply chain, such as suppliers, play an increasingly important role in the innovation process.

It is for these reasons that companies have started to look for other ways to increase the efficiency

5 More information about Professor Chesbrough can be found on the website of Berkeley University of California. URL: http://www.haas.berkeley.edu/faculty/chesbrough.html (visited 05-05-2010)

and effectiveness of their innovation processes. One of these ways is through active search for new technologies and ideas outside of the firm, but also through cooperation with suppliers and competitors. Another important aspect is the further development or out-licensing of ideas and technologies that do not fit the strategy of the company. Consider, for example, ASML, which is a Philips spin-off[6].

OI is about these new ways of innovating. OI can be described as: combining internal and external ideas as well as internal and external paths to advance the development of new technologies. This means that companies in the first place have to become aware of the increasing importance of open innovation. And that not all good ideas are developed within the own company, and not all ideas should necessarily be further developed within the own firm's boundaries. This is visualised in figure 5. Table 1 further illustrates the differences between the old way of thinking, closed innovation, and the new OI.

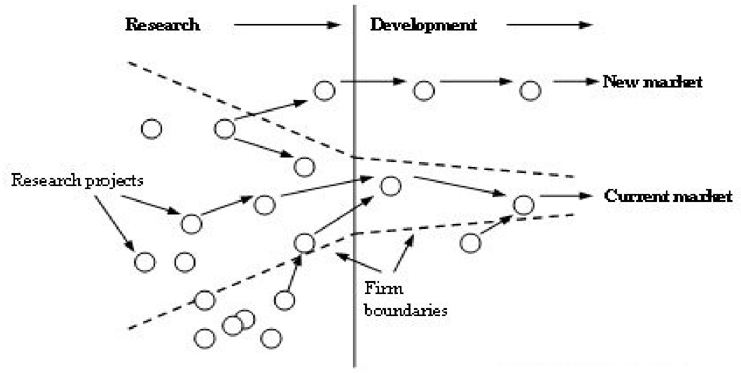


Figure 5: Open innovation [Chesbrough 2003: XXV]

Closed innovation principles	Open innovation principles
The smart people in the field work for us.	Not all the smart people in the field work for us. We need to work with smart people inside and outside the company.
To profit from R&D, we must discover it, develop it, and ship it ourselves.	External R&D can create significant value: internal R&D is needed to claim some portion of that value.
If we discover it ourselves, we will get it to the market first.	We don't have to originate the research to profit from it.
The company that gets an innovation to the market first will win.	Building a better business model is better than getting to the market first.
If we create the most and the best ideas in the industry, we will win.	If we make the best use of internal and external ideas, we will win.
We should control our IP, so that our competitors don't profit from our ideas.	We should profit from others' use of our IP, and we should buy others' IP whenever it advances our business model.

Table 1 Closed innovation vs. Open innovation [Chesbrough, 2003; XXVI]

This theory is all about interacting and being open, and the importance of education and learning in stimulating innovation is emphasized as well. Human and social capital incorporated by education can be regarded as the cement that holds together innovation systems [O'Doherty et al 2003]. First and foremost, education contributes to a high-quality labour force, one of the major conditions

6 ASML is the largest supplier in the world of photo lithography systems for the semiconductor industry. More information about ASML can be found on their website: http://www.asml.com

of OI. A high quality labour force leads to more knowledge that can be spilled over to other organisations, and also increases enterprises' absorptive capacity. The recruitment of academic graduates by incumbent enterprises also leads to this increase. In addition, according to de Jong et al, these graduates could be one of the main sources of fundamental knowledge for valorisation [De Jong et al., 2007].

According to this innovation theory educational cooperation is important for innovation, because education and interaction do clearly contribute to innovation. Education is of importance for the high-quality labour force and spill-overs that result from that. The interaction stimulates the mobility and availability of knowledge for all sorts of parties. The open innovation theory does require that education is focussed on the open innovation idea of sharing information instead of containing it. Furthermore, there should be a lot of emphasis on the ability to interact in all sorts of ways, for instance multi-disciplinary and multi-culturally.

3.3 Triple helix

The third innovation theory to be introduced in this chapter is the triple helix model of Etzkowitz and Leydesdorff [Etzkowitz and Leydesdorff 1998]. As was the case in the other theories, according to the triple helix innovation is the result of knowledge being valorised. The way in which this knowledge is valorised differs for each theory. According to the triple helix model of Etzkowitz and Leydesdorff innovation is the result of the interaction between three worlds:

- Knowledge institutions; education and research institutions
- Industry; from the smallest SME's to the biggest multinationals
- Government; governmental authorities on a regional, national and supra-national level

The interaction between these, once separated, worlds, is the result of the transformation from classic closed innovation to more open innovation in recent decades. The interaction between the three worlds that enables innovation, the triple helix, can be visualized as in figure 6: three flexible helixes (spirals), one for every world, that are woven together with many connections.

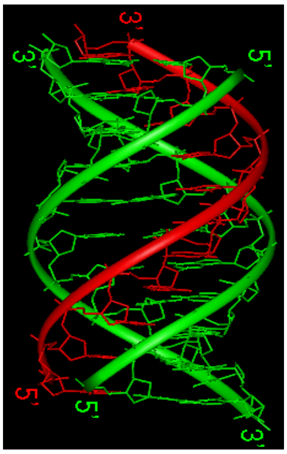


Figure 6 Dynamics between three helixes

The most important aspect of the triple helix model is the co-evolution between the dynamics within the model. As a result from the many communication networks and linkages between the helixes, movement or perturbation in one helix will trigger multiple changes in the other helixes, which will then again influence the first. For example, if a student develops a new idea and executes this during an internship at a company then this is a perturbation in the helix of knowledge institutes that is transferred to the helix of industry. Perturbation in this helix may lead to development requiring new regulation which perturbates the helix of government. But it may also lead to new knowledge for knowledge institutes and thus perturbate that helix again, etcetera. Therefore, Etzkowitz and Leydesdorff note, an important consequence of the knowledge that is exchanged through the interaction between the three helixes is that it leads to endless innovation.

According to this innovation theory, education and interaction, the components of education(al cooperation), are crucial for innovation. Education provides the knowledge to be valorised and results in innovation. Interaction enables the knowledge, a perturbation in one helix, to influence the other helixes and thus contributes to endless innovation. Education(al cooperation) will need to result in knowledge that can be valorised, and thus needs to provide students with the latest knowledge available. Furthermore, it should educate and train students in actively sharing their knowledge, also with the world of industry.

3.4 Innovation systems

The innovation systems theory states that innovation is the result of a complex set of relationships among actors (for example (someone from) industry, educational institutions and or research institutes) in a system. This theory of innovation systems has become popular particularly among policy makers and innovation researchers and has its origin in the research on the economics of innovation. The model was introduced by Bengt-Ake Lundvall in 1985 [Lundvall 1985], but the idea more or less dates back to List's "National system of political economy" of 1841 [Freeman 1995]. Freeman describes the innovation systems model as [Freeman 1987]:

a network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies

The idea behind this model is that innovation does not happen in isolation, but is a process that occurs in a particular context – the system. This system is a set of interrelated components aimed at achieving a particular goal [Carlsson et al, 2002]. A system can be anything from a single cell to the complete earth or from the whole society to one man. The factors (a new product, relationships, etc.) that affect an innovation can not easily be determined, since every innovation is affected by different factors and effects that actors have on the innovation system [Nooteboom 2001, Edquist 2001]. As a result the innovation processes or systems of different innovations can not be analysed with the same model [Lundvall et al 2002].

In order for the system to optimally contribute to innovation, it is essential that the actors within a system understand what role other actors and factors play in the system. It is called a system, because the interaction between the actors and factors is so essential, like for example the impact of an institution on the behaviour of another actor [Edquist 2001; Smits 2002, Edler et al 2003]. The synergy between the various components in a system is critical to the strength of a system and thus to the process of innovation [Fritsch 2004]. The importance of this synergy, actors understanding the whole system and cooperating with all elements in it, was illustrated by Von Hippel some thirty years ago. His research on the role of cooperation between users and producers showed that when users were recognised as actor in the system, and users where involvement during the development of successful new products (in other words, innovations) posed a significant positive contribution to that development [Hippel 1986; Lüthje 2004]. So, the theory of innovation systems shows that interaction and cooperation are seen as key elements in the development of innovations, since the whole of the system, its factors and actors and their interactions, is important. To successfully innovate, it is important to take advantage of that whole system and therefore the whole system needs to be aware of and use the rest of the system.

Innovation systems can be studied at the level of sectors and technologies, and the area can be regional, national, but also at the level of the EU (supra-national). Depending on the area the analysis applies to, it is referred to as regional, national or supranational innovation system. For instance a national innovation system includes all actors, social systems and institutions (rules of the game) of a given country, which affect the production, dissemination and use of knowledge [Kuhlmann 2001, Kuhlmann 2004].

Lundvall [Lundvall et al 2010: 4] states that national innovation systems play an important role in supporting and directing processes of innovation and learning. The uncertainties involved in innovation and the importance of learning call for a complex communication between the parties involved, which is easier when they originate from the same country. Especially when the knowledge exchanged is tacit and difficult to codify. When the parties involved originate in the same national environment, and because of that share the norms and culturally based system of interpretation, interactive learning and innovation will be easier to develop. Despite the change of the importance of national innovation systems compared to regional and supranational systems [Humbert 1993], one could argue that the high importance of interaction between the actors in national innovation systems might also be as important for all other innovation systems.

According to the theory on systems of innovation, education and interaction do contribute significantly to innovation. Educational institutions are part of the system, whether it is regional, national or supra-national. It's role in the system is comparable to the contribution of education in the triple helix: it provides the knowledge that is to be valorised. Interaction contributes to innovation by handling the complex communication system between the parties involved in the system that produces innovation. As was the case for the triple helix, in this theory it is also important for the success of education(al cooperation) for innovation that the educational institutions deliver knowledge that can be valorised.

Furthermore, the institutions need to transfer to students the knowledge and skills to handle the complex communication system that exists within an innovation system. The institution is preferably part of a national system, but no matter what system it is part of, it needs to be in close contact with the rest of that system. Since a public authority can support or direct this, such an authority is preferably closely involved.

3.5 Clusters

The fifth theory introduced in this chapter is the theory on clusters. The OECD [OECD 2001: 158], among others, refers to clusters as innovation systems reduced to the regional scale. A cluster is so to speak a well described system with clear “borders”, both areal and sectoral. And clusters contain the same institutions and companies as introduced in innovation systems theory. Clusters are becoming an increasingly popular concept, which is reflected by the growing number of policies and initiatives in support of it, also within the EU as will become clear from chapter 5.

Porters approach for explaining clusters ('new economics of knowledge') is one of the most well-known approaches and roughly explained by him in his book “The Competitive Advantage of Nations” [Porter1990]. As Porter explains in his book it isn't necessarily self-evident that clusters are becoming increasingly popular. We live in an era in which global competition and economic geography pose a paradox and thus location should no longer be a source of competitive advantage. High-speed communications and broad and fast transport possibilities allow any company to source anything from any place at any time. However, in practise, location remains central to competition and, as mentioned before, the importance of it is even rising. Porter explains this by characterising today's economic map of the world by clusters, that affect competition in three broad ways [Porter 1990]:

- they increase the productivity of companies based in the region;
- they drive the direction and pace of innovation (spillovers increase the rate of diffusion of new technologies and knowledge and lead to more innovations, although clusters can also lead to group think that might lead to slow adoption of new technologies and ideas);
- they stimulate the formation of new businesses within the cluster.

Porter explains clusters as being critical masses of linked industries and institutions – from suppliers, to universities, to government agencies – that enjoy unusual competitive success in a particular field, at one location. In this way, examples of clusters are Silicon Valley in the USA (computers), Rotterdam in the Netherlands (logistics) and Bangalore in India (software outsourcing).

The basic definition of clusters given by Porter, as mentioned earlier, has been developed further by different parties. Two explanations of definitions for clusters that have come from that are:

- The USA Community Framework for State Aid for Research and Development and Innovation defines innovation clusters as ….“*groupings of independent undertakings — innovative start-ups, small, medium and large undertakings as well as research organisations — operating in a particular sector and region and designed to stimulate innovative activity by promoting intensive interactions, sharing of facilities and exchange of knowledge and expertise and by contributing effectively to technology transfer, networking and information dissemination among the undertakings in the cluster.”*....[*Official Journal 2006: 10*]
- In more general terms, clusters are defined as a group of firms, related economic actors, and institutions that are located near each other and have reached a sufficient scale to develop specialised expertise, services, resources, suppliers and skills. In the broadest sense, clusters are being defined as regional concentrations of specialised companies and institutions connected through multiple linkages. [NGA 2007: 2]

Geographic, cultural, and institutional proximity provides companies with special access, closer relationships, better information, powerful incentives, and other advantages that are difficult to tap from a distance. The more complex, knowledge-based, and dynamic the world economy becomes, the more this is true. Competitive advantage lies increasingly in local things--knowledge, relationships, and motivation--that distant rivals cannot replicate.

According to this innovation theory on clusters, education(al cooperation) contributes to innovation by providing the cluster with new specialised knowledge. Interaction is needed since it enables the cluster participants to get even easier and faster access to the knowledge available than is already possible, spillovers can then increase the rate of diffusion of new technologies and knowledge even further, which can lead to more innovations. The institution and students should preferably also interact with actors from outside the cluster (so, for example, truly effectuate educational cooperation), to avoid the group think that's one of the dangers of clusters. So, for educational cooperation, and the educational programmes that are involved, to optimally contribute to innovation the educational institutions should be part of a cluster and thus localised close to companies, institutions, etc. in the same field. The educational institution and the students should (be taught to) interact with those other actors within the cluster and others actors outside the cluster.

3.6 Entrepreneurship

The last theory to be introduced is the theory on entrepreneurship. Introducing it here as a theory will be controversial to some readers. Firstly, because it's not officially a theory (yet) and secondly, because it's relationship with innovation is debated by many scientists. But, since it seems to be on it's way to becoming a theory and some do argue that entrepreneurship has the potential to boost innovation, I will introduce it here despite the objections. I will, however, address the controversy, before moving on to the current theoretical thoughts on entrepreneurship.

3.6.1 Controversy

As will show, Schumpeter [Schumpeter 1911] in the 20th century describes an entrepreneur in an advanced economy as an individual who has a set of personal skills that makes it possible to convert a new idea or invention into a successful innovation. The study of entrepreneurship however, reaches back to the work of Richard Catillon [Catillon 1755] and Adam Smith [Smith 1776] in the 18th century. These early economists already mentioned entrepreneurship in their works. These theoretical passages on entrepreneurship however, were largely ignored until the late 19th century. Schumpeter, amongst others, was one of the economists that re-introduced the concept in the beginning of the 20th century. From that point onwards many economists, and later social science experts, have been involved in the further development of entrepreneurship theory.

The importance of entrepreneurship to innovation has been at the centre of debates since Schumpeter re-introduced it. There are theorists who tend to qualify entrepreneurship as being of very little importance, and there are theorist like Jon Stuart Mill [Mill 1984] who go as far as to stress that entrepreneurship is of significant importance for innovation. In his writings, Mill claims that entrepreneurship requires “no ordinary skills”, and laments the fact that there is no good English equivalent for the French term 'entrepreneur' that encompasses the same specific meaning. Enterpreneur being derived from the French verb entreprendre, which means to undertake.

During the last two decades more and more research on entrepreneurship has been conducted and according to Gartner [Gartner 2001] this research has led to a 'bonanza' of theories about entrepreneurship. In his article about an 'Elephant in Entrepreneurship' he explains that entrepreneurship theory seems to be in the beginning stages of developing into a field of its own. According to him, the controversy around scholars developing and advancing entrepreneurship as a legitimate field of study is very similar to those around other academic fields in the social sciences. For example, one can find similar concerns and debates about the development of organisation theory, political science, and strategic management. Developing the field of entrepreneurship, and more specifically, developing theory in entrepreneurship, needs to be seen within the wider scope of these debates and efforts within the social sciences. Despite the number of published papers that might be considered related to the theory of entrepreneurship though, no generally accepted theory on entrepreneurship has emerged yet.

3.6.2 Concept

Throughout the theoretical history of entrepreneurship, scholars from multiple disciplines in the social sciences have grappled with a diverse set of interpretations and definitions for entrepreneurship. Their aim was to conceptualize an abstract idea into a definition, some interpretations continually resurfaced over time, no single definition of entrepreneurship has developed that is accepted by all economists and social science experts. According to Hoselitz [Hoselitz, 1952] some writers have identified entrepreneurship while attempting to coordinate productive resources, others while studying uncertainty bearing, others when introducing innovation, and still others while describing the provision of capital. I will introduce two other definitions before I will come with a definition that will be used in this thesis. As there is not one definition, I will introduce some of the most popular ones.

As stated, according to Schumpeter [Schumpeter 1911] an entrepreneur in an advanced economy is an individual who has a set of personal skills that makes it possible to convert a new idea or invention (following education and research) into a successful innovation. Furthermore entrepreneurship enables:
1 introduction of a new product
2 introduction of new methods of production
3 developing new markets and finding fresh source of raw materials
4 making changes

Schumpeter used creative destruction in his book 'Capitalism, Socialism and Democracy', first published in 1942 [Schumpeter 1942]. He popularized and used the term to describe the process of transformation that accompanies radical innovation. In Schumpeter's vision of capitalism, innovative entry by entrepreneurs was the force that sustained long-term economic growth, even as it destroyed the value of established companies and labourers that enjoyed some degree of monopoly power derived from previous technological, organisational, regulatory, and economic paradigms.

According to Block et al [Block et al 2010] entrepreneurship moderates the relationship between knowledge and innovation. Blocks research shows that it is equally necessary to have entrepreneurs who turn new knowledge into innovative products (subsequently leading to economic growth) as it is important to promote the production of new knowledge (e.g., by means of R&D subsidies) or university education. If there are only a few entrepreneurs in a knowledge-intensive region, the potential of the inventions being developed cannot be optimally turned into innovation. From an economic point of view, this means that the Swedish or European paradox [Ejermo et al 2006, Audretsch 2007] can emerge, meaning that many inventions will remain under-exploited or at best will possibly be exploited outside the region. In any case, the profits will not flow back to the region in which the knowledge was produced. Entrepreneurs can thus be seen as catalysts that help and often are needed to transform an invention into a successful innovation and by that economically boost a region.

Policy makers might therefore want to promote entrepreneurship in their own country or region to prevent the loss of innovation and economic potential, the European paradox, from occurring.

There are several ways in which entrepreneurship for innovation can be promoted, and education and interaction play important roles in this. On the short term, it could be beneficial to subsidize loans to hightech entrepreneurs, create regulatory exemptions for innovative new start-ups or create tax benefits for entrepreneurs. However, simply encouraging more people to become entrepreneurs will not be an effective policy. Entrepreneurs who really take the risk of transforming new knowledge into innovative products, instead of focussing on merely starting another shop around the corner, should be encouraged. Many start-ups do not fall into the first category, but rather belong to the latter group [Koellinger 2008].So, on the long term, the most promising approach would be to promote entrepreneurship education to increase the number of high quality entrepreneurs and optimise the potential for innovation.

However, learning about entrepreneurship through lectures, reading texts and analysing cases is too limited to develop creativity and does not advance the risk attitude of would-be entrepreneurs, and fails to mimic the real world. It is positive if mentoring or coaching from people with business experience is a basic element in all entrepreneurship training [Bird 2002]. Furthermore, the scope of entrepreneurship education is much wider than training on how to start a business. It also includes the development of personal attributes and horizontal skills like creativity, initiative and self-confidence, so curricula should also include attention for the development of these skills [Bird 2002].

3.7 Conclusions

The research of the six theories described, has shown that for five of them educational cooperation is indeed a factor that can influence innovation. The classical theory is the only theory for which could be said that this is not the case; educational cooperation could actually be a threat to innovation according to this theory. This paragraph will summarise the chapter and list the characteristics of educational cooperation that are beneficial to innovation distilled from the theories. These characteristics can then be used in the next chapter to create a model of factors that can be utilized when studying practice in the second part of this thesis.

The research about innovation theories showed that, rather than a linear process, innovation is seen as an interactive process in which cooperation and exchange of knowledge with different actors and organisations is crucial. This systematic approach is also fully compatible with the classical view that a successful innovation is the result of a specific original trajectory from idea to market. According to the five theories with an open innovation approach, educational institutions and their cooperation play a critical role in the innovation process.

Assembled from all the researched theories on innovation, the following characteristics can be identified that education (al cooperation) should theoretically meet to have positive effects on innovation:

- Focus on interactivity. This has shown to be essential since innovation is the product of a system of actors interacting. Innovation is a socially activated process, and there should be attention for the ability of students to interact, intercultural and interdisciplinary, but also with other 'worlds' like the industry. It will give them the ability to continue to be part of the innovation process once they are graduated, since they have the skills to handle the complex communication system that exists within an innovation system;
- Have and provide access to the latest knowledge. Educational institutions provide the highly educated and skilled human capital through education (a form of interaction which is a factor in the system in itself). When doing that, the participating education institutions should provide the latest knowledge available, since that is what needs to be valorised for innovation. To get this latest knowledge they should cooperate with the other actors in the innovation process that generate this latest knowledge, like the industry;
- Teach about innovation. Students that are able to handle the theory but are not able to get the knowledge valorised have an innovation skills gap. Educational institutions must teach students about the process of innovation and the system with its actors, so that they are able to work with it. This way they will understand their own role and that of other actors in the innovation system and so be able to use it when contributing to innovation;
- Be part of a cluster. Educational institutions should be part of a cluster, and thus localised close to companies, institutions, etc. in the same sector This will be beneficial for mutual knowledge transfer and open innovation;
- The educational institution is preferably part of a cluster in which a public authority is closely involved to support and direct the close contact among the actors in the cluster;
- Educational institutions in a cluster should preferably also interact with actors from other clusters (such as other educational institutions) to avoid the group think and stimulate even more knowledge transfer and spill-overs leading to innovation;
- More entrepreneurs should be educated to avoid the European paradox. Entrepreneurship education should be an important part of the curriculum of educational institutions, including basic personal entrepreneurial skills. Students should have the skills to convert new ideas or inventions into a successful innovation, optimising the potential for innovation;
- There should be a focus on teaching students to share knowledge, which is part of the set of skills taught for entrepreneurship, but is also mentioned in the theories not naming entrepreneurship. This will make students aware of the power of sharing and the contribution of it to the quality of their work as a professional;

CHAPTER 4 FACTORS

In chapter 3 it was concluded from the theory on innovation that education(al cooperation) can indeed contribute to innovation and it was also distilled which criteria need to be met. In this chapter a model will be formed with the theory from chapter 3. This model consists of factors, that later can be used to research educational cooperation in practice, and the question whether that can contribute to innovation according to the theory.

Combining the findings in chapter 3 leads to the identification of the six factors below, of which the assumption is that when these factors are part of the education(al cooperation), it has the potential to contribute to innovation, at least according to innovation theory. The more factors are met, the bigger the possible contribution.

As became clear from, namely, the theory on OI, those involved in educational cooperation that can influence innovation most are the students (not for example the teachers) of higher educational programmes in the sector in which the innovation takes place. The factors relate to their contribution to innovation. The factors can be divided into three categories that are important for the education(al cooperation) to be able to contribute to innovation. These are the sector, in which the students receive education, the surrounding in which they receive their education, and the (higher) educational programme that is offered to them.

Sector:

1. OI is present in the sector.

The first factor distilled from the theory is the presence of OI in the sector. As mentioned above, the more factors are met, the bigger the possible contribution of education(al cooperation) to innovation. This first factor, however, may be more important than that, since OI enables other factors to even have the possibility to exist and/or contribute to innovation. If a sector is closed, factors 3 (interaction and cooperation in clusters) and 5 (teach the latest knowledge generated by other actors) cannot be put into practice, and it may be much harder for the product of the other factors to contribute to innovation as well.

Surrounding (cooperation):

2. The educational institution is part of a cluster. If so, preferably, a public authority is involved and a form of cooperation with educational institutions in other clusters exists.

Factor two is the presence of the educational institution in a cluster within the sector, since the interaction within the cluster makes them breeding places of innovation. Preferably the educational institution should be part of a cluster in which a public authority is closely involved to support and direct the close contact among the actors in the cluster. Ideally, an institute should not just cooperate with other actors in the own cluster, but also cooperate with other educational institutions that are part of a (different) cluster.

3. The educational cooperation is shaped in such a way that, while enabling participating students to acquire skills and knowledge optimally, it facilitates interaction with (students from) other schools optimally

The third factor is about the focus on interaction for students. Educational cooperation between institutions in different clusters is important for spill over effects, but educational cooperation in general should also be shaped in such a manner that it is a way of challenging students to interact with different people in various ways. That will strengthen their interaction skill, which, according to theory, is a very important skill to be able to contribute to innovation. Actual educational cooperation, creating a surrounding that is all about interaction with other educational institutions, is a direct way of challenging and so teaching students to interact, maybe in an almost compulsory way (when, for example, offering joint courses or projects). Since the ability of students to interact includes intercultural interaction, the most complete cooperation would be cross border cooperation.

Educational programme:

4. Innovation theory is present in the educational programme.

The (higher) education programme that is offered to the students should contain education on innovation theory, the process of innovation and the system with its actors. This should be taught to students so that they are able to work with it and by doing so address the innovation skills gap.

5. Cooperation with other actors in the innovation process to address the technology gap, by the availability of lessons given by part time teachers that also work for the industry.

The programme should also make students aware of the most recent information so that they are able to contribute to innovation optimally. This addresses the technology gap, this gap is introduced in box 4.1. A way of doing this, that may also contribute to the interaction skills of the students, is interaction/cooperation by the institute with other actors in the innovation process that generate the latest knowledge. To make this more concrete, so that it can be researched in part B of this research, a well-known form of this cooperation can be studied, namely, if there are part-time teachers at the educational institution that also work for the industry and can thus teach students the latest from their experience in the industry.

Box 4.1 Technology Gap

The analyses of the importance of the increasing need for higher skills levels of the workers on the labour market has triggered an interesting discussion on what has been called, 'the race between education and technology', and has resulted in the warning that in Europe this race appears to be increasingly lost by education [Jacobs 2004]. The reasoning for this argument consist of the increasing Technology Gap (TG). TG is defined as the gap between what people learn during their education and the skills the companies need. A shift towards lower skilled services production is not to be expected, so a larger part of the gap has to be “fixed” by educational output. Students learn outdated information and skills at schools and universities because the qualifications needed by the companies are not matched with the requirements that are set by the education programmes. A good example is the ongoing electrification of the car with complex electronics and high voltage electric engines. New skills and new tools are needed, but the education institutions do not have the tools and information required to teach this new technology.

6. The education programme has attention for the development of personal skills of students such as creativity, initiative and self-confidence.

The final factor concerning the education programme is the integration of entrepreneurship education as part of curricula. Entrepreneurs learn from experience and are active learners. As became clear from the theory, the scope of entrepreneurship education is much wider than just training on how to start a business; It is essential to include the development of personal attributes and horizontal skills like creativity, initiative and self-confidence.

The six factors summed up in this chapter indicate what kind of educational cooperation is most likely to have the potential to contribute to innovation. These factors form the theoretical model that will be used for case study research in the further part of this research.

PART B APPLIED RESEARCH

CHAPTER 5 EUROPEAN POLICY FRAMEWORK

In the theoretical part A of this thesis, innovation theories were studied to see if education(al cooperation) influences innovation according to scientific theories on innovation. The conclusion was that, theoretically, education(al cooperation) can indeed contribute to innovation when it contains one or more of six factors that where defined the previous sector. The model of six factors, distilled from innovation theory, will be applied in this part B, to find out if existing education (al cooperation) *in practice* has the potential to contribute to innovation. To test that, I will look at EU policy on the subject, applied in the automotive sector in particular. To do this, two cases of existing educational cooperation will be studied. In part C conclusions can then be drawn on the potential contribution to innovation of education(al cooperation) as shaped by EU policy, in particular in the automotive sector. If necessary, recommendations will be given on how to improve that contribution of education(al cooperation) to innovation.

This first chapter of Part B will be a thorough research of the European policy framework with the aim to find out if educational cooperation plays a role in the vision of the EU on innovation and if yes, what role this is. The chapter starts with an explanation of EU innovation policy, after which EU education policy will be elaborated. Of course the EIT, and with that the GAST project that was the reason for starting this thesis, will be described in this chapter as well. Based on the assembled information I will conclude if, and how, the EU applies the factors distilled from theory into its policy when attempting to stimulate innovation through education(al cooperation). In the following chapters of this part of the research (chapters 6 and 7) I will then look at the way in which the theoretical factors on the influence of education(al cooperation) are reflected in practice in the automotive sector as it is shaped by EU policy.

5.1 EU and EU policy

The European Union is a supra-national organisation that has its roots in the post Second World War era. The EUs predecessor, the European Coal and Steel Community (ECSC), was set up with the aim of ending the recurrent wars between European nations, by setting up a community that fostered trade by making the countries economically interdependent. By doing this, the ECSC started the union of European countries, that would over the years develop into the extensive economical and political union that the EU is today. [EU website 2011] Starting with six founding member states, the EU has grown to 27 members states at the time of this research.

It is now a unique economic and political partnership that has delivered half a century of peace, stability, and prosperity, helped raise living standards, launched a single European currency, and is progressively building a single Europe-wide market in which people, goods, services, and capital move among Member States as freely as within one country [EU website 2011]. In order to be able to do this, the member states have handed over some of their sovereign decision-making powers to the EU, that is now allowed to make laws and policies for the EU in some areas. The exact competencies of the EU and it's institutions are laid down in Treaties. The EU has seven institutions to govern the Union, among which are the European Commission (EC, which stands above the nations, proposes policies and laws and implements and safeguards them), the Council (which represents the member states and adopts and implements new policies and laws) and the

European Parliament (EP, which represents the EU's citizens and also adopts new policies and laws).

As explained, the EU started as an economic partnership and this is still in the middle of its attention. The Unions main activities are focused on creating the single European economic market that can compete with the major economic powers in the world. It is in this context of economic well-being that the EU has developed policy on innovation: the EU considers innovation to be important source for the economic benefit, competitive power and economic growth that the EU is after.

5.2 EU innovation policy

The EC started including innovation policies in their public documents in the early 1990s. In 1995, the first big step was taken in this direction by publishing 'the Green Paper on Innovation' [EC 1995]. This was an exploratory document followed by the First Action Plan for Innovation in Europe [EC 1996], that presented a few policy suggestions on how to foster innovation in order for it to contribute to competitiveness and employment. In 2000, in Lisbon, the European Council decided to adopt a ten year strategy for economic growth. The so-called Lisbon strategy was aimed at the Union to become, by 2010:

> […*the most competitive and dynamic knowledge-based economy in the world, capable of sustainable economic growth with more and better jobs and greater social cohesion*….] [EC 2000]

With the Lisbon strategy, innovation gained increasing importance in the EU policy framework, because the strategy recognised the importance of innovation to the competitiveness of the EU and the need for the EU to therefore facilitate innovation more. The strategy did not, however, elaborate to a great extent on how this should be done. When former Dutch Prime Minister Wim Kok lead a group of experts to review the Strategy in 2004, it therefore hardly came as a surprise that it was concluded that the results of the Lisbon Strategy were not fully satisfactory. [*Facing the challenge* EC 2004]. The European Commission used the report of the expert group, *Facing the challenge,* as the basis for a proposal to relaunch the Lisbon strategy in February 2005. [EC 2005a] The relaunch was set during the European Council in Brussels in March 2005 and was a simplification of the former system by containing less targets and reporting mechanisms and fewer synergies between different strands. [EC 2005b]

EU innovation policy really started to get shape when in October 2005 former Prime Minister of Finland, mr. Aho, was mandated by the European Council to set up a high level group of experts from science, business and governments to improve innovation in Europe. The group presented its report *Creating an Innovative Europe* in January 2006 and current European innovation policy is broadly based on this document. [EC 2006a]. The report recommended a *pact for research* which requires simultaneous and synchronous efforts in three areas:

1. Fostering a culture which celebrates innovation by providing an innovation-friendly market for European businesses.
2. Measures are needed to increase resources for excellent science, industrial R&D and the science-industry nexus.

3. Mobility of human resources,, financial mobility and mobility in organisation and knowledge, meaning cutting across established structures to allow new linkages to be made through, for instance, European clusters.

European innovation policy truly got shape with the successor of the Lisbon Strategy: the EU2020 Strategy. Discussions about this new strategy started in 2009 when the EC opened a public consultation to receive input for a new, more successful, ten year strategy for jobs and economic growth [EC 2009a]. The EC then prepared the Strategy that was adopted by the European Council in June [EC 2010a]. The new Strategy has three priorities for growth and jobs:

Priority 1; Smart growth: growth based on knowledge and innovation, using:

- education
- research
- digital economy

Priority 2; Inclusive growth: growth by making use of everyone, and therefore focus on:

- fostering innovation
- developing skills
- fighting poverty
- developing entrepreneurship

Priority 3; Sustainable growth: environmental friendly growth, through:

- efficient consumption of resources
- upgrading and inter-connecting infrastructures
- reducing administrative burden

The strategy is based on innovation and education as the backbone of EU prosperity. These priorities already make clear that the EU sees a clear role for education in contributing to innovation. The EU2020 identified seven “flagship initiatives” as new 'engines' to boost growth and jobs. The EC wrote policy papers for most of these flagships in 2010, that contained action points for which both the EU and national authorities have to coordinate their efforts and make them mutually reinforcing.

One of the seven flagships of the EU2020 strategy for jobs and growth focuses specifically on innovation and what needs to be done to foster it, contributing to all three EU2020-priorities. This flagship, and the policy document, is called 'Innovation Union' (IU) [EC 2010b]. When looking for the role of educational cooperation in the innovation process according to the EU, this document is predominantly the most important policy document, because it displays the vision and innovation policy of the EU for the period until 2020.

The IU will be discussed in the next sub-paragraph. Two of the other six flagships contain references to educational cooperation in relation to innovation. The policy documents on these flagships, 'Youth on the move' and 'An agenda for new skills and jobs', that complement the Innovation Union, will be discussed in paragraph 5.3.1 on EU2020. The other four flagships will not be mentioned, because they have none or just distant relevance for this research.

5.2.1 Innovation Union

In October 2010 the most recent step in European innovation policy was set by the presentation of the flagship initiative Innovation Union (IU) [EC 2010b] as part of the EU2020 strategy. The IU states that it's even at the heart of EU2020, since innovation should become Europe's overarching policy objective, in order to move away from business as usual and change to remain competitive in a changing world. At the moment, the EU is losing its leading position to China and South Korea, that have a strategic approach to create an innovation-friendly environment. The EU needs to exploit its huge scientific and innovation potential and therefore the IU sets out a bold, integrated and strategic approach to innovation, exploiting and leveraging Europe's strengths in new and productive ways [EC 2010b]. It aims to improve conditions for innovation to ensure that innovative ideas can (rapidly) be turned into products and services that create growth and jobs. The IU displays over thirty action points for this, in relation to 10 identified essentials for achieving the Innovation Union:

1. Increased investment in education, R&D, innovation and ICT
2. More cooperation for more efficient use of the available money
3. Education that raises skill levels and attracts talent
4. Free movement of researchers and innovators across the EU (as within a country)
5. Full use of the EU-funds available
6. More innovation out of research through cooperation between science and business
7. No barriers for entrepreneurs to bring ideas to market (access to finance, patent, etc.)
8. European Innovation Partnerships should be launched: pooling of expertise and resources
9. Success should be celebrated and progress needs to be measured
10. International cooperation should be improved, while protecting EU interests

What stands out from these points and the policy document, is that it is recognised that innovation throughout the IU is considered to be a process that more and more is developed in cooperation, since it is so complex and expensive. Five of ten points refer to this. In the document it is stated that 'It should be made easier in the single market for different players to work together across borders, using and sharing knowledge from all sources, because this is increasingly how successful innovations are developed'. Working together increase the effectiveness of the investments needed to get ideas to market. Therefore, the EU needs to create free movement of research, including innovative ideas, in which all actors, both public and private, can operate freely, form clusters and gather critical mass in order to compete and cooperate on a global scale. Knowledge transfer between business and academia should be strengthened, and made to happen transnationally. But there are still many legal and practical obstacles that prevent them from operating freely, particularly across borders. The EU needs to work on removing these obstacles, which are financial, legal (patent) etc., before 2020 and stimulate trans-regional cooperation (e.g. Framework Programme 7 (FP7) Regions of Knowledge, Competitiveness and Innovation Framework Programme (CIP) funded cluster initiatives and Enterprise Europe Network, and operations co-financed under the European Territorial Cooperation programmes, the new

'European Innovation Partnerships').

When it comes to education, it should be noted that there is only so much the EU can do, since the decision-making powers in this area still lie with the member states. The EU does have the competency to “contribute to the development of quality education by encouraging cooperation between Member States and, if necessary, by supporting and supplementing their action, while fully respecting the responsibility of the Member States for the content of teaching and the organisation of education systems” [Treaty of Lisbon 2010]. The division of power as laid down in the Lisbon Treaty in European policy is referred to as the subsidiarity principle. In the IU the EC does recognise that education can play its part in stimulating innovation and needs to be invested in. It can strengthen the knowledge base (provide a sufficient supply of highly qualified workers) by providing quality education and raising the skill levels of Europeans, this is mostly addressed in "Youth on the move" and "An agenda for new skills and jobs".

On this subject the IU however, also makes some statements. In the future, businesses should be more involved in curricula development and doctoral training, so that skills better match industry needs. This interdisciplinary approach in universities is necessary, bringing together skills ranging from research to financial and business skills and from creativity and design to intercultural skills. As mentioned, the EU can not determine what curricula should look like, since this is up to the member states. The EU can, however, facilitate it if universities would want to change their curricula. So, the IU states that the EC will support business-academia collaborations through the creation of "Knowledge Alliances" between education and business to develop new curricula addressing innovation skills gaps. They will help universities to modernise towards inter-disciplinarity, entrepreneurship and stronger business partnerships.

This is how the EU contributes to quality education within the EU. Illustrating how important the EU considers education to be for innovation, they also make some recommendations about education to the member states, hoping to improve the value of education to innovation despite not having the power to do it itself. The EU states that education is needed to provide the right mix of skills for innovation. Therefore member states could consider to focus education curricula on equipping people with the capacity to learn and to develop transversal competencies such as critical thinking, problem solving, creativity, teamwork, and intercultural and communication skills. Entrepreneurship education and training should be widely available or included in curricula, and partnerships between formal education and other sectors should be actively promoted to that end. Partnerships between higher education institutions, research centres and businesses, at regional, national and international level, should be actively promoted and there should be no obstacles to setting up and operating transnational partnerships.

The action points of the Innovation Union have been presented at the end of 2010. Some of them, like the European Innovation Partnerships (EIP's) are starting up and some, like the smart specialisation platform will be set up in the near future at the time of writing this thesis. Of all the action points relating to educational cooperation, the EIT is already up and running and shows that the EU thinks highly of educational cooperation when it comes to innovation.

5.2.2 European Institute of Innovation and Technology (EIT)

The idea for the EIT was put forward by the President of the European Commission, Barroso, as a means to contribution to the relaunch of the Lisbon Strategy in 2005. The EIT should integrate education in the Strategy, completing the so called 'knowledge triangle': where research and innovation were already highlighted as important factors for the development of the Lisbon Strategy, education was not.

The term 'knowledge triangle' refers to the interaction between research, education and innovation; the key drivers of the knowledge-based society. Figure 7 visualises this. The term knowledge triangle was invented by the European Research Advisory Board[7] (EURAB) to draw attention to the inter-relatedness of new knowledge, the educational system and innovation.[8] It could be described as a simple version of the supra-national European innovation system; the system the EU attempts to influence with its innovation policies. Accordingly, the triangle refers to an attempt to better link the three key concepts. The knowledge triangle has become an increasingly popular concept in European policy over the past 10 years. The first official EU-publications that mention it appeared in 2005/2006. Now, the knowledge triangle is widely accepted as a policy concept by European policy makers.

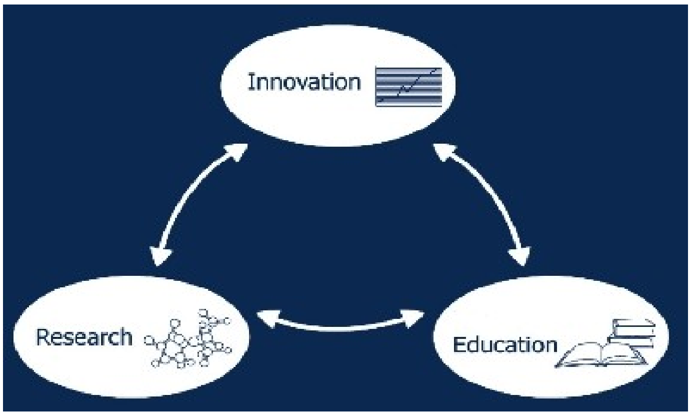


Figure 7: The knowledge triangle

So, given the rise of the knowledge triangle at the time of the review of the Lisbon Strategy, in which research and innovation were already highlighted, it was decided to incorporate education in the Strategy and (innovation) policy as well, by setting up the EIT.

In 2006, the EC presented its first paper on the EIT: *European Institute of Technology: the Commission proposes a new flagship for excellence*.[EC 2006b]. In this document the EC defines the key elements for a proposal for the EIT. Later in 2006 the EC published a second paper, *The Commission details its plan for a European Institute of Technology* [EC 2006c], which shed light on a number of specific issues related to the proposed structure and operations of the EIT. In the same year, these two papers led to the final proposal of the EC for the establishment of the EIT: *The Commission paves the way for a 2008 launch of the European Institute of Technology* [EC 2006d]. The Commission envisioned the EIT to be

> [….. a flagship for excellence in innovation, research and higher education in Europe. It

7 EURAB is a high-level, independent, advisory committee created by the EC to provide advice on the design and implementation of EU research policy. EURAB is made up of 45 top experts from EU countries and beyond. Its members are nominated in a personal capacity and come from a wide range of academic and industrial backgrounds,as well as representing other societal interests. EURAB focuses its attention on the realisation of the European Research Area and the use of policy instruments such as the community RTD Framework Programmes.

8 According to Professor Helga Nowotny, one of Europe's leading sociologists of science and Chair of the European Research Advisory Board in an interview with *BioSocieties.* [BioSocieties 2007]

> will be a reference model in the way it combines the worlds of academia, research and business so as to enable Europe to face the challenges of a globalising, knowledge-based world economy more effectively….] [EC 2006d]

The EIT should consist of 'Knowledge and Innovation Communities (KICs): communities that make up the networks and fulfil the goal of the EIT.

For the proposal of the Commission to become effective, it needed to be approved by both the European Council and the EP. In 2007, the EP indicated that it would only approve if it would be researched what would be the best way of shaping the EIT and its KICs. [Euractiv 2007]. Following the commitment of the EC to do this, the EP agreed on the establishment of the EIT [EP 2007], and the Council of Ministers followed. The initial question for this research arose out of one of the pilot project (GAST) researching the shape of the EIT and KICs as requested by the Parliament. Box 5.1 summarizes this project.

Box 5.1 GAST project

In early and mid 2007 several discussions about the need to test the EIT took place between the EP and the EC. In September 2007 the EP emphasised the need to test the EIT and its KICs with a number of pilot projects before agreeing to establishing it [Euractiv 2007]. The Commission agreed to this and in the summer of 2007 its Directorate-General for Education and Culture (DG EAC) published a call for proposal for pilot projects that fit the following description: models of cooperation in the knowledge triangle which aim to facilitate knowledge-sharing and technology transfer by building up the capacity of European networks in strategic interdisciplinary fields to bring their collaboration to a new, more integrated form of partnership.[EC 2007c]. After a selection process the following 4 projects where selected in November 2007:

- BRIDGE, Bridging Biomaterial Research Excellence between Industry and Academia across Europe [BRIDGE]
- ComplexEIT, Complexity from nano to large electronic systems [ComplexEIT]
- GAST, Green and Safe Road Transportation [GAST]
- SUCCESS, Searching Unprecedented Cooperations on Climate and Energy to ensure Sustainability [SUCCES]

The projects started operation in December 2007 and had to be finished in December 2009. This was a month before the then future KICs would be selected, so they would be able to optimally benefit with the experiences gained by the pilot projects.

I was personally involved in the GAST project. This project came up with four ways of shaping a KIC of which the 'cluster of clusters' got the most attention. A majority of the GAST participants expected that this would be the most promising approach with the highest impact on innovation, and thus best suited as a model for future KICs. The idea behind the cluster of clusters test case was that clusters would benefit from knowledge spillover in other clusters.

According to GAST, one of the ways to achieve that one cluster could benefit from the spillover in another cluster, could possibly be by creating cooperation between the educational institutions involved in the different clusters. GAST recommended it should be tested whether educational cooperation between clusters has a positive effect on innovation. This lead me to think about the affect of educational cooperation, in general, on innovation and thus prompted the question for this thesis.

More information about GAST can be found in Annex II.

In the spring of 2008 the EIT became operational with the following mission[EIT 2010]:

> *….The European Institute of Innovation and Technology (EIT) is a new initiative which aims to become a flagship for excellence in European innovation in order to face the challenges of globalisation. Although Europe already has excellent education and research institutions, their representatives are often isolated from the business world and do not obtain together the "critical mass" necessary for innovation. The EIT is the first European initiative to integrate fully the three sides of the "Knowledge Triangle" and will seek to stand out as a world-class innovation-orientated reference model, inspiring and driving change in existing education and research institutions. By boosting the EU's capacity to transform education and research results into tangible commercial innovation opportunities, the EIT will further bridge the innovation gap between the EU and its major international competitors….*

One of the first actions was setting up the first level of the EIT, the Governing Board (GB), that consists of 18 people from the worlds of higher education, research, business and innovation in Europe. They make the strategic decisions and selected the first KICs.

The three KICs, that are currently being established, were designated in December 2009. They are established around the following fields of innovation:
- Climate change mitigation and adaptation: Climate-KIC
- Sustainable energy: KIC InnoEnergy
- Future information and communication society: EIT ICT Labs

The KICs are autonomous partnerships between universities, research organisations, companies and other stakeholders in the innovation sector. These partnerships are linked to the EIT by a contractual agreement with a time frame of 7-15 years.

The potential of entrepreneurship is an integral part of the KICs. According to the EIT the educational institutions in the KICs should take a leading role in introducing innovative approaches to graduate education, by developing new European Master's, doctoral and post-doctoral curricula, integrating scientific progression and depth with a strong entrepreneurial profile and multi-disciplinary skills (described earlier in this chapter). Such an approach is relevant not only to technical universities; entrepreneurial educational programmes in medicine, social sciences, humanities and arts are also needed to create new learning outcomes and interdisciplinary skills. The idea is that this new approach will lead to an innovation web with more different participants, and even with new participants that would not have contributed to the innovation process before. Europe’s competitiveness, innovation and economic growth depend on being able to produce future leaders with the skills and attitudes to be entrepreneurial in their professional lives, whether by creating their own companies or innovating in larger organisations. Entrepreneurship education is the first and arguably the most important step for embedding an innovative culture in Europe.

At the time of the presentation of the IU, the EIT had been up and running for a year. And, according to the IU, in that time it had shown to be a pioneer and a role model for stimulating innovation in Europe. IU states that the KICs integrate the three sides of the knowledge triangle, covering the entire innovation chain, in a powerful way. They bring together the world's best creative and innovative partners from research, business and academia to work together on important issues through innovation-driven research, business creation and development and entrepreneurial education. The IU announces that the EIT needs to be continued and new KICs should be developed to guide Europe in stimulating innovation. And in 2011, the entrepreneurial education will become internationally recognised in multi-disciplinary "EIT-branded" degrees as a label of excellence that partner universities within the KICs will award.

5.3 EU education policy

In conjunction with the IU, two other flagships of the EU2020 Strategy improve conditions for innovation, also by focusing on educational cooperation: "Youth on the move" and "An agenda for new skills and jobs". These flagships, containing not innovation but educational policy, argue that the EU must ensure that it has a sufficient supply of highly qualified workers to be able to innovate. So again, the EU stresses the importance of education for innovation. Youth on the move addresses the policies and measures for (promoting access to) quality education that are needed. The skill development that is needed for Europe's future labour force, and innovation, is addressed in An agenda for new skills and jobs. Besides this innovation oriented educational policy however, the EU also has other policy dealing with educational cooperation. Their focus is not on strengthening innovation but on strengthening mutual understanding. Since the actions from these policies are existing, and not in progress as is the case for the EU2020 policy, and since these actions might have potential and are sometimes referred to by EU2020, it will also be part of this chapter and will be introduced in the second sub-paragraph.

5.3.1 EU2020

With the thorough introduction of the IU, this paragraph will give a quick scan of the two other EU2020 flagships that are of relevance to this research. The reason for using a quick scan, instead of a thorough introduction, is that these initiatives do not contain as many and direct links with innovation compared to IU.

5.3.1.1 Youth on the move

The main aim of the EU2020 flagship Youth on the move is to reduce unemployment of young people, helping them to succeed in the knowledge economy, [EC 2010c] and with that contribute to being able to make use of the full potential of the EU to be more competitive. Youth on the move presents four action lines to achieve its goal:

- extend and broaden learning opportunities for young people, including non-formal educational activities like volunteering and traineeships;
- reform higher education, improving the quality and making it more attractive and accessible;
- improve mobility (between countries) for students, young workers and entrepreneurs;
- facilitate the transition from school to work, for example by creating a European Vacancy Monitor and supporting young entrepreneurs.

More young people within the EU have to participate in higher education to keep up with competitors in the knowledge-based economy and to foster innovation. Youth on the move recognises that also education is needed to achieve more competitiveness, also by contributing to more innovation. In this context, the policy paper mainly stresses that the youth needs to learn entrepreneurial skills and have the capacity to innovate, but also needs to be mobile.

The need to learning entrepreneurial skills is part of the second action line that aims at improving the quality of education. Good education is necessary, because key competencies for the knowledge economy and society have become much more important. By 2020 an estimated 35% of all jobs will require high-level qualifications, combined with a capacity to adapt and innovate. In identifying several key competencies, youth on the move names: learning to learn, communication in foreign languages and entrepreneurial skills. This will help the youth to contribute to the EU's competitiveness, also by being innovative.

In order to be competitive, Europe also needs to have a big capacity to innovate. As stressed in the IU, Youth on the move states that Europe’s innovation capacity will require knowledge partnerships and stronger links between education, research and innovation. Youth on the move announces that the EC will reinforce and extend the activities of the European platform for dialogue between universities and business to increase the employability of students and to developing the role of education in the knowledge triangle. But, for the strong knowledge triangle, it also stresses the role of the EIT, which should be fully exploited. The EC will propose a multi-annual Strategic Innovation Agenda at the end of 2011, that will define the role of the EIT in Europe’s multi-polar innovation context and that will lay down priorities for higher education, research, innovation and entrepreneurship over the next seven years.

Finally, one of the key action lines in the Youth on the Move initiative, is to support the development of transnational learning mobility for young people. This learning mobility is an important way in which young people can strengthen their future employability and acquire new professional competencies, while enhancing their development as active citizens. It helps them to access new knowledge, which of course is important for innovation, and develop new linguistic and intercultural competencies. Europeans who are mobile as young learners are more likely to be mobile as workers later in life. Erasmus Mundus (EM), which will be introduced later on in this paragraph, is the instrument that is used by the EU to support mobility.

Youth on the Move supports the aspiration that, by 2020, all young people in Europe should have the possibility to spend a part of their educational pathway abroad They also need to learn educational skills, and the knowledge triangle, mainly the EIT, should improve the capacity of the EU to innovate Youth on the move clearly suggests actions to be taken before 2020 that include education to improve innovation and, with that, competitiveness. Youth on the Move will be implemented in close synergy with the Agenda for new skills and jobs flagship initiative.

5.3.1.2 Agenda for new skills and jobs

The last flagship initiative to be introduced here is the Agenda for new skills and jobs initiative [EC 2010d]. The Agenda for new skills and jobs focuses on the right conditions to create more jobs and a better skilled workforce to fulfil these jobs in order to develop the competitive and innovative economy that EU2020 aims for. It identifies actions needed in four areas: better functioning labour markets, a more skilled workforce, better job quality and working conditions, and stronger policies to promote job creation and demand for labour (like employment subsidies for employers to recruit the long-term unemployed, promote entrepreneurship and self-employment, etc.). According to the subsidiarity principle within the EU, it is mainly the member states' responsibility to achieve these objectives. The EU can try to pool all efforts and instruments to contribute to them, and it does with the actions proposed in the Agenda for new skills and jobs.

The Agenda for new skills and jobs also makes reference to educational cooperation, but doesn't introduce anything new when heaving read the IU, and, to a lesser extent, Youth on the move. It refers to the 'knowledge alliances', mentioned in the IU. These ventures should be supported. They bring together business and education/training institutions to develop new curricula addressing innovation skills gaps and matching labour market needs. The Agenda also makes mention of the Erasmus placement in companies, which needs to be developed. Furthermore, like the IU and Youth on the move, the Agenda stresses the importance of entrepreneurship and entrepreneurship education. This will stimulate employment and help the EU's competitiveness, but may also increase innovation.

Again the EIT is named in the context of this Agenda, as an important element, fostering business creation and development through innovation-driven research, particularly through its strong emphasis on entrepreneurship. According to the Agenda, entrepreneurship should become a more widespread means of creating jobs, and training is most important. Education systems need to truly provide the basis to stimulate the appearance of new entrepreneurs and teaching the right skills to those that want to start and manage a business. As was stated in the IU, Member States should develop entrepreneurship in school curricula.

5.3.2 Existing policies

The purpose of this chapter was to look at whether educational cooperation is present in current European innovation policy. Similar to the literature on innovation theories, the EU does not make mention of the term educational cooperation as a factor for innovation either. It does not in the IU, nor in the other flagship initiatives of the EU2020 strategy. This does not mean that the EU does not have any policy on educational cooperation as such. In fact it does. Joint degrees and Erasmus Mundus are both policy actions that are aimed at achieving educational cooperation and they have been existent for several years now. These two instruments for educational cooperation were developed to strengthen mutual understanding between European countries and not to improve EU's innovation or competitiveness. Erasmus Mundus is, however, referred to in the EU2020 flagships and both instruments may have the potential to contribute to innovation This paragraph will introduce both of them.

5.3.2.1 Joint degrees

Joint degrees is a general concept, but it is mainly linked to the Bologna Process[9], a process

9 It is based on cooperation between ministries, higher education institutions, students and staff from 46 countries, with the participation of international organisations. More information can be found on the website http://www.ond.vlaanderen.be/hogeronderwijs/Bologna/http://www.ond.vlaanderen.be/hogeronderwijs/Bologna/

bigger than the EU with as main element the creation of the European Higher Education Area (EHEA). This Area should ensure more comparable, compatible and coherent systems of higher education in Europe. A joint degree (JD) in the context of this EHEA is then a programme which results in one award and is authorised by two or more institutions in different countries [EUA 2002]. The participating institutions have a joint role in developing and implementing the given programme. The student needs to spend part of their studies at another institution and receives a degree that is officially recognised in the countries that are home to the offering institutions.

JD's, and Joint Curricula, are considered to be a particularly effective means of promoting the European dimension. They help to promote student mobility between countries and by doing so educate students to gain language and intercultural skills that will help them to interact better in the future. This promotes the European dimension and common understanding.

5.3.2.2 Erasmus Mundus

The EU has a long and successful track record of supporting mobility through various programmes and initiatives, of which the best known is the Erasmus Programme. Erasmus is an educational exchange programme of the EU that enables hundreds of thousands to study and work abroad each year: students, professors and business staff who want to teach abroad. It also finances co-operation between higher education institutions and helps university staff to receive training. The programme was set up to give students a better sense of what it means to be European, by enriching their academic and professional lives, improving language learning, intercultural skills, self-reliance and self-awareness. Mobility through Erasmus also increases students employability and job prospects. The name of the programme comes from Desiderius Erasmus Rotterdamus, a 15th-century Dutch humanist and theologian, one of the most brilliant students of the time, who studied in the best monastic schools throughout Europe. Erasmus is an EU programme, but is a result from and contributes to the bigger EHEA.

The programme is a result of the joint declaration of the European Ministers of Education who noted in 1999 that:

> ….....A Europe of Knowledge is now widely recognised as an irreplaceable factor for social and human growth and as an indispensable component to consolidate and enrich the European citizenship, capable of giving its citizens the necessary competencies to face the challenges of the new millennium, together with an awareness of shared values and belonging to a common social and cultural space [Bologna 1999]..........

The Bologna Declaration contained a number of objectives including comparable degrees, a common system of credits and a simplification of academic cycles. It also sought to promote the mobility of students, teachers and researchers and introduced a series of developments to meet these aims, including creating the Erasmus mobility scheme. The Erasmus scheme has been successful, [Keeling 2006: 216] noted that 87% of Higher Education institutions across 31 countries were participating in 2006 and it is likely that the numbers will continue to increase.

In 2001 it was decided to set up Erasmus Mundus (EM) as part of the Erasmus programme. EM is a programme to enhance the quality of higher education in Europe and promoting international mobility and cooperation with third countries (hence the term 'Mundus', which is Latin for world). It has been extended until 2013. EM offers scholarships for students and researchers preparing them for life in a global, knowledge-based society'.

The current EM programme is implemented through the following actions:

- Action 1: EM joint programmes at Master's and doctoral level, including scholarships/fellowships to participate in them. These are designed and implemented by a consortium of European universities from at least three different countries and include study periods in at least two universities, awarding recognised double, multiple or joint degrees;
- Action 2: EM Partnerships between higher education institutions in Europe and third countries for scholarships/fellowships for mobility;
- Action 3: Promotion and enhancement of attractiveness of European higher education.

5.4 Summary

This chapter has shown that educational cooperation as such is mentioned in some EU education policy documents, but not with the aim to strengthen innovation, but to strengthening mutual understanding. So here the conclusion can be the same as in chapter 3 about innovation literature: educational cooperation as such is not mentioned as a tool to strengthen innovation. But, as was concluded from in chapter 3, education and the other element of educational cooperation, cooperation, are (very) present in documents about strengthening innovation.

Over the past two decades, the EU has developed innovation policy, in the context of its main goal, strengthening Europe's competitiveness. The EU's current innovation policy, unveiling its vision and views on how to accomplish that, is laid down in the IU. The IU, and other EU2020 flagship initiatives, acknowledges that one of the ways of stimulating innovation in Europe is by involving education. The IU even states that the instrument set up to promote this, the EIT which stems from the believe in the knowledge triangle, is a pioneer and a role model for stimulating innovation in Europe. The cooperation between educational institutions, research centres and the industry is believed to be essential for innovation in the EU. Education can feed research and industry with knowledge, and industry can help educate students entrepreneurship and knowledge to close the innovation skills gap, so that they will have the right skills and knowledge to be innovative. The importance of teaching entrepreneurship is highlighted in other sections of the IU than the section on the EIT and also in the flagships Youth on the move and Agenda for new skills and jobs.

EU2020 is a vision for the next ten years and we cannot yet check if the policy and vision of the EU indeed contributes to innovation and competitiveness as it envisions. But it does show how the EU thinks about innovation and educational cooperation. Throughout EU2020, in the IU, but also in Youth on the move and the Agenda for new skills and jobs, it is stressed that strengthening the knowledge triangle, teaching entrepreneurial skills (so that more people are able to innovate) and stimulating mobility (to stimulate interaction as in the knowledge triangle and for later life) are essential to stimulate innovation. The GAST project also concluded that educational cooperation is probably beneficial for innovation. Even more so, when the educational institutions are part of a cluster, because then it not only strengthens innovation, but also the cluster, strengthening innovation even further.

Summarising the characteristics educational needs to meet according to European policy in order to be beneficial to innovation we find that:

- It should strengthen the knowledge base, and is needed to provide the right mix of skills for innovation: education curricula need to equip people with the capacity to learn and to develop competencies such as critical thinking, problem solving, creativity, teamwork, and intercultural and communication skills;
- JDs and EM offer information and programmes to promote student mobility between countries and by doing so educate students to gain language and intercultural skills that will help them to interact better in the future. This promotes the European dimension and common understanding, but, as explained earlier in this research, mobility and cooperation also contribute to innovation;
- Partnerships between higher education institutions, research centres and businesses, at regional, national and international level, should be actively promoted, facilitating knowledge-sharing and technology transfer using and sharing knowledge from all sources;
- There should be cooperation between the educational institutions involved in the different clusters with the knowledge triangle, to achieve that one cluster could benefit from the spillover in another cluster (GAST);
- Entrepreneurship education and training should be widely available or included in curricula;
- Businesses should be more involved in curricula development, so that skills better match industry needs; and by doing so address the technology or innovation skills gap.

5.5 Conclusions

When comparing the outcomes of chapter 3 about innovation literature with the summary of this chapter, one can conclude that the EU has recognised the importance of education(al cooperation) for innovation and that its long term policy documents are focused on bridging the gap between the two fields. When looking at the six factors education(al cooperation) needs to include to contribute to innovation, according to literature, it can be concluded that factors, though some are “hidden” in documents and some are clearly present, are addressed in European policy.

The six factors are re-introduced below and compared with European policy:

The first factor, *presence of OI in the sector*, can be found to some extend in EU policies regarding the EIT and in innovation policies. EU policies regarding the EIT and EU innovation policies introduce thematic areas as having specific innovation characteristics. These areas are usually bigger than one sector, because they concern big challenges in society that mostly require results in more than just one sector. So the EU recognises the need to consider specific innovation characteristics, but not for sectors specifically and not OI specifically.

The second factor, *the participation of an educational institute in a cluster*, cannot directly be found in EU policy. But, European regional policies have recognised the importance of clusters for regional development and the EU recognises that partnerships between higher education institutions, research centres and businesses, at regional, national and international level, should be actively promoted. GAST has even recommended to look into cooperation between the educational institutions involved in the different clusters with the knowledge triangle. The EU clearly recognises the possible value of clusters and clusters cooperating, but it has not been put into practice yet; the EIT may shape this further.

The third factor,*The educational cooperation is shaped in such a way that, while enabling participating students to acquire skills and knowledge optimally, it facilitates interaction with (students from) other schools optimally*, is ultimately shaped by the European JDs and the EM Master's, which can be used to find suitable cases for the case study research.

Factors four to six relate to the education programme offered by educational institutions. As explained in this chapter, when concerning educational programmes the EU supports and encourages, but does not have the competency to prescribe specific programme items: that is up to the institutions themselves. This is the subsidiarity principle in relation to the Lisbon treaty. Therefore, the factors will most likely not be found in EU policy, but the general ideas leading to the factor, may be apparent.

The fourth factor, *the presence of innovation theory in the educational programmes*, cannot be found in European policy documents. EU policy documents do, however, stress the importance of innovation, in more than one document, but there are no documents that really encourage to teach innovation theory in any way.

The fifth factor was *cooperating with other actors in the innovation process to address the technology gap, by the availability of lessons given by part time teachers that also work for industry.* Like the previous factor It is of course not within the competency of the EU to prescribe lessons by part timers from the industry. But, in this case, it can be concluded that the EU does encourage it. The EU does aim to address the technology gap and indicates that this can be done by more involvement of businesses in curricula development. How business is involved, is up to the educational institutions, and that can be by providing students with lessons from part time teachers that also work for the industry.

The sixth and last factor, *attention for creativity, initiative and self-confidence in the programme*, is clearly mentioned in for instance the Council conclusions on the role of education and training in the implementation of the ‘Europe 2020’ strategy [EC 2011a] but also in other policy documents. In these documents the EU points out that attention for creativity, initiative and self-confidence is an important aspect of the education of the future with more attention for entrepreneurship.

Overall, it can be concluded that EU policy, to the extent possible when considering the EU competencies, does resemble innovation theory in many ways. The EU does seem to recognise the importance of the factors distilled from innovation theory, accept for the importance of incorporating innovation theory in education programmes. For the remaining five factors, the EU has not developed actual policy for all factors, but that can sometimes be explained by the in depth nature (eventually its up to the institutions) and sometimes by the early stage in which the ideas still are in the EU and still need to be shaped.

CHAPTER 6 EUROPEAN AUTOMOTIVE SECTOR

This chapter and the following chapter, will study the way in which the theoretical factors on the influence of education(al cooperation) are reflected in practice in the automotive sector as it is shaped by EU policy. This chapter will look at the first factor, relating to the sector in which the educational cooperation and innovation take place. The factor stated that OI should be presented in the sector that is being researched, enabling other factors to exist and/or contribute to innovation.

The sector researched in this thesis is the European automotive sector, following the choice of the EP to look into the possible enhancement of innovation through the knowledge triangle in this particular sector, and the GAST project then recommending to research educational cooperation in the sector. This chapter will first introduce the sector, providing a background and explaining why the EP chose this particular sector to enhance innovation further. The next paragraph will then study the innovation characteristics of the sector in the search for an answer to the question whether or not the first theoretical factor enabling education(al cooperation) to contribute to innovation, the presence of OI, is present in the European automotive sector. It will explain whether or not the automotive sector is able to absorb education(al cooperation) and its possible contribution to innovation when applying the factors. This paragraph may also provide some insight in the importance of the remaining factors for innovation in this particular sector.

6.1. Introduction to the automotive sector

During the past century, the automotive industry has become a key sector in the European economy, characterised by a handful of big companies and a substantial number of independent suppliers.

The automotive sector has been under constant development since German Carl Benz invented the car in the late 19th century [Eckermann 1989]. Hundreds of companies picked up his idea in the first part of the 20th century and started producing cars. Due to the first and the second world wars, and the economic crisis of the 30's and 70's many companies disappeared, and the sector has seen many mergers and acquisitions. As a result, in Europe, the number of companies has gone down from hundreds to

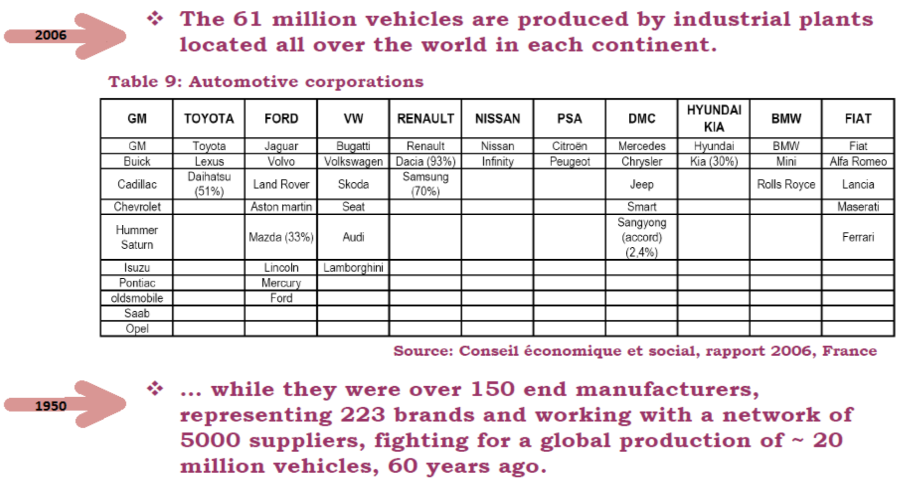


Table 9: Automotive corporations

GM	TOYOTA	FORD	VW	RENAULT	NISSAN	PSA	DMC	HYUNDAI KIA	BMW	FIAT
GM	Toyota	Jaguar	Bugatti	Renault	Nissan	Citroën	Mercedes	Hyundai	BMW	Fiat
Buick	Lexus	Volvo	Volkswagen	Dacia (93%)	Infinity	Peugeot	Chrysler	Kia (30%)	Mini	Alfa Romeo
Cadillac	Daihatsu (51%)	Land Rover	Skoda	Samsung (70%)			Jeep		Rolls Royce	Lancia
Chevrolet		Aston martin	Seat				Smart			Maserati
Hummer Saturn		Mazda (33%)	Audi				Sangyong (accord) (2,4%)			Ferrari
Isuzu		Lincoln	Lamborghini							
Pontiac		Mercury								
oldsmobile		Ford								
Saab										
Opel										

Source: Conseil économique et social, rapport 2006, France

Figure 8: Reduction of manufactures from 1950 until 2006

seven big companies that own about 40 brands.[10] Figure 8 demonstrates this reduction of companies in the automotive sector from 1950 to 2006.

Currently the European sector is composed of Daimler, Volkswagen (VW), Bayerische Motoren Werke (BMW), Ford Europe, General Motors (GM) Europe, Renault, PSA (Peugeot-Citroën) and Fiat. From this point on they will be referred to as Original Equipment Manufacturers (OEMs). But this current composition is unstable as well: Porsche was bought by VW in 2010 and GM Europe still exists because merger and/or acquisition talks didn't work out in 2009. In addition to the big seven, there are a number of small manufacturers, like Spyker/Saab in the Netherlands.

The biggest part of the vehicle production in the sector, about two thirds, is outsourced to independent suppliers, of which there are many in Europe. The output of the actors in the sector includes cars, light trucks and vans, buses and coaches, medium and heavy trucks, motorcycles and agricultural and forestry tractors.

With that output, the industry in the automotive sector comprises the significant share of 6,5 % of the total manufacturing in the EU. [EC 2009b]. The sector has seen rising output and employment over several years, both peaking in 2007, and despite its slump towards the end of 2008, overall production has not sunk below the level of earlier years. In 2009 and 2010 growth rates were very negative in both domestic and foreign markets because of the global economic downturn, but, for 2011, total vehicle production has grown again. The sector is not just important for employment and export in Europe. With approximately € 20 billion (ca. 5% of the sector’s turnover) invested into research and product development, the automotive industry is also the largest industrial R&D investor in Europe in absolute terms. [EC 2007b] More information regarding private R&D investment in Europe can be found in Annex III.

The EU has recognised the importance of the automotive sector, as is demonstrated by the choice of the EP for the GAST project. The EC has also introduced sector specific communications with the aim to further strengthen the sector and with that, the European economy. One of the most recent of these communications was the EC communication entitled “a European strategy on clean and energy efficient vehicles” [EC 2010e], published in April 2010. It was introduced as a significant contribution to the EU2020 priorities smart, sustainable and inclusive growth and intends to promote a more resource efficient, greener and more competitive sector.

6.2. Innovation characteristics

The automotive sector is driven by innovations, which is proven by incremental developments in the sector like for instance the development of adaptive speed control, or more fundamental developments like the transition to a new main power source. At the moment of writing, there are signs that the automotive sector is on the verge of a technology transition from combustion engines towards electrical engines as main power source [Tate et al 2008]. These developments need to be accommodate optimally, but at the same time have a big impact on the technology gap and require

10 On the following Wikipedia pages you can find a list of every western and Eastern European car brand that ever existed: http://en.wikipedia.org/wiki/List_of_Western_European_cars, http://en.wikipedia.org/wiki/List_of_Eastern_European_cars. These websites clearly show that there has been a significant decline in the amount of companies. The ones that didn't disappear are with a few exceptions all part of one of the big seven European Automotive companies.

a fast adaptation by actors in the sector. OI, and the interaction and cooperation with many different actors in the system, is therefore indispensable for innovation in the automotive sector.

The automotive vehicle started out as a relatively simple mechanical method of transport and gradually evolved into today's sophisticated vehicles, with a significant (and still growing) electronic content. To provide comfort and safety, while still being friendly to the environment, these new vehicles use the latest developments of many different technologies. Research in the automotive sector is therefore characterised by its diversity. Developing, producing and selling a vehicle, involves many scientific fields working together. From engine electronics to control emissions to material science to enhance the durability of tyres, and from marketing to selling vehicles on a global market to sound engineering to having the vehicle make the most desirable sounds. Managing all these developments means that the big manufacturers have always maintained close relationships with universities and research institutes for their research.

To produce all the modules, components and sub-components, that come together in OEMs factories to become a vehicle, the sector is characterized by a web of companies, As observed by Dilk [Dilk et al 2008] the innovation output has to be delivered de-centrally by different suppliers more and more. That makes it necessary to coherently integrate the single modules into the final product, i.e. in this case the vehicle ready to be driven. However, a successful and good integration needs to be considered early in the process of R&D by every involved company. Thus, a close exchange between the different companies is necessary. As a result, innovation networks are gaining relevance in the automotive sector because they can provide the companies with the close exchange they are looking for, and thus it is important for the people involved to have interaction skills and function within the network. The research by Dilk confirmed the high relevance of these networks for the automotive sector. It can be expected that innovation networks will spread further and gain more importance in the coming years. They are believed to grow more regional (and thus resemble clusters) in the future [Sturgeon et al 2009]. The most important goals that the involved companies aim to realize by using innovation networks include flexible access to technologies, intensified contact to clients and markets and long-term bonding of suppliers and clients.

The web of companies now producing the modules for OEMs, is illustrated in figure 9. The web is divided in so-called tier 1, tier 2, tier 3 etc. suppliers,showing the number of connections with the OEM and the web is growing to be more and more intertwined. The tier 1 suppliers, suppliers that directly supply their products to the OEMs, have increased their overall R&D involvement significantly since the 80's, because. The main reason for this is reduction of OEM development costs by making use of existing spillover effects at suppliers. The biggest tier 1 supplier, Robert Bosch from Germany, has, since this development started, transformed into a company with a comparable revenue and turnover as the OEMs. and another tier 1 supplier, Canadian Magna was even in talks of merging with GM Europe, one of the OEMs. Because

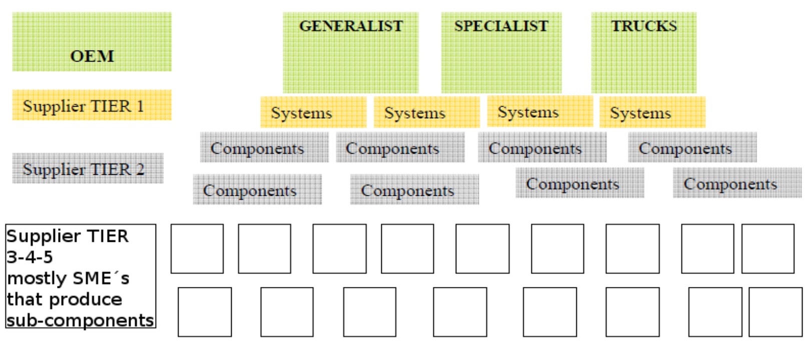


Figure 9: Tier x suppliers

of this trend of shifting R&D involvement, more and more researchers are needed in the development departments of the tier 1 suppliers. Accordingly, the percentage of added value of suppliers compared to OEMs has raised significantly over the past 30 years as illustrated in figure 10.

The innovation in the automotive sector is complicated and therefore involves many different actors, even more so because of the high speed of innovation taking place. The European automotive sector is facing global competition, which induces the life cycle of vehicle models to become significantly shorter. At the same time, new methods and tools, like simultaneous or concurrent engineering, are spreading, helping to decrease the development time for new models accordingly. To give an idea of the pace in which this is changing, figure 11 shows the decrease in development time for a new vehicle over the last two decades. The process of innovation is complicated even further since the number of models and variants of vehicles is increasing and new market segments are opening up as a result of the rising customer demand for more tailor-made vehicles. Speed and numbers are increasing, while in the meantime the technical complexity of vehicle development is rising as a result of the electro-mechanical integration and inter-connectedness of most vehicle components and modules. All these simultaneous developments make it that much more difficult to have expert knowledge in all technological aspects. That's one of the main reasons why the big companies in the sector cannot exist without their relations with universities and research institutes and their big web of supplying companies.

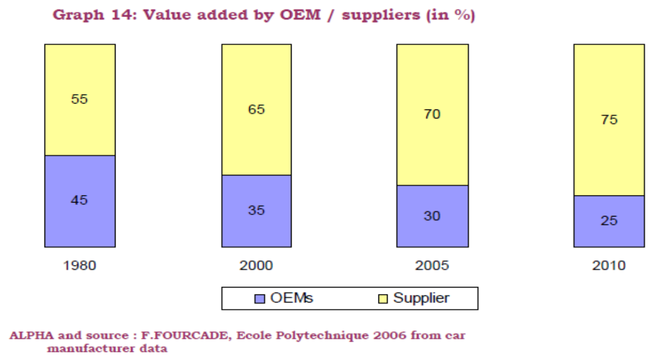


Figure 10: Added value of suppliers compared to OEM's

These relations can be shaped in a cluster, which, as previously described, may grow from innovation networks. To determine whether there, already, are any automotive clusters in the EU, and if so where, a tool was used that has been developed by academics and the EC's Directorate General for Enterprise and Industry (ENTR): European Cluster Observatory (ECO). ECO was launched in June 2007 and funded by the Europa INNOVA initiative of ENTR and is aimed at enabling policy makers to design evidence based cluster strategies.

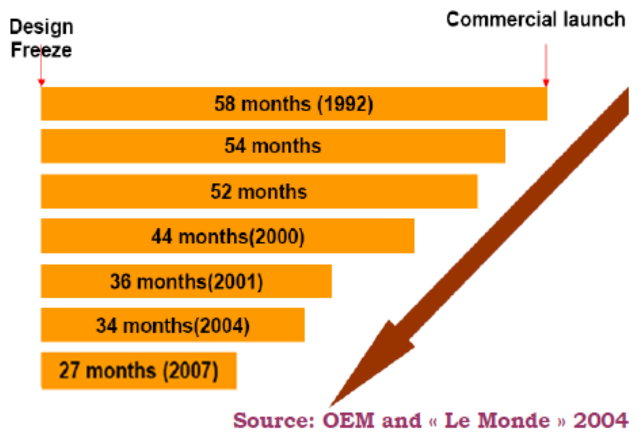


Figure 11: Reduction of development time in the last two decades

ECO combines the two dimensions of geography and industry (sectors). It uses statistics, to trace regional agglomerations of employment in a sector, which ECO calls ‘statistical regional clusters’. These are so-called ‘micro clusters', since they give an indication of the regional activity in automotive related companies, but do not include, for example, educational institutions. There is, however, no tool available (yet) that does provide an overview of clusters as defined in chapter 3: a group of firms, related economic actors, and research/education institutions that are located near each other and have reached a sufficient scale to develop specialised expertise, services, resources, suppliers and skills in the automotive sector. An overview of micro-clusters in the automotive sector will therefore be used as the basic input to locate automotive clusters. The next chapter will compare this overview of micro cluster locations with the location of the institutions offering the educational programmes selected for case study, to find overlap. When these overlap there is a strong possibility that the educational institutions are part of a cluster instead of a micro cluster, since the presence of the educational institution itself means that the whole is more than a micro cluster and resembles a cluster.

The use of ECO to identify the clusters in Europe in the automotive sector, resulted in the map of clusters as shown in Figure 12. The figure shows the location of automotive statistical regional clusters in Europe (the EU-27 and the five associate countries of Iceland, Israel, Norway, Switzerland and Turkey). The size of the stars indicates the amount of people working for the automotive sector in that particular statistical regional cluster.

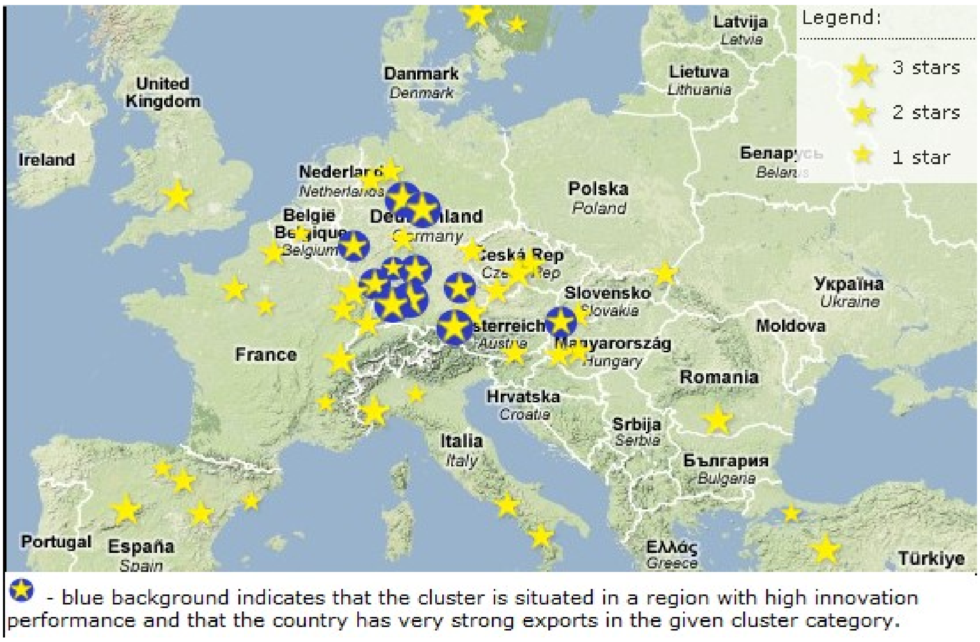


Figure 12 Automotive statistical regional clusters in Europe [ECO 2009]

The automotive sector consists of many different and important actors, whether or not in a cluster. The many developments, high speed and large demand in the automotive sector have lead to a significant shift of added value from manufacturers to suppliers and researchers, that, as a result, causes a shift of development tasks and technological competencies away from the big companies dominating the sector[Becker 2006, Chanaron et al 2007, Birchall et al 2001]. The formerly highly secured R&D departments of the OEMs have opened up and have started cooperating with suppliers, researchers and even with competitors on new innovative solutions. Others, outside the OEM, are being involved to close the technology gap and facilitate possible future innovations.

This way, the automotive sector is very capable of absorbing education(al cooperation) and is embracing Open Innovation [Ili et al 2010].

6.3. Conclusions

As illustrated in this chapter, the automotive sector is constantly adapting to changing market conditions and will continue to do so in the future. The OEMs that are best equipped to rapidly adapt to the changing market conditions, are the OEMs that will remain successful in the future. With the eminent technology transition from internal combustion engines towards electric propulsion, this adoption will be a tougher and bigger challenge than earlier ones and will depend highly on the capabilities of their engineers and network.

In short the European automotive sector can be summarized as

- a crucial sector for the European economy;
- consisting of a few big players that rule the game;
- surrounded by many actors, researchers, suppliers from tier 1 to tier xx that have become important development partners for the big players over the years, etc;
- constructed of innovation networks;
- presence of many micro-clusters;
- constantly innovating at high speed;
- and thus a sector in which Open Innovation is very much present and the ability to absorb education(al cooperation)

This chapter has provided an answer to the question if the first theoretical factor enabling education(al cooperation) to contribute to innovation, the presence of OI, is present in the automotive sector. It is present, and with that education(al cooperation) may contribute to innovation in this particular sector, according to the theory.

From this chapter, it can also be concluded that the other factors will be as important for the automotive sector as for any other sector in which OI is present. The sector is able to absorb the contribution that the education(al cooperation) has when applying the other factors. The foremost challenge for the sector is that the established players need to understand that innovation is distributed now. Key to survival is the innovative capability of an organization and therefore innovation network. This innovation network is not constituted of subsidiaries of the same company. It’s a way of tapping into resources, tapping into the most innovative people using alternative tools. The use of complex electronics for instance, has significantly increased over the past two decades and requires competencies that originate outside the OEMs development centres. They often cross national borders, which makes multi-cultural skills desirable. So, with the rising complexity of the innovation system the requirements for employees change. Their education should be focused on interdisciplinary and intercultural skills. intercultural experiences are therefore a big advantage in working within such a network. Furthermore, entrepreneurial skills will help to get the attention of the network on possible innovations, and, since the system of actors is so complicated in a sector that is constantly innovating, knowledge of innovation systems may be very useful as well.

Also, strong interaction between industry and education is necessary for education to be able to teach the newest most relevant info to keep the technology gap small, and deliver best skilled workers. This is now more important than ever because of the eminent transition in propulsion technology.

As to the factor relating to clusters, this paragraph demonstrates that innovation networks and the interaction and cooperation with many different actors is increasing in importance for the automotive sector. Part of an innovation network may be present in a cluster. Partially, because not all companies/institutes of the innovation network will be present, since some of them might be at a different location. But, there is a trend towards more and more cluster presence, following from chapter 3, an automotive cluster is a group of firms, related economic actors, and research/education institutions that are located near each other and have reached a sufficient scale to develop specialised expertise, services, resources, suppliers and skills in the automotive sector. It could not be determined in this chapter whether or not these clusters are present in the EU, but the micro clusters in Europe were identified for further research in chapter 7. Because of the big web and many linkages, possible automotive clusters will often be interdependent and overlap, with some companies being part of more than just one cluster. The next chapter may, for the cases, determine whether or not automotive clusters really are present in the EU, but this chapter has already demonstrated that, at the least, there are many micro automotive clusters in the EU.

CHAPTER 7 CASE STUDIES

This chapter will conclude part B of this research on the question if the theoretical factors, criteria to be met by educational cooperation for it to contribute to innovation, are applied in practice in the automotive sector, as shaped by EU policy. The questions what the EU policy is for education(al cooperation) in relation to innovation has been answered in chapter 5. It has also already been concluded in chapter 6 that the factor that OI should be present in a sector, which is only partly recognised by the EU, is being met in the European automotive sector. This chapter will now study what EU policy for education(al cooperation) in relation to innovation looks like in practice in the automotive sector, by carrying out a case study into two individual samples of educational cooperation in the automotive sector. It can then be concluded if the remaining five factors that resulted from part A are applied in the automotive sector, as it was shaped by EU policy, as well. In part C it can then be concluded if educational cooperation has the potential to contribute to innovation in practice according to theory, and if applicable, what can be done to improve it.

This chapter will bring the theory that was found to the practice of two cases. Paragraph 7.1 will first explain the choice for the case study research methodology, after which the cases for this research will be selected. Paragraph7.3 is devoted to the two selected cases. In this paragraph detailed information is gathered through the study of documents found on internet and by interviewing the coordinators of the two selected programmes, and another coordinator from one of the other participating institutions. That collected information will be compared with the factors found in chapter 4 to be able to conclude if the education(al cooperation) has the potential to contribute to innovation.

7.1. Case study methodology

When the first ideas for this research started to arise, the method for gathering usable data came right after. The nature of the research questions eliminates several research methods. A history study might have been a good method if there had been a lot of literature about the influence of educational cooperation on the other two legs of the knowledge triangle, but this is not the case. Experiments, for instance, require a controlled environment [Yin 2009: 11] which is not possible for educational institutions. For this research, data has to be collected from people and institutions in their everyday situations, not within the controlled confines of a laboratory, the sanctity of a library, or the structured limitations of a survey questionnaire.

Yin mentions three conditions that influence the research method [Yin 2009: 8]. These conditions are the type of research question, the extend of control over actual behaviour events and the degree of focus on contemporary events. This research has an exploratory question with minor control over actual event and the degree of focus is on actual events. According to Yin, these conditions favour case study research as the preferred data collection method. Yin describes a case study as being an empirical inquiry that investigates a contemporary phenomenon in depth and within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident. This research is indeed focused on a contemporary phenomenon, education(al cooperation), with unclear boundaries with its context. So, the choice to use case study research was made and cases could be selected.

7.2. Case selection

The purpose of this paragraph is to select the cases to be studied in the remainder of this chapter: samples of educational cooperation in the automotive sector. Before searching for the actual programmes constituting the educational cooperation, it needs to be determined what level of education is suitable and what the focus of these programmes should be to be able to speak of a programme in the automotive sector.

The first step in the search for programmes in the EU offered by cooperating educational institutions in the automotive sector, that can be the case to be studied, is determining the level of education that is suitable for this research. To do this, the structure of education levels in the EU is investigated and that shows that these have developed into a standard system over the years that is used by the majority of countries and EU member states. This system is roughly divided into four time periods:

1. preschool education, for ages ~0-5;
2. primary education, for ages ~5-13;
3. secondary education, for ages ~13-17;
4. and, finally, tertiary education, or higher education for ages 17+.

The ages for each period vary between countries and even within countries, but the four periods mentioned in this system are an average of all countries. Of these levels of education, tertiary education is best suited for this research to focus on, for four reasons. Most importantly, it became apparent from the literature that it is the students at this level of education involved in educational cooperation that can influence innovation most. Research has found that the main feature of innovative countries is LifeLong-Learning (LLL) [Villalba 2007], to which the tertiary Master's programmes are one of the biggest contributors [DG EAC 2010]. The second reason this research should focus on tertiary education is that the study on European policy in chapter 5 has shown that educational cooperation in Europe has developed on the PhD and Master's levels and it is developed to such a degree that it is possible to research them. When looking at other levels, there is cooperation, but scarcely and on such a small scale that it is not possible to research. The third reason is of a more practical nature: Tertiary education institutions are very active on the internet and therefore relatively easy to research.

When having selected tertiary level of education for this research, a final restriction needs to be made since tertiary education is itself divided into two levels: the Master's and PhD level. At the PhD level, the existing educational cooperation is mainly built up as an exchange of knowledge between universities to help PhD students when doing their research. Those PhD students are mostly employees in the EU and as such do not receive education. So for this research, the Master's level, at which students do attend classes and receive education, should be the level to focus on.

Having determined that the cases should offer education in the Master's phase of tertiary education, the next step is to identify the Master's programmes offered for the European automotive sector. The automotive sector is a sector that requires a broad range of competencies that cannot all be part of a single Master's programme. The sector uses a large amount of technology and science fields to develop, produce and sell an automotive end product like a car or light truck; Knowledge and skills are needed in relation to, for instance, combustion engines, materials, mechanical engineering, electrical engineering, marketing, production technology. This means that a lot of different Master's programmes educate students the competencies needed to later be able to contribute to the automotive sector. Having to collect all these studies delivering suitable students and then selecting cases would be a study of its own and would exceed the time limitations for this research. So, the decision was made to limit the search for cases to Master's programmes that are directly related to automotive engineering. These are the programmes that are most likely to contribute to innovation in the sector, since these are technical programmes aimed at automotive development.

Having determined the level and focus of the educational cooperation, the selection process, consisting of four steps in total, can now start.

Selection step 1

The first step is to list all programmes, with the universities offering it, that:
- are programmes offered by educational institutions cooperating in the EU,
- at Master level,
- that are directly related to automotive engineering.

These were listed by searching the database of http://www.mastersportal.eu/ and the database of DG EAC with EM Master's courses, education/programmes/mundus/projects/index_en.html.

Selection step 2

A long list of possible cases remains after step 1. To make a further selection, but most importantly, further research possible besides research through interviews, it is important that a significant amount of information is available fast. Thus, step 2 is to select those programmes of which at least one of the universities that offer the programme is listed in the top 100 of the webometrics[11] ranking of best performing institutions on the web. This leaves 133 programmes possibly suited for case study, listed in Annex IV.

Selection step 3

The list contains those programmes with relevance to automotive engineering. Now that step 1 and 2 have limited the amount of programmes to 133, all to be found on the internet, these can now be looked into closer to find the better suited cases. Step 3 assesses the relevance of the programmes, by studying their content as available on their websites or those of the institutions offering the programme: and highly relevant, 5 means remotely linked and thus low relevance to this case study research.

1 automotive engineering, highly relevant
2 mechanical engineering/economics with importance to the automotive sector, relevant
3-5 extended field of engineering, low relevance

Since the selection of just the programmes scoring 1 for relevance leaves sufficient programmes for further selection, these are the programmes to be taken to step 4.

Selection step 4

11 The "Webometrics Ranking of World Universities" is an initiative of the Cybermetrics Lab, a research group belonging to the Consejo Superior de Investigaciones Científicas (CSIC), the largest public research body in Spain. It can be found on the following website: http://www.webometrics.info/top100_continent.asp?cont=europe

To select the cases to be studied in this research from the programmes left after step 4, a final cut is made by choosing those programmes offered by the biggest and most diverse group of cooperating institutions. The reason for this is that for the other factor relating to cooperation, factor 3, it was determined that intercultural interaction is very important and the most complete cooperation would therefore be cross border cooperation. The more different countries involved the more complete the cooperation and potential for students to learn the skills to interact interculturally. Step 4 is therefore to select those programmes, offered by cooperating institutions from at least three different EU-countries.

The final step has left two programmes, which will therefore be the cases to be studied for this research. The educational cooperations constructed of a programme that is a JD Master's programme in the EU in automotive engineering, on which sufficient information can be found on the internet and in which institutions are involved from at least three different EU-countries, are: the European Master of Science in Intelligent Transport Systems (MSc-ITS), and the European Master's Degree in Automotive Engineering (MSc-EMAE). These will be the cases studied in the next paragraph.

7.3. Case studies

In this paragraph the two selected cases will be studied to be able to conclude if the theoretical factors enabling education(al cooperation) to contribute to innovation are applied in the automotive sector, as it was shaped by EU policy. The first case that will be studied is the European Master of Science in Intelligent Transport Systems (MSc-ITS). That case will be followed by the study of the European Master's Degree in Automotive Engineering (MSc-EMAE). First, the case study protocol will be described that is used as guide during the data-collection and study of the cases.

7.3.1. Case study protocol

Now that the cases have been selected, the in-depth research can start. According to Yin [Yin 2009] a good case study needs to start with a case protocol that defines the questions needed to get the right information. With this in mind, a case protocol was created, consisting of several dozens of questions, to learn about the general aspects of the programmes selected and the specific information needed to answer the research question for this case study if the factors, identified in chapter 4, are reflected in practice in education(al cooperation) in the automotive sector as shaped by EU policy. Having in mind that general information on the selected cases needs to be retrieved for the background and the question needs to be answered for all factors if they are reflected in the case or not, the questions relate to the following areas of interest:

- General information
- The cooperation between the educational institutions offering the programme
- Education offered in the programme

The full list of questions used to gather the information on the cases can be found in Annex V.

As meant by Yin, the protocol of questions will be used as a guideline when gathering the information. Several techniques for gathering the information will be used for this research, being the study of documentation on the cases available on the internet and the conduction of interviews with the key persons involved in the cases for more in-depth information.

The next two paragraphs will summarize, per case studied, the results of the analysis of the documents and the interviews. First, general information on the case studied is given, followed by the more specific characteristics on the cooperation between the educational institutions offering the programme and the education offered. The reflection of the factors in the case, and the answer to the research question of the case study, will then be dealt with factor by factor. The case is concluded with some additional lessons learned about educational cooperation by those involved in the case.

7.3.2. Study on case 1, European MSc-ITS

This first case studied to find if the theoretical factors of chapter 4 are applied in theory in education(al cooperation) in the European automotive sector, is the European Master of Science in Intelligent Transport Systems (MSc-ITS). This is a joint Master between three different universities: the Fachhochschule (university of applied sciences) Technikum Wien (FHTW) from Austria, Linköpings University (LiU) from Sweden and the Czech Technical University (CTU) from the Czech Republic. The MSc-ITS is a full-time course that, according to the website (http://www.em-its.eu/), is designed to satisfy the growing demand for professionals in modern high tech transport engineering, better known as ITS. The course is coordinated by the FHTW. The information on the case provided in this paragraph, was gathered with the use of the internet, mainly the website mentioned, and through interviewing Professor Simeonov of the FHTW, overall coordinator of the Master's programme, and Dr. Ing. Gabriela Achtenová, contact person for the Master's programme at the CTU.[12]

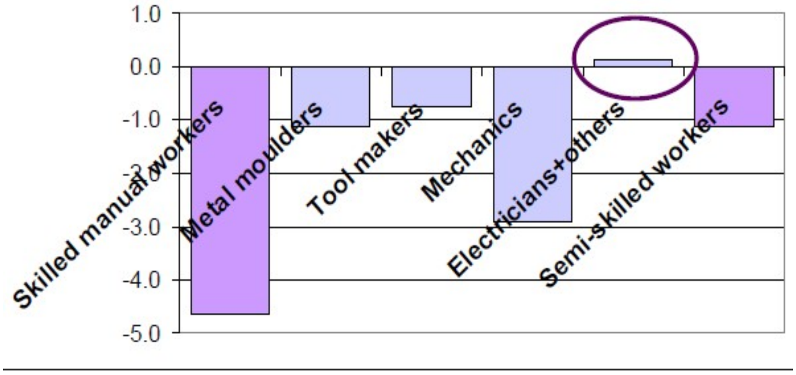
7.3.2.1. General information

Specialisation of the programme
The European Master of Science in Intelligent Transport Systems, MSc-ITS, focuses on education about the performance of transport systems. According to the website of the programme, the performance of these systems is of crucial importance for individual mobility and commerce and for the welfare and economic growth of a country. ITS solutions are focused on streamlining existing bottlenecks in transport systems with the aim to increase the performance of the whole system. With the rise of globalisation in the last two decades, the tension on transport systems has grown. A region or country with a good performing transport system increasingly has an important competitive advantage. And thus ITS solutions are very likely to become very important.

Two examples that show that ITS solutions have grown in importance over the past decade are the use of Global Positioning System (GPS) in the production process and the use of GPS for avoiding congestions. GPS data is collected in real time and used integrally in the production process of a car to determine when which car parts will be available at the factory, so that the sequence of production can be adjusted to that information. More sophisticated car navigation systems are

12 The audio files of the interviews are attached to the digital version of this thesis and can also be sent upon request

used to avoid congestion by guiding cars to less congested roads. The anticipated rising of electro-mobility[13] will only increase the demand for complex ITS solutions even further [Paar et al 2010]. Figure 13 shows that for skilled workers the only growth is within the ITS related area of *electricians + others*.



Source: Alphametrics

Figure 13: Change in share of skilled and semi-skilled workers employed in EU15, 2000-2007 (percentage pointchange)

The development of ITS solutions requires people that have knowledge of transport systems as a whole, have good insight in system thinking and have thorough knowledge of technological solutions. Furthermore, ITS solutions demand a lot of negotiating and debating skills to reach generally accepted agreements with all kinds of people. These negotiations are necessary on different levels, like negotiations between ITS engineers of companies originated in different countries. This means that a high level of interdisciplinary and intercultural knowledge is highly preferred.

Universities involved

The universities that set up the Master's programme on ITS are FHTW, CTU and LiU. The FHTW is a relatively young university that started seventeen years ago and has seen a rapid growth:

1994: Start of the University with its first course electronics with financial backup from the community of Vienna and big electronics companies.

2000: appointment as the first Vienna University of applied science (Wiener Fachhochschule).

2003: move into new building.

2005: complete transition towards Bachelor's and Master's programmes.

2011: start of building extension II of the main building.

Nowadays, FHTW is the largest purely technical university in Austria with 2700 approved student places in eleven Bachelor's and seventeen Master's degree programmes in 2011/12 [Wissensbilanz 2011]. The University also offers several joint programmes. At the time of the interview with Mr. Simeonov (September 2010), besides the MSc-ITS, the university was involved in three other joint programmes. The automotive Master was the first Master's programme that started a joint programme at FHTW. Since then two more programmes were started, but when asked if there is any intra-university consultation on how to best shape a joint-programme Dr. Simenov explained that this was not the case.

Contrary to FHTW, the CTU is a very old university; Its age reaches back to the beginning of the 17th century:

1707: Start of the university by a decree of Emperor Joseph I in which he ordered the Czech general Estates to found an engineering school in Prague.

1938-1945: developments in the Czechoslovak Republic were slowed down by the Nazi

13 Electro-mobility is the ongoing transformation of the auto mobile from a vehicle that uses combustion engines as main power source to vehicle that uses Electricity and electric engines as main power source.

occupation, which included the closing of universities for a period of six years.

- 1948-1989: the communist regime, accompanied by the political oppression, lead to economic stagnation. Hundreds of students, lectures and researchers were kicked out from the universities and research institutes. In spite of this, during these difficult times graduates and staff members of the Czech Technical University created numerous remarkable engineering and architectural works, developed noteworthy technologies, mechanical and electrical equipment, and achieved notable scientific accomplishments and inventions.
- 1960: Only four faculties remained as result of the economic stagnation.
- 1976: Founding of the faculty of architecture.
- 1993: Founding of the faculty of transportation science.
- 2005: Founding of the faculty of biomedical engineering.
- 2009: Founding of the faculty of information technology.

Nowadays, the CTU has eight faculties and is the biggest polytechnic university in the Czech Republic. [Survival guide 2011] According to the website, there are about 32 Bachelor's and 30 Master's degree programmes, but this is difficult to determine since each faculty seems to have its own website and definition of what a programme is. Some faculties have clearly listed the degree programmes where other faculties only have one programme with specialisations, no Bachelor's or Master's programmes at all, or have only just started. It shows that this university is lagging behind with the other universities in offering the right information. The faculty that is subject to this research, however, the faculty of transportation sciences, has a clear website listing five programmes that are offered. Like FHTW, CTU has several other joint programmes, but again no intra-university consultation is taking place.

Like FHTW, the LiU is a relatively young University:

- 1975: Start of the University, the sixth in Sweden. Although it already started taking shape in the 1960's when the Swedish Parliament decided to locate some higher education programmes in technology and medicine in Linköping.
- 1980: Department of Thematic Studies introduced interdisciplinary research.
- 1986: The new faculty of Health Sciences was first in Sweden to use problem-based learning.

Nowadays, LiU has four faculties and 27.600 students receive education in 140 different programmes. These programmes consist of 109 undergraduate degrees (Bachelor or lower) and 31 Master's programmes [Facts and Figures 2011]. It is unknown how many joint degree the university offers in total.

To determine whether one or more of these institutions is involved in a cluster, the map of micro clusters in the automotive sector, found in chapter 6, was used. After all, when a location of such a micro cluster matches with the location of the educational institute, this will potentially mean it is a cluster instead of a micro cluster, since the presence of the educational institute itself means that the whole is more than a micro cluster and resembles a cluster. Comparing the locations of both the micro clusters and the educational institutions, however, learns that there are no matches. So, it cannot be concluded that the educational institutions involved in this educational cooperation are part of a cluster and the interviewees have not refuted this.

Origin of the programme offered

The first thoughts about the programme now offered by the three institutions started to arise during a session of the European ITS-EduNet network, a pan-European, multi-sector organisation that aims to offer validated ITS training material. This network was a result of the European Leonardo Da Vinci 'European network for training and education in Intelligent Transportation Systems' (etnite) project. This project was set up to improve the scope and quality of ITS training and education in Europe. The idea was that in the long term, high quality ITS training and education of students and professionals will lead to a faster implementation of ITS applications that will improve efficiency, safety and sustainability of European transport systems. The project started in October 2004 and lasted until April 2007. Funding for the project was made available through the Leonardo Da Vinci Programme of the EC DG EAC[14]. The consortium of partners that participated in the project consisted of:

Figure 14: Logo of the etnite project. source ERTICO website[14]

- Istituto Superiore Mario Boella (ISMB) – http://www.ismb.it/,
- Association des Constructeurs Européens d'Automobiles – http://www.acea.be/,
- ERTICO – http://www.ertico.com/,
- Technische Universität München (TUM)- http://www.tum.de/,
- County of North Jutland – http://www.nja.dk/,
- Technical University of Crete – http://www.tuc.gr/,
- Ecole Nationale des Ponts et Chaussées – http://www.enpc.fr/,
- Ministero delle Infrastrutture e dei Trasporti – http://www.infrastrutturetrasporti.it/,
- Kungliga Tekniska högskolan – http://www.infra.kth.se/new/,
- University of Ljubljana, Traffic Technical Institute – http://www.pti.fgg.uni-lj.si/,
- Transportation Research Group – http://www.trg.soton.ac.uk/,
- Fachhochschule Technikum Wien (FHTW) - http://www.technikum-wien.at/,
- Czech Technical University in Prague, Faculty of Transportation Sciences (CTU)- http://www.fd.cvut.cz/.

The project was coordinated by ISMB, an institute of the Politechnico di Torino, that supported the European Network on ITS Training and Education (ITSEduNet).

During one of the project meetings the idea was put forward to set up a programme and apply for the EM[15] status to improve the education and attract more students. Four universities participating in the project, together with two universities from outside the project, formed a group that started discussions about this programme in 2006. These six universities were:

- TUM,
- University of Southampton,
- Politechnico di Torino,
- FHTW,
- CTU,

14 Source ERTICO website http://www.ertico.com/etnite and CTU website http://www.lss.fd.cvut.cz/etnite.

15 See paragraph 5.3.2.2 for an explanation on Erasmus Mundus

- Linköping University.

The discussions resulted in a first application for EM in 2006, which was not granted because it did not meet the high EC requirements. A second application done in 2007 was not granted for the same reason. This resulted in three of the six universities leaving the group. The three remaining Universities (FHTW, CTU and LiU) did not want to abandon the work that was done and decided to start the Master's programme, resembling an EM as much as possible, but without applying for it. This resulted in the start of the current programme in 2008.

Figure 15: Group of Universities applying for Erasmus Mundus in 2006&2007

The MSc-ITS programme is set up for a maximum of 90 students a year, but in at the time of the interview with Mr. Simeonov in September 2010 only 20 students were involved in the programme and only one student had graduated the programme, with a further six students were expected to finish the programme before the end of 2010[16].

7.3.2.2. Cooperation between the educational institutions offering the programme

The educational cooperation between the three universities that offer the Master's programme, consists of an integrated curriculum resulting in multiple degrees when more than one university is attended. It makes use of the coherent systems of higher education in the European Higher Education Area and offers a degree as described in chapter 5.3.2.1. The programme is set up as a two year Master's programme and students finish the programme if they acquire 120 European Credit Transfer and Accumulation System (ECTS)[17] points, which complies with the requirements for an EM. The curriculum has a total duration of four semesters and consists of a mix of computer science, telecommunication, automation, sensor technology, transport economics and human-machine interface interaction. Students choose their preferred study-paths after their first semester, but the final assignment of study paths is made by the consortium (FHTW, CTU, LiU) based on performance and availability. For acquiring a double degree students have to change universities after stage 1 (after the second semester) or 2 (after the third semester). For acquiring a multiple degree students have to change universities, the can do this after stage 1 and after stage 2. If they move ones they will acquire a double degree, if they move twice a "triple" degree. Stage 1 can be attended at FHTW or CTU and consists of basic theory. Stage 2 can be attended at all three

16 Mr. Simeonov was the first to be interviewed and as programme coordinator the only source available

17 ECTS was designed by the EC to make teaching and learning in higher education more transparent across Europe and facilitates the recognition of all studies. The system allows for the transfer of learning experiences between different institutions, greater student mobility and more flexible routes to gain degrees. Source: http://ec.europa.eu/education/lifelong-learning-policy/doc48_en.htm.

universities and consists of specialisation by the student. Where each institution has its own field of specialisation, stemming from past individual university programmes: FHTW Engineering in Intelligent Transport Systems, CTU Safety Systems, and LiU Transportation Systems Engineering. The final stage concerns writing a Master's thesis and can again be attended at all three universities.

7.3.2.3. Education offered in the programme

The MSc-ITS consists of sixteen modules. Each module consists of several subjects, that differ per university because of the difference in specialisation between the universities. Students will thus have to be prepared to choose at an early stage which focus they want. Annex VII lists the subjects each university offers with the modules. An example of the different ways of shaping a module can be found in box 7.1.

> **Box 7.1 Example of differences within modules**
> In module 3, *Automated Data Acquisition and Processing,* the CTU teaches two subjects, *Pattern Recognition* and *Data Processing*, that are both rewarded with 3 ECTS. In Austria the FHTW rewards the students also for two subjects, *Sensorics* and *Algorithms and Data Structures, Soft Computing*, both rewarded by 3 ECTS. However, at LiU the module consists of only one subject: *Traffic Demand Modelling*, rewarded with 6 ECTS.

The modules and subjects shaping the programme are the result of combining the programmes existing before this programme was set up. Before the start of MSc-ITS each university had its own programme. During discussions before starting the joint programme these older programmes were compared and evaluated. Out of these discussions came a compromise that uses the best of the old programmes.

The ultimate purpose of the modules, though differing in exact content, is the same at every university. Below, the purposes of the sixteen modules taught during the Master is explained (source: Master programme brochure September 2010[18]).About half of the classes is being offered by (part-time) teachers from the industry.

- Module 1: Transportation Systems (6 ECTS):
  In this module students will obtain knowledge on transportation systems for the various modes of transport. The module comprises assessment and economic evaluation of transport systems, set against the often conflicting background of local and national political objectives. National and international competition in transport systems across all modes is addressed. Quality management in transport systems, as well as safety and security requirements are emphasised. The module covers the transportation of people as well as of goods.
- Module 2: ITS Basics (6 ECTS):
  In this module students will obtain knowledge about how ITS can contribute to the design and control of transport systems. The module discusses systems for traveller information, traffic management and control, driver assistance and vehicle control, freight transport management, public transport management, electronic fare payment and toll collection, and

18 The latest version of the programme brochure can be found on the website: http://www.em-its.eu/pdf/Infoblatt2_ITS.pdf

emergency management. The module also includes ITS in rail, water and airborne transportation.

- Module 3: Automated Data Acquisition and Processing (6 ECTS):
  This module introduces the student to the front end of the information flow chain for an ITS. Starting with sensor technology and elementary sensor systems at the very beginning of the chain, the module then gives an introduction to algorithms and data structures which enables the students to gain an insight into the underlying principles and to realise the necessity of data processing. The module also addresses the principles of data compression and real time data processing for video stream processing.
- Module 4: Mathematical Tools (6 ECTS):
  In this module the students gain knowledge in important techniques for mathematical modelling in the field of transportation and ITS. The module may include topics like linear programming, classical transportation and network flow problems and the simplex algorithm. Special optimisation problems, optimal strategy, reversible and irreversible processes are discussed as well as discrete event processes, random distribution and probability. In queuing theory basic processes, processes of revitalisation, Markov processes, Markov models and non-Markov models, Kendall classification, models with continuous flow, serve processes and examples of Petri nets are used to describe ITS.
- Module 5: Complex Systems (6 ECTS):
  In this module students will learn to use complex system approaches to ITS. They will improve their practical knowledge concerning models and analyses of systemic features, means of detection of systemic characteristics, ways of system decomposition, formulation of states under uncertainly defined conditions and methods for judging the stability of systems. Reliability, control, stability, dependability.
- Module 6: Telecommunication (6 ECTS):
  The focus is on mobile telecommunication and emerging communication systems. One aim is to introduce the concept of wireless communication, to understand problems specific for wireless and mobile communication, to understand design and performance of wireless systems, and to give an overview of existing systems. The students will gain in-depth knowledge of specific communication protocols, networks and systems, and they will be able to solve basic tasks in system engineering, data transmission, computer networking and telecommunication. More basic telecommunication - not just mobile communication.
- Module 7: ITS Management skills (6 ECTS):
  This module provides the students with knowledge of quality assurance, project planning, controlling as well as of legal aspects of ITS deployment. Students learn how to organise and manage R&D projects in industrial and academic setups. The module also includes the practice and development of oral and written communication skills.
- Module 8: Required elective Module (6 ECTS):
  This module is offered in order to reach a homogeneous basic knowledge of all students. Assigned on the basis of their first degree, the students broaden their knowledge in ITS through attending individually assigned modules in transportation fundamentals, sensor

technology, mathematical tools, computer science or telecommunication.

- Module 9, 10: Specialisation in ITS 1 and 2 (6 + 6 ECTS):
  Each partner institution offers highly specialised courses or projects from its own areas of excellence. The particular courses or projects offered can be found in the programme brochure[18].
- Module 11: Traffic modelling and simulation (6 ECTS):
  This module gives the student knowledge about the theoretical foundations of traffic models and about the practical application of traffic models using commercial software systems with the aim of describing, analysing and evaluating ITS. Both static and dynamic models are discussed in different levels of system decomposition. The module includes demand models for the choice of destination, mode and route in a traffic network, models for isolated and coordinated arterial and network signal control, traffic flow theory, car following models and traffic micro-simulation.
- Module 12: GIS, Positioning, Navigation and Identification systems (6 ECTS):
  This module gives knowledge in geographic information systems (GIS) including data structures, cartography and database technology. The module also covers theory, principles and technologies for positioning, navigation and identification of both vehicles and goods. The technology covered in the course is navigational systems (GPS, GALILEO), cell phone positioning and radio communication related to navigation, Wireless Identification Systems (RFID, ZigBee), and sensor and transponder networks. Applications concern all kinds of transport modes and include Automatic Vehicle Location (AVL), location based services, route guidance and navigation, Automatic Vehicle Identification (AVI), fleet management and tracking of goods.
- Module 13: Human and environmental impacts, safety and sustainability (6 ECTS):
  This module introduces the students to the requirements of the transport system with respect to sustainable development and therefore highlights the interrelation between economic, ecological and social impacts. It addresses how efficiency of transport can be improved by using ITS technology and how ITS-technology can be used for satisfying the basic needs of all people. The objective is to lay out long term development strategies for the transport system. Beside this overall approach, the module also covers a selection of particular environmental and safety/security questions like the e-Safety initiative, e-Call, traffic psychology, human-machine-interfaces.
- Module 14 and 15: Specialisation in ITS 3 and 4 (6 + 6 ECTS):
  Each partner institution offers highly specialised courses or projects from its own areas of expertise.
- Module 16: Master Thesis (30 ECTS)
  The Master's thesis provides an opportunity for the students to become engaged in, and where possible, part of running ITS research projects. This enables the student to take ownership of their learning and will help foster the deeper, project based learning necessary to gain a true understanding of the ITS concepts in practice. This module will provide an excellent basis for a career in the ITS industry and is a good foundation for further

academic study (e.g. the enrolment in an ITS related PhD- course).

The desired competencies gained and learning outcomes of the total programme were defined by the initial six universities at the start of the programme development. As mentioned before, three universities left, but this did not affect the then already set competencies and outcomes students should have acquired when having successfully finished the programme. They are summed up below (Source: Master programme brochure September 2010). After having successfully finished the programme, students should be able to:

- Design, analyse and evaluate state of the art ITS by using or developing appropriate mathematical tools (modelling, optimising, statistics, discrete mathematics);
- Understand the function and use of technical and technological equipments (for sensoring, detection, positioning, communication, data processing and pre-processing); understand the role of ITS for improving the transportation systems; understand and asses the different modes of transport including intermodal solutions;
- Take into account human behaviour and the way it influences the effect of ITS (Human Machine Interface (HMI), traffic psychology, user needs, behavioural response to ITS);
- Consider the connections between transport and the economy, transport and the environment, transport and land use;
- Take into account legal requirements regarding the transport system especially with respect to ITS (safety, interoperability, data protection, liability, environmental aspects);
- Manage ITS projects in an international and intercultural context;
- Compare and contrast the advantages and disadvantages of different business concepts;
- Students having acquired a double or multiple degree will more easily get a job in the country that provided the degree. It is also a proof of conduct for having international experience.

7.3.2.4. Factors

As mentioned in Chapter 4, there are six factors that, when met in practice, will make it possible for education(al cooperation) to contribute to innovation. The case studied, the MSc-ITS, will now be concluded by discussing the presence of each of these factors in the programme in this paragraph. Since the first factor was already proven to be present in the sector, and thus both cases, this factor will not be discussed further in this paragraph.

Factor 2 *The educational institution is part of a cluster*
A comparison of locations of automotive micro clusters, found in chapter 6, and the locations of the educational institutions involved in this case, learned that none of the universities were located in the proximity of a micro-cluster in the automotive sector. Thus, the universities participating in the MSc-ITS are not part of a cluster. It is interesting to mention that Mr. Simeonov is of the opinion that educational cooperation may have a negative effect on the cooperation of single participating universities with the industry in the area (that would have been part of the cluster). Part of the

students namely originate from the industry and start as part-time students. If they then want to go abroad for their studies, they have to quit their job.

Factor 3 *The educational cooperation is shaped in such a way that, while enabling participating students to acquire skills and knowledge optimally, it facilitates interaction with (students from) other schools optimally*
The educational cooperation for this case is shaped by the Master's programme offered by the three participating universities. As concluded in paragraph 7.3.2.1, containing general information on the case, it is important when working with ITS to have interaction skills. While offering students to acquire skills and knowledge, it is therefore facilitated that students attend one or both of the other universities for part of the programme; it is even encouraged, though not required. This way the cooperation can even be characterised as the 'most complete' form of cooperation, namely cross border cooperation, offering students the chance to not just enhance their interaction skills, but to enhance their intercultural interaction skills. In addition, module 7 teaches the students participating in the programme management skills, including communication skills, which will of course also significantly improve the students' interaction skills. The competency gained, according to the universities themselves, is the competency to manage projects in an international and intercultural context. According to Mr. Simeonov, students truly gain important competencies during their international semester, including better social skills. Leaving the trusted environment and moving to a completely new one demands them to be more open towards new and sometimes strange behaviours and learn to work with that.

Factor 4 *Innovation theory is present in the educational programme*
When looking at the content of the different modules and subjects of the MSc-ITS programme, it cannot be concluded that there is any attention for innovation theory at all. It is not mentioned in the list of learning outcomes and competencies either. There is an explanation for the lack of attention to innovation theory in the programme: The programme developers believe that it is more important to teach students a management game and offer them technical subjects.

Factor 5 *Cooperation with other actors in the innovation process to address the technology gap, by the availability of lessons given by part time teachers that also work for industry*
Mr. Simeonov estimated that a bit more than half of the points (60+ ECTS) are collected from subjects that are given by staff that is also employed in industry. He could not give an exact number, because some subjects are given by more than one teacher of whom some do work for the industry and some do not. With close to half of the programme being given by teachers from industry, it can be concluded that yes, the educational programme does contain lessons given by part time teachers that also work for the industry. The large number of classes offered by these part-timers will provide the students participating in the programme with sufficient information on the latest developments, knowledge and experiences.

Factor 6 *The education programme has attention for the development of personal skills of students such as creativity, initiative and self-confidence*
For this factor, again, the modules and subjects were scanned for the presence of these three attributes. Out of this scan came one promising module, module 7: management skills. In this module students learn how to organise and manage R&D projects in industrial and academic setups. The module also includes the practice and development of oral and written communication

skills. But it does not mention creativity, initiative or self-confidence as such. These are the skills of an entrepreneur, who are important for innovation. When asking Mr. Simeonov about the attention for entrepreneurship learning in the programme he needed explanation on what entrepreneurship learning is. After clarifying the meaning of entrepreneurship, teaching students to be entrepreneurial, he also mentioned the management course that is part of module 7, confirming the conclusions drawn above. When looking closer at module 7 and its subjects, which includes a management game, it can be argued that creativity, initiative and self-confidence will play a certain role. One could also argue though, that a management game is not suited for developing entrepreneurial skills; It's predominantly focused on developing management skills. This is also what is enlisted as one of the competencies acquired through the programme. That is why the conclusion about this factor is that in this case there are subjects that may trigger development of the three attributes, but that their focus is not the focus meant in the theory of chapter 3. And there is just one module out of the 16 offered that has somewhat attention for the three attributes.

7.3.3.Study on case 2, European MSc-EMAE

The second case studied is the European Master's Degree in Automotive Engineering (MSc-EMAE). The MSc-EMAE is the educational cooperation, a joint master with a double degree, of the HAN University (or 'Hogeschool van Arnhem en Nijmegen') from the Netherlands, the Czech Technical University in Prague (CTU) from the Czech Republic and Ecoles Nationales Supérieures de Techniques Avancées (ENSTA), which is a leading French multidisciplinary engineering school in Bretagne. CTU is the coordinator of the programme.[19]

The case information described in this paragraph was gathered with the use of the internet, mainly the website of the programme, and through interviewing Dr. Ing. Gabriela Achtenová of the CTU, who is the overall coordinator of the programme, and Mr. Hans Vooren, coordinator of the programme at HAN University.[20]

7.3.3.1. General information

Specialisation of the programme
The European Master's Degree in Automotive Engineering is a Master that purely focuses on automotive engineering. The course is a full time programme, with a double degree, and is set up to combine technical, management and linguistic skills. The idea behind the course is that, with the offered education at different participating institutions, the automotive engineer is best suited to work in the international technical environment.

Universities involved
The universities that set up this Master’s programme in automotive engineering are the CTU, HAN and ENSTA. The CTU is also involved in the first case studied, so an introduction on this university

19 At the time of finishing this thesis, two more institutions have joined the cooperation: Technische Universität Braunschweig (Braunschweig, Germany) and Institut Francais du Pétrole (Paris, France). Since this is a recent development of which no further documentation is available yet (the website does not even make mention of the joining of the institutions yet), the choice was made to limit the study of this case to the established cooperation.

20 The audio files of the interviews are attached to the digital version of this thesis and can also be sent upon request.

can be found in the previous paragraph. Also in this case, the CTU is by far the oldest institution involved in the cooperation.

HAN University consists of several former Dutch higher education institutions that have merged. The HAN offers a total of 63 Bachelor's and exchange courses and 21 Master's courses, to approximately 29,700 students. The HAN Automotive Institution, that offers the MSc-EMAE, is a part of HAN University, but is an independent organisation, uniquely positioned to exchange and disseminate automotive information to industry players and government institutions. HAN Automotive Institution consists of the Mobility Research Group, the Vehicle Mechatronics Research Group, the Vehicle Acoustics Group, the Applied Research Laboratory-Automotive (ARL-A) and HAN's undergraduate and postgraduate courses in automotive engineering. Approximately 80 people work within HAN Automotive institution. The Automotive Institution has its roots in Apeldoorn where it began life as the "Auto Technische School" (ATS) Apeldoorn:

Figure 16: Current logo of HAN university

- 1942: start of the ATS in Apeldoorn [Gunnink 2006], at the time the only technical automotive education in the Netherlands.
- 1954: the school is divided into MTS-Autotechniek and HTS-Autotechniek. MTS for students at the lower educational level and HTS for students at higher educational level.
- 1989: merger with Hogeschool voor Techniek Arnhem.
- 1996: move to its present location at the Campus of HAN University in Arnhem.
- 2001: start with research activities under a lectureship.
- 2006: start with offering MSc course.

Figure 17: Logo of the HTS-autotechniek

Currently, the automotive faculty is still mainly focussed on BSc students, but it started offering MSc courses in 2006 because of the growing demand for students with MSc degrees and the lack of MSc automotive education in the Netherlands. The MSc EMAE triggered the development of a full international strategy for HAN University, which it did not yet have. Currently 2,100 international students from over 70 different countries are coming to Arnhem for education. HAN University offers more joint programmes and there is intra-university consultation to exchange experiences.

According to the website of the ENSTA, and that of the EMAE programme, ENSTA is a leading French, multidisciplinary engineering school. The institution started life as ENSIETA and is located in Brest:

- 1971: *École nationale supérieure des ingénieurs des études et techniques d'armement* (ENSIETA) Bretagne was founded as a multidisciplinary engineering institution under the auspices of the French Defence Ministry (DGAC). The only goal of the institution was to train French engineers for DGAC.
- 1990: first civilian students are allowed. Since then, the percentage of civilians has gradually increased over the years to such an extent that they now make up 80% of the students.
- 1992: beginning of research activities at the institution.

Figure 18: Current logo of ENSTA

2010: creation of the École Nationale Supérieure de Techniques Avancées (ENSTA) group, a merger between ENSIETA and ParisTech. And a new name: ENSTA Bretagne.

Figure 19: Logo of the ENSTA predessesor ENSIETA

Currently, ENSTA Bretagne has about 500 students in various fields of research. It has a permanent staff of 65 staff, and are about 350 part-time or visiting lecturers from industry or other universities that also educate the students.

To determine whether or not these three educational institutions are part of a cluster, the map of micro clusters, found in chapter 6, was compared to the locations of the three educational institutions. Like the first case, no matches were found between the locations of the micro clusters in the automotive sector and the locations of the institutions. So there is no evidence that any of these three educational institutions cooperating through the MSc-EMAE is part of a cluster, and the interviewees did not argue with this.

Origin of the programme offered

The initiative for starting the educational cooperation that has resulted in the MSc-EMAE, came from CTU, more specifically Dr. Achtenová, the current coordinator of the programme. During the interview she explained that she met mr. Pauwelussen from HAN University during her postdoc assignment at Delft University of Technology. After she got back to Prague and got a job at the CTU, she contacted Mr. Vooren via Mr. Pauwelussen with her idea to set up a cooperation. Her motivation for doing this did not come from an international strategy of CTU, but out of a personal interest in setting up an international cooperation to attract more students.

First talks between CTU and HAN University thus started in 2005 and the first action resulting from this were Czech students arriving in Arnhem in 2006. In 2007 the first Dutch students moved to Prague. It was at this time that ENSTA (then ENSIETA) got involved and students were exchanged with this third institute as well. With this part, student exchange, of the educational cooperation established, the cooperation was accelerated and quickly developed further and CTU contacted its partners from industry to consult them about the contents of the programme of a joint MSc EMAE.

At the time of the interviews, at the end of 2010, about 30 students had successfully finished the programme. They all got employed while finishing the programme or right after finishing the programme. This comes down to an average of 10 students every year. The MSc-EMAE is set up for a maximum of 20 students a year. In the academic year 2010-2011, there were 15 students participating in the programme. Dr. Achtenová hopes that this number of students, and universities participating in the cooperation, will increase further in the future.

7.3.3.2. Cooperation between the educational institutions offering the programme

The educational cooperation between the three institutions in this case consists of a two year, four-semester, programme [EMAE 2011]. It makes use of the coherent systems of higher education in the European Higher Education Area and offers a degree as described in chapter 5.3.2.1. Students finish the programme if they acquire 120 ECTS. The first two semesters of the programme are filled with applied courses in Prague that are taught in English, mainly by CTU lecturers, but also by lecturers from the two partner institutions. After the first year, students specialise in their second year by going to ENSTA (taught in French) or to HAN University (taught in English). ENSTA offers a programme in vehicle architecture and modelling, HAN University in vehicle dynamics and advanced transport systems. In their last semester, in France or the Netherlands, the students write their thesis while spending five months on an internship at an OEM, an OEM supplier or a vehicle related research centre. Figure 20 summarizes the built up of the programme.

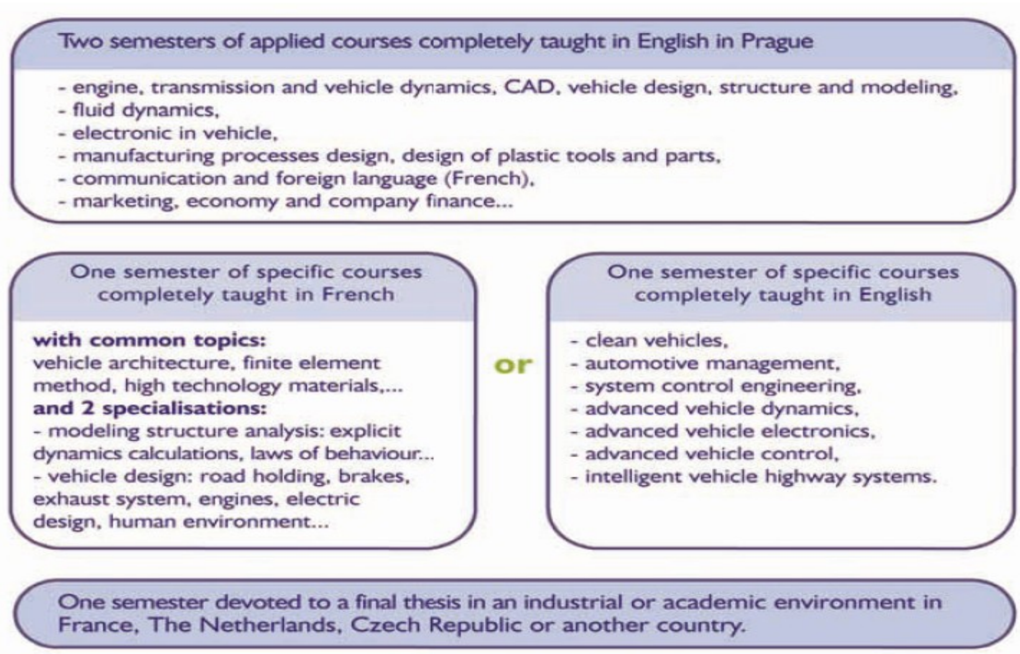


Figure 20: Built up of the 2 year programme (source www.emae.eu)

Institution	Title of degree	Type of degree awarded
Czech Technical University in Prague	Inženýr	Double
ENSIETA	Diplôme National de Master	Double
HAN	Professional Master	Double

Figure 21: Title of degrees (source www.emae.eu)

When having completed the programme, students receive a double degree Master in automotive engineering (see Figure 21) from either CTU/HAN or CTU/ENSTA. The degrees are approved by the national certification boards of all countries involved (Czech Republic, France, Netherlands).

7.3.3.3. Education offered in the programme

The first year of the European Master's Degree in Automotive Engineering consists of sixteen courses, taught at the CTU in Prague. You can find a short description of these courses here:

Semester 1 (taught at CTU) [1st_semester_CTU 2009]

- Internal combustion engines
  Objective of this course is to provide fundamental information dealing with recent concepts of vehicle powertrains, especially internal combustion engines (ICE) and tools for their realization, especially considering mixture formation, combustion and gas exchange principles.
- Mechanical and hydraulic transmissions I
  Objective of this course is to educate the basic design and calculation methods of frictional driveaway clutches and manually shifted transmissions, and their elements.
- Microelectronics in vehicles
  Objective of this is course is to provide students with knowledge about the basics of microelectronics, its use in intelligent devices (sensors and actuators) and their applications in cars. Other topics like real-time software control, communication and Electromagnetic Compatibility (EMC) and are included as well.
- Multibody modelling for vehicle systems
  Objective of this course is to educate the basics of multibody systems, meaning the modeling of vehicle as systems.
- Technology for automotive production
  Objective of this course is to provide students with knowledge about manufacturing methods for the production of parts in mechanical engineering industry and on applications of these methods in automotive production.
- Computation of fluid dynamics
  Objective of this course is providing fundamentals of fluid dynamics and numerical solution of its equations to the students.
- Marketing, Economy and company finances
  Objective of this course is to develop management skills, firstly, to understand consumer and business markets to stipulate marketing goals and marketing strategies. Secondly, to provide the students with knowledge from the economical and financial control of a company, which are necessary to successfully perform leading functions in a company.
- Design against fatigue
  Objective of this course is two fold, firstly, it's aimed at educating the basics of design and calculation of mechanical parts and structures against fatigue damage and fracture. Secondly, it's aimed at educating the basic theory of the Finite Element Method (FEM), this is then used for modeling and calculation on simple machine parts.
- French or Czech
  Objective of this course is to teach students a level of understanding of the French/Czech language, spoken and written, sufficient to enable them to continue their second year of studies in France/Czech Republic.

Semester 2 (also taught at CTU) [2nd_semester_CTU 2009]

- Project + 3D CAD
  Objective of this course is to educate students necessary basics for usage of 3D Computer Aided Design (CAD) software and its application.
- Vehicle dynamics
  Objective of this course is aimed at giving students a basic understanding about vehicle horizontal and vertical performance. With this basis, students will learn how to set up equations of motion and derive fundamental mathematical models to understand and experiment the basics of vehicle dynamics.
- Computation of fluid dynamics
  This course is a continuation of the course given in the first semester.
- Vibration of vehicles
  Objective of this course is to educate students in understanding the basics of mechanical vibrations of vehicles.
- Technology of automotive production
  Objective of this course is to teach students applications of manufacturing methods in automotive production.
- Design of tools and plastic parts
  Objective of this course is give students an overview of the technological procedure for manufacturing plastic parts, and basics of designing manufacturing tools. The course also provides knowledge about guidelines for plastic parts design.
- Vehicle concept, structure, aggregates and safety
  Objective of this course is to give the students insight in the remaining vehicle components that have not been taken into account in other courses with the aim to complete the knowledge of vehicle design and technology.
- French or Czech
  This course is a continuation of the course given in the first semester.

<u>Semester 3</u> (taught in France or in the Netherlands)
This semester has a total of three possible specialisations:

1. Specialisation *design of vehicles* (taught at ENSTA in France)
2. Specialisation *computation and modelisation* (taught at ENSTA in France)
3. Specialisation *vehicle dynamics and advanced transport systems* (taught at HAN in the Netherlands)

1. Design of verhicles:

Objective of this specialisation is to train engineers to integrate complex systems and to design automotive parts with specific automotive constraints. (see figure 22 for the subjects, in French)

MATIERES DU TRONC COMMUN	Volume horaire	Travail personnel	Crédits ECTS
ARCHITECTURE DES VEHICULES	54	10	3
MATERIAUX DE HAUTE TECHNOLOGIE	15	0	0
RAPPELS SUR LA METHODE DES ELEMENTS FINIS	12	10	1
METHODE DES ELEMENTS FINIS EN LINEAIRE ET NON LINEAIRE GEOMETRIQUE	56	10	3
FRANÇAIS LANGUE ETRANGERE	97	55	5
MANAGEMENT	25	10	0
CONFERENCES « FONCTIONS DE L'ENTREPRISE »	7,5	0	0
TOTAL	234	95	12

Figure 22: Specialisation 1 design of vehicles (source www.emae.eu)

2. Computation and modelisation

Objective of this specialisation is to train engineers technical knowledge that enables them to do the dimensioning of structures. Furthermore basic knowledge in vehicle design is used to produce a model that takes into account the strong interaction between the part to model and its environment. (see figure 23 for the subjects, in French)

MATIERES OPTION ARCHITECTURE DES VEHICULES	Volume horaire	Travail personnel	Crédits ECTS
COUPLAGE SUSPENSION-TENUE DE ROUTE	30	10	2
SYSTEMES D'ECHAPPEMENT	26	5	2
ENVIRONNEMENT HUMAIN	30	5	1
SYSTEMES DE FREINAGE	25	10	2
DESIGN INDUSTRIEL	45	20	3
ARCHITECTURE DES SYSTEMES ELECTRIQUES	20	10	2
TRAVAUX PRATIQUES MOTEURS ET VEHICULES	24	3	2
AVANT PROJET VEHICULE	67,5	15	4
TOTAL	267,5	75	18

Figure 23: Specialisation 2 computation and modelisation (source www.emae.eu)

3. Vehicle dynamics and advanced transport systems

Objective of this specialisation is to teach students advanced skills in vehicle dynamics and transport systems so they are able to design and construct vehicles that operate in advanced transport systems. (see figure 24 for the subjects)

TOPICS	Contact hours	Personal work (estimation)	ECTS Credits
ADVANCED VEHICLE DYNAMICS	84	60	6
ADVANCE VEHICLE CONTROL	56	40	4
VEHICLE ELECTRONICS	70	50	5
SYSTEM CONTROL ENGINEERING	42	40	3
AUTOMOTIVE MANAGEMENT	70	20	5
INTELLIGENT VEHICLE HIGHWAY SYSTEMS	56	20	4
CLEAN VEHICLES	42	20	3
TOTAL	420	250	30

Figure 24: Specialisation 3 vehicle dynamics and advanced transport systems (source www.emae.eu)

Detailed information about the subjects of this 3rd specialisation are given here [3rd_semester_HAN 2009]:

- Advanced vehicle dynamics
  This course is a follow-up vehicle dynamics that is offered in the second semester and

offers a more in depth treatment of vehicle dynamics topics.

- Advance vehicle control
  Objective of this course is to give students understanding of dynamic system behaviour and control technology, with a prominent role for discoveries in the field of mechatronics and the driver-vehicle interface. Attention is also given to the driver-vehicle system and modern vehicle control, with the fundamental vehicle dynamics aspects as a firm basis.
- Vehicle electronics
  Objective of this course is to establish the know-how and understanding on the functionality of motor management systems and the (chassis) electronic subsystems, components, sensors etc. and to gain a comprehensive understanding of micro-controllers and electronic devices and corresponding terminology related to these subjects. In addition, attention is given to the monitoring of electronic devices, analysis and cancelling of failures.
- System control engineering
  Objective of this course is to offer the necessary tools for automotive engineers to understand the problems of intelligent vehicle and traffic performance from a system point of view.
- Automotive management
  Objective of this course is to give students knowledge about the latest well-established and recognised values within the automotive society. Part of the course is a small project where the student has to analyse an automotive organisational problem and suggest a strategic change, as well as the process to move from the present Ist-situation to the new Soll-situation.
- Intelligent vehicle highway systems
  Objective of this course is to treat vehicle design within the framework of an intelligent traffic system.
- Clean vehicles
  Objective of this course is to give students insights into the large variety of activities going on about alternative fuels. This course will discuss these development from an in-depth technological but also socio-economic point of view.

Semester 4
The fourth semester is spent on the internship and a thesis concludes this Master.

The courses of the two year joint Master are given by either members of the faculties that are involved in the educational cooperation, or by engineers from the industry (from, for example, TNO, Renault, Peugeot PSA, Bosch, Mecas ESI and Valeo). In the Czech Republic, however, national law limits the possibilities for people from the industry to be involved in educating students. In the Czech Republic the university professors are responsible for offering the education. They are allowed to invite guest speakers from the industry, but only to a certain extent, and the professors are not allowed to also work for the industry themselves.

The acquired competencies during the programme can be found on the EMAE website [EMAE 2011]:

- Technical knowledge of design and technology of the complete vehicle
- Deep knowledge in one of three (six) specialisations[21]
- European overview
- Knowledge of two European languages
- Experience with multinational (multicultural) environment
- Management skills

7.3.3.4. Factors

The six factors that, when met in practice, will make it possible for education(al cooperation) to contribute to innovation, according to the theory found in chapter 3, will now be studied for this case. This paragraph discusses the presence of each of the factors in the MSc-EMAE programme. As mentioned when studying the first case,the first factor was researched in the previous chapter, which proved that OI is present in both cases. Therefore, that first factor will not be discussed further in this paragraph.

Factor 2 *The educational institution is part of a cluster*

The comparison of the locations of micro clusters in the automotive sector and the locations of the institutions involved in the MSc-EMAE programme led to the conclusion that none of the universities were located in the proximity of a micro-cluster in the automotive sector. Thus, the universities participating in the MSc-EMAE are not part of a cluster.

Factor 3 *The educational cooperation is shaped in such a way that, while enabling participating students to acquire skills and knowledge optimally, it facilitates interaction with (students from) other schools optimally*

The educational cooperation for this case is shaped by the Master's programme offered by the three participating universities. While the students participating in the MSc-EMAE programme receive education to acquire skills and knowledge, it is compulsory for them to study abroad for a year. Students of the Czech CTU go to HAN University in the Netherlands or ENSTA in France for their second year, and the students from France and the Netherlands receive their first year of education in the Czech republic. With it being required for students to spend part of their programme in a different country, the educational cooperation can even be characterised as the 'most complete' form of cooperation, namely cross border cooperation, offering students the chance to not just enhance their interaction skills, but to enhance their intercultural interaction skills. It being required, and not just recommended, to go abroad, makes the facilitation of interaction by the cooperation even more optimal. In addition, students are also taught French and Czech during their first two semesters, enabling them to interact with the people from the other countries involved in the programme the language of those people.

In conclusion, by offering part of the programme at an institute across the border and making this mandatory, but also by teaching the students the language of the country in

21 With the joining of two more institutions, there are now six possible specialisations within the programme. As noted before, unfortunately no further information on these institutions, its coordinators or courses is available, and therefore this case study is limited to the established cooperation.

which they complete that part of their programme (when Czech or French), the MSc-EMAE illustrates that the programme clearly does facilitates interaction with (students from) other schools optimally.

Factor 4 *Innovation theory is present in the educational programme*

When looking at the content of the different courses offered by the MSc-EMAE programme, it cannot be concluded that innovation theory is taught to the students. However, when looking at the different courses more closely, one can find that courses offered by HAN University, like 'Automotive management', do teach students about the characteristics of innovation in the automotive sector and the changing roles of the actors involved. However, this education is only available to those students who have chosen the specialisation offered at HAN University, and true innovation theory is still not part of the programme.

Factor 5 *Cooperation with other actors in the innovation process to address the technology gap, by the availability of lessons given by part time teachers that also work for industry*

There is a big difference between the two interviewed universities regarding this factor. At HAN University about fifty percent of the classes offered in the third semester is given by teachers from the industry. However, at CTU this is limited to guest lectures that are given by teachers from industry, because of Czech law requiring professors to offer the education and not allowing them to also work for the industry. CTU offers the largest amount of the courses of the programme to the students, the overall amount of courses offered by teachers that also work for the industry is not that large. But fact is that the programme does contain these kind of courses. A good example is "Vehicle electronics" offered at HAN University. The description of this subject states that the fast developments in the sector requires a skilled staff with specialized know-how and understanding in the specific area of automotive electronics. And thus, the course teaching students about that, has a strong input from the automotive industry (SME's and larger companies) so that the practical use of the course for automotive application is guaranteed.

Addressing the technology gap by cooperating with the industry, is also being done in a different way in this case studied. Every student is required to be involved in a five month internship in the last semester of the programme. This way, students will find themselves in the middle of the reality of the automotive sector, experiencing first-hand what the latest developments are (instead of hearing it from the part time teachers).

Factor 6 *The education programme has attention for the development of personal skills of students such as creativity, initiative and self-confidence*

It cannot be concluded that the development of the skills named are truly part of the programme. Like the first case studied, the programme does contain courses that teach the students management skills, and the three entrepreneurial skills may be part of that. The students choosing HAN University for their second year will be taught "Automotive Management" and the students choosing ENTRA "Management, Conférences «Fonctions de l'entreprise". When asking about the attention for entrepreneurship learning in the programme, the interviewees indicated that this was not part of the programme. So the conclusion about this factor needs to be that, at best, the skills may be developed while enhancing other skills. It does need to be mentioned that, while the management courses may enhance the entrepreneurial skills, the year spent at a cross border institute and the five month internship may also contribute to the initiative, creativity and self-confidence of the student.

7.4. Conclusions

This chapter concluded part B of this research on the question if the theoretical factors, criteria to be met by educational cooperation for it to contribute to innovation, are applied in practice in the automotive sector in the EU. A study of the sector, in the previous chapter of this part B, had already led to an answer for the first factor on Open Innovation, so this chapter researched the remaining five factors. This was researched by performing a case study.

To identify the cases to be studied, it was first determined that the focus should be on educational cooperations on Master's level, because of the information available on the tertiary level and the lack of education for PhD students on that level. The focus of that programme should be related to automotive engineering. To be able to then select the cases, a lot of effort was put into building a small database of all existing European cooperations on that Master's level related to automotive engineering, and then reduce that enormous amount of programmes to a few cases that could be studied. This meant that knowledge about the sector, understanding of Master's programmes and internet skills had to be combined. With the help of rankings and a factor for sector relevance the database was enriched to make it easier to find usable cases. The selection process contained 4 steps aimed to distillate good practices and the right field of knowledge. By using data from different internet databases and checking websites of more than 130 programmes and 150 universities, suitable cases were eventually found when two cooperations in automotive engineering stood out: the European Master of Science in Intelligent Transport Systems (MSc-ITS), and the European Master's Degree in Automotive Engineering (MSc-EMAE). After having developed a case protocol, the study on these two cases was started, through interviews and study of documents, to research if the five remaining factors were present in practice in educational cooperation in the automotive sector. The outcome for the two different cases on the five factors turned out to be rather similar and may be illustrative for educational cooperation in the sector.

For the second factor, on participation in a cluster, the case study resulted in the conclusion that, in both cases, none of the universities involved in the educational cooperation was involved in an automotive cluster. This information was found by comparing the location of automotive clusters with the locations of the participating institutions. Leading to the conclusion that no, the studied educational cooperation in the automotive sector does not involve universities that are part of a cluster and thus factor 2 is not met.

Factor 3 demands that the educational cooperation facilitates interaction with (students from) other schools optimally. This factor is met by the educational cooperation in the automotive sector; research of both cases showed that students are stimulated to interact with the, cross border (the most complete form of cooperation), partnering institutions. It does need to be mentioned that the second case scored better than the first case, because the programme requires that students study abroad and even teaches them the language. This could be improved further for the first case.

The conclusion for the fourth factor, the presence of innovation theory in the educational programme, needs to be that it is not met by educational cooperation in the automotive sector. Nor the courses of case 1, nor the curriculum of case 2 demonstrated any education on innovation theory. The subject taught at HAN University, ‘Automotive management’, came closest with teaching students about the characteristics of innovation in the automotive sector and the changing roles of the actors involved.

Factor 5, however, is clearly present in both cases. Many courses of the programmes, mostly in case 1, are being taught by part time teachers that also work for industry. Cooperation with other actors in the innovation process, addressing the technology gap, is taken even further in case 2 by requiring that every student is involved in a five month internship to experience the innovation process first hand.

Lastly, the case were studied to find if factor 6 is present in educational cooperation in the automotive sector: attention for the development of personal skills of students such as creativity, initiative and self-confidence in the education programme. These skills can be improved in many different ways and therefore, when no educational expert, it is difficult to assess whether this is done in a programme or not. For this cases, the best answer that can be given is probably that it is not a direct goal of both programmes to improve these skills, but improvement may be a side effect of some courses taught (like management) and of the time spent cross border or when fulfilling an internship.

When then looking at the overall score of the educational cooperation in the automotive sector, it can be concluded that it does meet part of the factors, three and one partly, and can thus, according to theory, contribute to innovation. But, since the application of one of the factors leaves room for improvement and two factors are not met at all, the contribution of educational cooperation in this sector still leaves a lot of potential for the future. It can be expected that the programmes will be improved further in the future. After all, both cases are relatively young when looking at the year in which they started and the number of graduates they have produced. Case 1 had produced 1 graduate at the time of the interview and is still a reservoir of older subjects of the three different universities that needs to develop into a more coherent programme. Case 2 had delivered 30 graduates, but only because it was already in place as a programme for student exchange before it was truly a joint degree.

The case study in this chapter has managed to answer the question if educational cooperation in the automotive sector has the potential to contribute to innovation. The information gathered from the documents and interviews has turned out to be sufficient to be able to research all factors and answer all questions. Further data gathering that was considered on forehand was therefore not necessary.

PART C CONCLUSION

CHAPTER 8 CONCLUSIONS AND RECOMMENDATIONS

Having completed the theoretical research in part A of this thesis and the research into EU policy and the automotive practice in part B, this part C will conclude this research into the question if education(al cooperation) can contribute to innovation. First, the research question and sub questions will be discussed and answered. This research will end with recommendations to those that can influence the contribution of education(al cooperation) to innovation and to those that can research it further.

8.1. Conclusion of the research

This research was set up to answer the question if education(al cooperation) could contribute to innovation. The EU wants to further improve innovation to increase the competitiveness of the EU in the world, and one of the instruments it wants to use to achieve that is the EIT. GAST as a pilot for the EIT, reckoned educational cooperation might be the way to achieve the goals and suggested to look into educational cooperation as a tool to improve innovation in a sector. This led to the research question, if education(al cooperation) can contribute to innovation. That question was researched in both theory and practice, in an exploratory way, since this subject is still a blind spot in innovation theory in need for further research such as this thesis.

To answer the first sub question, on the theoretical potential contribution of education(al cooperation) on innovation, that also provides the basis for the research on practice, innovation literature was studied. Educational cooperation itself is a blind spot in this theory, but the study of different innovation theories, looking for their perception of the importance of education and cooperation – the important elements of educational cooperation according to chapter 2-, did lead to a model of factors. According to theory, education(al cooperation) can contribute to innovation if one or more of these six factors are present in the cooperation:

1. Open Innovation is present in the sector;
2. The educational institution is part of a cluster;
3. The educational cooperation is shaped in such a way that it enables participating students to interact with (students from) other schools optimally
4. Innovation theory is present in the educational programme
5. The education programme contains lessons given by part time teachers that also work for the industry
6. The education programme has attention for the development of personal skills of students such as creativity, initiative and self-confidence

With the finding of these factors the question was answered if a contribution is possible, and how, according to theory. In part B of this research it was researched if these factors are reflected in EU policy and the automotive practice to be able to answer the same question for practice.

The study of EU policy documents learned that the competencies of the EU are limited; when it comes to education and educational cooperation the EU facilitates but does not impose with its policy. Innovation policy is getting more prominent and, though for other reasons, policy on educational cooperation is present and growing in the EU. Most importantly, the EU facilitates the cooperation between cross border educational institutions through its measures taken developing the European Higher Education Area for more comparable, compatible and coherent systems of higher education in Europe. The EU recognises the importance of education(al cooperation) for innovation and wants to bridge the gap between the two fields. Measures taken do resemble some of the factors found in theory.

The EU has eye for the importance of OI, but cannot really influence this and thus only recognises it as a factor of influence. The importance of clusters, and partnerships between higher education institutions, research centres and businesses, has been recognised by EU policy as something that needs to be encouraged, but it has not been put into practice yet; the EIT, with recommendations from GAST, may shape this further. The third factor on facilitation of interaction with (students from) other schools, is ultimately facilitated by the EU with the EHEA, the idea for JDs and the EM Master's. This is recent policy and the EHEA may be developed even further. The final three factors all relate to the education programme that is offered by educational institutions in which the EU has no role. But, the general ideas of the factors on cooperation with other actors in the innovation process to address the technology gap and the attention for creativity, initiative and self-confidence, are recognised and encouraged by the EU.

Overall, it can be concluded that EU policy may only be able to directly influence two factors, clusters (though this remains to be seen in the future) and facilitation of interaction. It does also recognise the first factors and two of the factors relating to the educational programme, of which it also distantly encourages the latter. Educational cooperation shaped by this EU policy may therefore be able to contribute to innovation, since it profits from EU policy on the facilitation of interaction and may work on the recommendations of the EU on the education programme. It may also profit from cluster policy in the future. Involvement of innovation policy in the education programme will have to be an own initiative, while OI needs to come from the sector.

Apart from EU policy, the characteristics of the automotive sector also influence the answer to the question if the six factors are applied and education(al cooperation) in the automotive sector, as shaped by EU policy, can contribute to innovation according to innovation literature. Most importantly, it determines whether the factor on the presence of OI is met. It was concluded that the automotive sector is an important sector for the European economy in which developments happen fast in a complicated system, making OI indispensable and thus present in the sector. With that, an answer to the question if education(al cooperation) in the automotive sector, as shaped by EU policy, can contribute to innovation according to innovation literature, was already found, since one of the factors distilled from theory now was discovered to be met. Of course, the other factors were still researched in chapter 7. As to these factors, following chapter 6, it was noted that no specific factor is of special importance to the sector, but that the sector can absorb the contribution of education(al cooperation) and all factors are important to bring automotive innovation further. (intercultural) interaction skills and entrepreneurial skills are important for the automotive sector, since the cooperation with other actors to come to innovation is essential and often crosses national borders. Receiving the latest knowledge is also important, because of the constant development in the sector, and knowledge of the innovation system will be helpful when trying to understand and work with the complicated innovation process in the automotive sector. Important for the factor on clusters was the observation that no databases of clusters exist, but that many micro clusters (regional agglomerations of employment) in the automotive sector were identified for

Europe, that could be used for further research in the final chapter, chapter 7.

The final chapter 7 was the core of the research into the practice of educational cooperation, studying cases to find if educational cooperation, as shaped by EU policy, in the automotive sector can contribute to innovation. Theoretically, an answer to that question was given when the first factor turned out to be met, but theory identified 5 other factors that, when met, might increase the potential of the cooperation to contribute. These were researched for two cases studied.
The cases selected were educational cooperations existing of a programme that is a JD Master's programme in the EU in automotive engineering, on which sufficient information can be found on the internet and in which institutions are involved from at least three different EU-countries. They showed that educational cooperation in the automotive sector as shaped by the EU, takes the form of a JD that has only recently been set up, using the possibilities offered by the EHEA of coherent systems of education. If they complied with the five factors distilled from theory, was researched by using a case protocol supporting the study of documents and conducted interviews:

Factor 2. The result of the study was that it could not be concluded that institutions are part of an automotive cluster. This may not be a factor that can be changed by the institutions, since the practice of clusters does need to be present in a sector which cannot be determined to be the case. As resulted from chapter 5, EU policy on this matter is in its early stages, but it may be within the influence of the EU to change this. The next paragraph will discuss this further.

Factor 3 turned out to be fairly optimally met by the educational cooperation, though there may be room left for improvement when it is not obligatory for a student to spend part of his/her education across border.

Factor 4 was not met by the educational cooperation in the automotive sector. Even though chapter 6 showed that it is important to understand the innovation system and its actors, the programmes have not incorporated this. Remarkably, this is the factor – together with factor 2 for which there is also no policy in place yet – the EU does not encourage.

Factor 5, part time teachers from industry, is very clearly present and factor 6 partly since the students may acquire these skills indirectly.

Contrary to factor 2, factors 4, 5 and 6, when leaving room for improvement, should be addressed by the educational institution in a sector, further optimising its contribution to innovation. Some of these factors are encouraged by the EU, and the sector demonstrates that it is important for an institute to incorporate the factors, but it is mainly the institutions that should do it. This will be discussed further in the next paragraph.

Concluding the question if educational cooperation can contribute to innovation, the answer is yes for both theory and practice, confirming the hypothesis. Practice however does leave room for improvement and may increase its potential to contribute even further since not all factors are (optimally) met. It may be up to the sector or the policy makers to work on those issues (clusters), but it may also be up to the educational institutions to further improve on the issues already addressed (factors 3, 5 and 6) or to implement those that are neglected until now (factor 4).

The conclusion on theory is general, since all theory, applying to all policy areas and sectors, was studied. It may be used when researching different policies or sectors. But also the research on EU policy, which is applicable to all sectors, and even the automotive sector may be more generally applicable. The cases studied for the European automotive sector are probably a good indication for the possible contribution of educational cooperation in Europe. The outcome for the factor on the presence of OI and its general applicability is difficult to answer, since every sector may be different. But when reasoning from the open world we live in and the easiness with which information can be shared (or leaked), it is hard to believe that sectors can be as closed as the classical theory describes. Some form of OI, enabling education(al cooperation) to take place will probably be existent. Clusters are not just a new concept in the automotive sector, but in all sectors and EU policy, and when a sector like the automotive sector has not organised itself in such a way yet, even though it highly depends on the results of OI and the actors strongly depend upon each other, this may lead to the assumption that clusters will not have developed in most sectors yet. Having seen the enormous amounts of joint programmes in the databases when selecting the cases, and the facilitating role that the EU is playing and has played in the past to make these possible, makes it plausible that a lot of programmes in the EU do offer the possibilities of interaction with (students from) other schools. To teach innovation theory is a bold idea and makes sense when studying innovation science, but it makes just as much sense that, when educating engineers that will be responsible for future innovations, it is not incorporated in the programme. It is logical that the automotive programmes offer lessons from people in the field, constantly developing the sector, and it may be assumed that other programmes, that are technological and innovation related, will do the same. Lastly, entrepreneurial skills are new and unknown, as became clear from theory and the reaction of the interviewees to questions on the issue, so not many programmes will have incorporated them in a good way yet. So also for this last factor it is not unlikely that the findings for the automotive sector would be the same when researching a different sector.

It is interesting to notice that a recent research has shown that one of the KICs that started at the end of 2009, EIT ICT Labs, has opened an application for their Master's school that will end 15-2-2012. Their description of this Master's school has some remarkable resemblance with the results of this research. See Figure 25 for a short explanation of the EIT ICT Labs programme.

Figure 25: EIT ICT LABS master school setup (source: http://eitictlabs.masterschool.eu/programme/)

When looking for the 6 factors found in this research, one can spot most of them in figure 25. Factor 1, the presence of open innovation in the sector that makes it possible for the sector to absorb educational cooperation is not really visible, which is logical because it is sector specific. EIT ICT Labs operates in the ICT sector, a sector that is the birthplace of open innovation. So it is fair to say that this factor exists. Factor 2, presence in clusters, can be found in the different co-location centres. Factor 3, enable interaction, is clearly visible in the availability of mobility and double degrees. Factor 4, availability of innovation theory, can be found under the innovation & entrepreneurship tab, which is the same for factor 6, entrepreneurship skills. The remaining factor 5 can be found in the leading business partners and European top researchers tab.

It cannot yet be concluded if practice has proven theory right, or wrong. Only future research, answering the question if educational cooperation in fact does contribute to innovation, can answer that question. When educational cooperation, not complying with any or most of the theoretical factors, does lead to a strong contribution to innovation, theory can be proven wrong. Even though it may seem unlikely that a closed system, with no interaction between clusters or institutions, not educating innovation theory or entrepreneurial skills and not involving people from the industry in the curriculum, will even exist, let alone contribute to innovation. But future research will need to prove that. As will some of the above mentioned issues, this will be discussed further in the paragraph on recommendations.

The contribution of educational cooperation to innovation is a new phenomenon, in theory, in policy and in practice. The document lying in front of you has shown you the ins and out, making you one of the few people who do know its value. This research may be helpful to you as a policy maker, educator or researcher and therefore have added value in multiple ways. If just one of you reads this thesis and takes it further, educational cooperation may be one step closer to contributing to innovation. Increasing the competitiveness of the EU. Changing the world.

8.2. Recommendations

As mentioned when starting this research, the outcomes of this thesis may be of added value for three different groups: policy makers, educational institutions and researchers. These are the people that, either through policy, education or research, can influence whether or not education(al cooperation) can contribute to innovation even more.

Policy makers
When making recommendations to policy makers, I direct myself to the EU, and the EIT in particular, since this research studied EU policy in particular and started with that one recommendation from the pilot project for the EIT, GAST. But these same recommendations may just as well be implemented by policy makers at other levels.

The EU can facilitate and stimulate most of the factors for educational cooperation that contribute to innovation. The EU has identified the importance of interaction between education, research and innovation and has come up with the idea of the EIT and its KICs, that incorporates most of the EU policy on educational cooperation in relation to innovation. With the EIT ICT Labs Master, the EIT proves to be on the right way of stimulating innovation through educational cooperation, since it supports many of the six factors found in innovation literature. The EIT, and its KICs, should therefore develop further, taking this research and make educational cooperation and its six factors the standard. An important task, that was also foreseen by the EU, will be to further stimulate cluster development. Research showed that this is one of the factors facilitating the contribution to innovation, but also that this is a factor determined by the sector which may be hard to be actively stimulated. The EU, however, may be able to stimulate that with encouraging measures like the setting up of KICs, setting an example. Apart from this, the EU has its role in further developing the European Higher Education Area. A lot has been done to make joint programmes possible, but the systems of higher education in Europe can be made even more comparable, compatible and coherent, facilitating educational cooperation even more.

Educational institutions
Policy makers at educational institutions may wish to educate future innovators, like mentioned in the first chapter when the profile of the Eindhoven University of Technology was quoted. There is a lot educational institutions can do to contribute to innovation through educational cooperation, especially since three of the six factors influencing this concern the content of the education programme. EU policy can encourage the incorporation of these factors into the education programmes, but ultimately the education programmes are solely determined by the educational institutions. To improve their educational cooperation an educational institution should offer, or improve if already in place:

- innovation theory in their curriculum
- classes given by part time teachers from the industry
- courses to increase the entrepreneurial skills of students: creativity, initiative and self-confidence.

As concluded in the previous paragraph, educational institutions can also improve the application of another factor: the factor stating that interaction with (students from) other schools should be facilitated for students optimally. A period spent at an educational institution across the border needs to be mandatory. Educational cooperation should become the standard. Since the cases researched and most forms of educational cooperation are still young and set up recently, they naturally will not be shaped perfectly and are flexible and able to adjust in such a way that their potential to contribute to innovation is optimized.

Researchers
Finally, this thesis may be of value to researchers, since it researches a blind spot in research on innovation, and because it is an exploratory thesis that may be the starting point for further research.

As described when starting this research, the Master Innovation Sciences focuses on the analysis of technological change and innovation and the ways in which public and private actors attempt to influence the speed and direction of technological change in society. The influence of education(al cooperation) on innovation is a blind spot, and the scientific relevance of this research lies in its contribution to what is known about this subject. The research may also contribute to what may be known in the future, since it can be the starting point for future research as well. It is recommended that future research studies the theory in practice further and so strengthen this research, but also that future research will go one step further and research if practice proves theory right. This thesis has taken the automotive sector as a case study. To conclude how theory is brought into practice generally, other sectors should be studied in future research to verify the conclusions of this thesis. Most exciting, however, is probably the research to be conducted in about ten years, asking the question that follows the sub questions posed by me: if practice not just applies theory, but if practice proves the theory right. Ideally, a cooperation is researched that adapts its programme in such a way that it scores high in most of the factors, while another cooperation studied tries to keep the current programme running or while another educational programme without any of the factors keeps that programme running. When the programmes have delivered graduates that have found their place in society, and, possibly, the innovation system. The results of the programmes may then be compared to concluded whether the programme complying with the factors really did contribute to innovation more than the other programme.

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ABBREVIATIONS

Abbreviation	Name	URL
ACEA	Association des Constructeurs Européens d'Automobiles	http://www.acea.be/
ATS	Auto Technische School	
AVI	Automatic Vehicle Identification	
AVL	Automatic Vehicle Location	
BMW	Bayerische Motoren Werke	
BRIDGE	Bridging Biomaterial Research Excellence between Industry and Academia across Europe	http://www.knowledgetriangle.eu/index.php/kb_2/kb.html
CIP	Competitiveness and Innovation Framework Programme	http://ec.europa.eu/cip/
ComplexEIT	Complexity from nano to large electronic systems	http://www.knowledgetriangle.eu/index.php/kb_6/kb.html
CTU	Czech Technical University	http://www.cvut.cz
DG EAC	Directorate General Education and Culture	http://ec.europa.eu/dgs/education_culture/index_en.htm
DGAC	Ministère de la Défense (French Defence Ministry)	http://www.defense.gouv.fr/
EC	European Commission	www.ec.europa.eu
ECO	European Cluster Observatory	
ECSC	European Coal and Steel Community	
ECTS	European Credit Transfer and Accumulation System	
EHEA	European Higher Education Area	
EIP(s)	European Innovation Partnership(s)	
EIT	European Institute of Innovation and Technology	www.eit.europa.eu/
EM	Erasmus Mundus	
EMC	Electromagnetic Compatibility	
ENSIETA	École Nationale Supérieure des Ingénieurs des Études et Techniques d'Armement	
ENSTA	Ecoles Nationales Supérieures de Techniques Avancées	http://www.ensta-bretagne.fr/

ENTR	Directorate General Enterprise and Industry	http://ec.europa.eu/enterprise/index_en.htm
EP	European Parliament	http://www.europarl.europa.eu/
Etnite	European network for training and education in Intelligent Transportation Systems	
EU	European Union	www.europa.eu
EURAB	European Research Advisory Board	http://ec.europa.eu/research/eurab/index_en.html
FHTW	Fachhochschule (university of applied sciences) Technikum Wien	http://www.technikum-wien.at/
FP7	Framework Programme 7	http://cordis.europa.eu/fp7/home_en.html
GAST	Green and Safe Road Transportation	http://www.knowledgetriangle.eu/index.php/kb_3/kb.html
GB	Governing Board	
GIS	Geographic Information Systems	
GM	General Motors	
GPS	Global Positioning System	
HAN	Hogeschool van Arnhem en Nijmegen (HAN University)	http://www.han.nl/
HMI	Human Machine Interface	
ICE	internal combustion engines	
ICT	Information and Communication Technologies	
ISMB	Istituto Superiore Mario Boella	http://www.ismb.it/
ITS	Intelligent Transport Systems	
IU	Innovation Union	http://ec.europa.eu/research/innovation-union/index_en.cfm
JD	joint degree	
KICs	Knowledge and Innovation Communities	http://eit.europa.eu/kics1/knowledge-and-innovation-communities/overview.html
LiU	Linköpings University	http://www.liu.se
LLL	LifeLong-Learning	
MSc-EMAE	European Master of Science in Automotive Engineering	http://www.emae.eu/
MSc-ITS	European Master of Science in Intelligent Transport Systems	http://www.em-its.eu/

Neth-ER	Netherlands house for Education and Research	www.neth-er.eu
OECD	Organisation for Economic Co-operation and Development	http://www.oecd.org
OEM	Original Equipment Manufacturer	
OI	Open Innovation	
PhD	Philosophiae Doctor (Latin for Doctor of Philosophy)	
PSA	Peugeot Société Anonyme	Abbreviation of the carmanufacturer that produces Peugeot and Citroën automobiles
R&D	Research & Development	
SMEs	Small and Medium sized Enterprises	
SUCCESS	Searching Unprecedented Cooperations on Climate and Energy to ensure Sustainability	http://www.knowledgetriangle.eu/index.php/kb_5/kb.html
TG	Technology Gap	
TNO	Nederlandse Organisatie voor Toegepast-Natuurwetenschappelijk Onderzoek (Netherlands Organisation for Applied Scientific Research)	www.tno.nl
TU/e	Technische Universiteit Eindhoven (Eindhoven University of Technology)	www.tue.nl
TUM	Technische Universität München	http://portal.mytum.de
USA	United States of America	
VW	Volkswagen	www.volkswagen.com

Annex I Experts

You can find the names, phone numbers and e-mail addresses of the experts I talked to during the research in the table below.

Name (organisation)	Phonenumber	E-mail address	Date of contact
Dr. Ing. G. Achtenová (CTU)	+42 224 352 499	gabriela.achtenova@fs.cvut.cz	09 December 2010
Dr. J. Affenzeller (GAST)	+43 316 787 253	josef.affenzeller@avl.com	September 2008 – November 2009
Prof. F. Gauterin (GAST)	+49 721 608 423	frank.gauterin@kit.edu	September 2008 – November 2009
Dr. G.P.A Mom (TU/e)	+31 402 475 764	G.P.A.Mom@tm.tue.nl	September 2008 – December 2009
Mr. R. Pelzer (TNO) (GAST)	+31 088 866 579	rine.pelders@tno.nl	September 2008 – November 2009
Prof. E. Simeonov (FHTW)	+43 334 077 380	simeonov@technikum-wien.at	15 September 2010
Mr. H Vooren (HAN)	+31 243 530 500	H.Vooren@han.nl	24 September 2010
Prof. F. van Vught (Neth-ER)	Upon request	f.a.vanvught@utwente.nl	September 2008 – December 2011
Prof. Dr. J. Wismans (GAST)	+31 634 333 355	jac.wismans@safeteq.com	September 2008 – November 2009
Mr. A. Wolthuis (HTAS)	+31 492 562 500	aw@awprojects.nl	January 2009

Annex II GAST project

In early and mid 2007 several discussions about the need to test the EIT[22] took place between the EP and the EC. During an informal trialogue[23] with the EP in September 2007 the EP emphasised the need to test the EIT with a number of pilot projects before agreeing on the future of the institute beyond 2013. [Euractiv 2007] As a result the EC's Directorate-General for Education and Culture (DG EAC) published a call for proposal *for pilot projects for cooperation between European Institutes of Technology* in the summer of 2007. [EC 2007c]

The proposal suggests that the strategic objective of the pilot projects is to design, implement and test new models of cooperation in the knowledge triangle. With the final goal to facilitate knowledge-sharing and technology transfer by building up the capacity of European networks in strategic interdisciplinary fields to bring their collaboration to a new, more integrated form of partnership. Outputs should include designs for new models of governance for integrated partnerships. These models should overcome barriers and contribute to a closer collaboration between leading players in the knowledge triangle. A substantial part of the projects is implementing and testing some of the critical components identified to create a set of recommendations and good practices that can be used to disseminate and further exploit. Each project should address the above-mentioned goals with a specific focus on an interdisciplinary field that will be used as a case study to test the applicability of the results.

After a selection process the following 4 projects where selected in November 2007:

- BRIDGE, Bridging Biomaterial Research Excellence between Industry and Academia across Europe [BRIDGE]
- ComplexEIT, Complexity from nano to large electronic systems [ComplexEIT]
- GAST, Green and Safe Road Transportation [GAST]
- SUCCESS, Searching Unprecedented Cooperations on Climate and Energy to ensure Sustainability [SUCCES]

The projects started operation in December 2007 and had to be finished in December 2009.

The European automotive sector is involved in several European initiatives for supporting the automotive sector. One of these initiatives was the set up and participation in GAST. The GAST project is central to this thesis and it's aim was
[…..*creating, testing and validating the conditions, structures and processes which will enable a successful transition towards a sustainable partnership addressing the needs of European Community in terms of education, research and innovation for greener and safer road transportation*.....] [GAST].

A total of 18 partners where involved in GAST, including the Eindhoven University of Technology (TU/e), ranging from OEM's to Universities. The project consisted of three parts:

- identifying current collaboration's in the automotive field;
- design new collaboration models;
- testing the newly designed collaboration models on existing collaboration initiatives.

The first year of the project was dominated by a search for collaboration models suitable for the automotive sector and GAST. At the end of 2008 this search lead to the selection of four test cases

22 More information about the EIT can be found in paragraph 5.2.2

23 A trialogue is a conversation or discussion in which three people or groups participate [van Dale]. The groups that are involved in the mentioned trialogue are the EC, European Council and the EP.

for further research:

1. Project Workshop, a single project set up by a tier 1 supplier for three student teams from three different universities, with each University bringing in its own discipline;

2. European Automotive Master, setting up a joint master by three participating universities;

3. Cluster of clusters, an international cooperation of strong existing national clusters;

4.Project House, setting up a location where students can work on projects for industry.

During the project the cluster of clusters test case got most of the attention because a majority of the GAST participants expected that this would be the most promising project with the highest impact on innovation. And thus best suited for being the model that can be used for future KICs. These future KIC's where to be chosen a month after the finish of the GAST project, so the gathered knowledge from GAST could be used to set them up. The idea behind the cluster of clusters test case is to benefit from knowledge spillover in other clusters. Grililiches [Grililiches 1992] and Soete et al [Soete et al 1999] have shown that knowledge spillovers contribute to economic growth by contributing innovation.

Knowledge spillovers appear to be a local phenomenon. Interpersonal contacts and companies that are situated close together are most likely to benefit from spillover effects. This seems surprising, given that with modern information technologies information is available at virtually no cost and can be disseminated worldwide. Audretsch and Thurik [Audretsch et al 1999: 5] speak of a paradox, they explain this by distinguishing information and knowledge. Information is spread simple and free of charge. They mention the price of gold in Tokyo and the wheather in New York as examples. Knowledge however, is not easy (or impossible) to code. Dissemination of knowledge mainly takes place through social interactions during meetings and other social events. Kleinknecht and Naastepad [Kleinknecht et al 2000: 578] have confirmed this local character of knowledge spillovers. The idea of cluster of clusters is that transferring the knowledge spillovers of one cluster to another clusters could be benificial for innovation in all participating clusters.

Three of the four test cases, clusters of clusters being one of them, have been worked out in the final report of GAST that was presented to the EC in November 2009. The project house test case was never set up because of a lack of time. One of the recommendations of the cluster of clusters test case was to test whether educational cooperation between clusters had a positive effect on innovation, the starting point of this research.

Annex III Private R&D investment in Europe

The European Automobiles & parts sector is the biggest R&D investor in Europe with a total of 28.6 Billion Euro in 2008. See Table 3. [EC2008]

Table 3. ***Overall sector R&D and average sector R&D intensities by main world region for the world top 1402 companies in the 2008 Scoreboard.***

Rank	Sector	EU		US		Japan	
		R&D investment (€ m)	R&D intensity (%)	R&D investment (€ m)	R&D intensity (%)	R&D investment (€ m)	R&D intensity (%)
1	Pharmaceuticals & Biotechnology	20031.1	15.7	34853.6	16.7	5616.0	15.9
2	Technology Hardware & Equipment	16573.8	13.5	35451.9	9.6	10074.2	5.3
3	Automobiles & parts	28589.6	4.7	14101.6	3.9	18306.4	4.1
4	Software & Computer Services	3831.5	9.7	20227.9	10.6	1587.2	4.8
5	Electronic & Electrical Equipment	5604.8	3.7	2906.7	3.8	8899.4	5.3
6	Chemicals	6793.6	2.9	4118.5	2.4	4257.9	3.2
7	Aerospace & defence	7999.5	6.6	6557.8	3.3	51.3	6.1
8	Leisure goods	1822.1	5.9	2042.0	7.8	9672.9	6.2
9	Industrial Engineering	5330.8	3.1	3040.9	2.4	1507.1	2.7
10	General industrials	1571.7	2.8	4613.0	2.4	1253.8	2.8
11	Fixed line telecommunications	4247.1	1.6	673.7	0.8	1665.7	2.5
12	Health care equipment & services	1385.8	4.4	4717.1	7.8	243.6	5.6
13	Oil & gas producers	2179.8	0.3	1050.6	0.2	138.9	0.2
14	Food producers	1673.3	1.7	811.2	0.9	473.3	2.3
15	Household goods	1141.1	2.3	2207.4	2.5	343.5	1.2
	Top 15 sectors	108775.6	3.8	137373.9	5.0	64091.2	4.4
	Rest of 21 sectors	11099.2	0.7	6126.7	1.4	4859.6	1.1
	Grand Total	119874.7	2.7	143500.5	4.5	68950.7	3.6

Source: The 2008 EU Industrial R&D Investment Scoreboard. European Commission, JRC/DG RTD

Four of the top ten EU companies in R&D investment are automotive companies: Volkswagen (number two R&D investor in the EU),Daimler, Robert Bosch and BMW. For the top ten EU companies in R&D investment see table A2.1.

Table A2.1. Ranking of the top 1000 EU companies by level of R&D investment

				R&D Investment		Net Sales	R&D/Net Sales ratio	Operating Profit
Rank	Company	ICB Sector	Country	2007	change 07/06	2007	2007	2007
				€m	%	€m	%	% of Net Sales
			Top 1000 Companies	126,358.38	8.6	5,515,078	2.3	12.2
		number of companies for calculation		*1000*	*983*	*983*	*974*	*965*
1	Nokia	Telecommunications equipment (9578)	Finland	5,281.00	42.3	51,058	10.3	11.7
2	Volkswagen	Automobiles & parts (335)	Germany	4,923.00	16.1	108,897	4.5	6.3
3	Daimler	Automobiles & parts (335)	Germany	4,888.00	-6.6	129,436	3.8	6.8
4	Sanofi-Aventis	Pharmaceuticals (4577)	France	4,563.00	3.6	28,052	16.3	23.0
5	GlaxoSmithKline	Pharmaceuticals (4577)	UK	4,419.43	-6.1	30,928	14.3	33.5
6	Robert Bosch	Automobiles & parts (335)	Germany	3,580.00	4.8	46,320	7.7	6.9
7	AstraZeneca	Pharmaceuticals (4577)	UK	3,448.55	29.8	20,217	17.1	27.4
8	Alcatel-Lucent	Telecommunications equipment (9578)	France	3,368.00	69.4	18,005	18.7	-24.4
9	Siemens	Electrical components & equipment (2733)	Germany	3,366.00	1.7	90,348	3.7	6.5
10	BMW	Automobiles & parts (335)	Germany	3,144.00	-2.0	56,018	5.6	7.1

By comparison, three of the top six world R&D investors are car manufacturers, General Motors (GM) being the world's number two. For the global top six R&D investors see table A2.2.

Table A2.2. Ranking of the top 1000 non-EU companies by level of R&D investment.

				R&D Investment		Net Sales	R&D/Net Sales ratio	Operating Profit
Rank	Company	ICB Sector	Country	2007	change 07/06	2007	2007	2007
				€m	%	€m	%	% of Net Sales
		Top 1000 Companies		252,983.77	9.2	6,638,605	3.8	11.3
		number of companies for calculation		*1000*	*994*	*997*	*995*	*994*
1	Microsoft	Software (9537)	USA	5,583.89	14.6	41,325	13.5	37.6
2	General Motors	Automobiles & parts (335)	USA	5,540.11	22.7	124,719	4.4	-2.2
3	Pfizer	Pharmaceuticals (4577)	USA	5,532.59	6.4	33,116	16.7	16.2
4	Toyota Motor	Automobiles & parts (335)	Japan	5,453.73	9.6	141,280	3.9	9.8
5	Johnson & Johnson	Pharmaceuticals (4577)	USA	5,252.85	7.8	41,787	12.6	21.5
6	Ford Motor	Automobiles & parts (335)	USA	5,129.74	4.2	117,962	4.3	3.5

Annex IV List of Master programmes in the wider field of economics and engineering

	Degree type	Programme name	Involved universities	Thematic orientation	Thematic relevance (1 high, 3 low)	No. of involved universities	Website
1	double	European Master's Degree in Automotive Engineering	CTU Prague(Czech Republic) ENSIETA (France) HAN (the Netherlands)	Automotive Engineering	1	3	http://www.emae.eu
2	double/triple	European Master of Science in Intelligent Transport Systems	Czech Technical University in Prague (Czech Republic) Linköping University (Sweden) Fachhochschule Technikum Wien (Austria)	Automotive Engineering	1	3	http://www.em-its.eu
3	joint	Professional MBA Automotive Industry	Slovak University of Technology (Slovakia) Vienna University of Technology (Austria)	Economics	2	2	http://automotive.tuwien.ac.at/overview/mission/
4	double	Automotive Engineering Double Degree HsKA & ENSMM	ENSMM (France) HsKA (Germany)	Automotive Engineering	1	2	https://www.hs-karlsruhe.de/servlet/PB/menu/1073415_l1/index.html
5	double	2-Year Double-Degree Master in Mechanical Engineering at TU Darmstadt and Virginia Tech	TU Darmstadt (Germany) Virginia Tech (USA)	Engineering	2	2	http://www1.tu-darmstadt.de/international/outgoing/international/aussereuropa2/vt_dd_master.tud
6	single	Euromind: European Master in Design and Technology of advanced vehicle systems/European Master in Transportation Engineering	ESTACA (France) Linköping University (Sweden) University of Southampton (United Kingdom)	Engineering	2	3	http://www.euromind-edu.org/
7	triple	IDEA League Joint Master's in Applied Geophysics	ETH Zurich (Switzerland) RWTH Aachen (Germany) TU Delft (the Netherlands)	Physics	3	3	http://www.idealeague.org/geophysics
8	double	Joint European Masters Programme in Advanced Materials Science and Engineering	Luleå University of Technology (Sweden) National Polytechnic Institute of Lorraine (France) Saarland University (Germany) Technical University of Catalonia (Spain)	Engineering	2	4	http://www.amase-master.net
9	joint	Master Nuclear Engineering	EPF Lausanne (Switzerland) ETH Zurich (Switzerland)	Engineering	3	2	http://www.master-nuclear.ch
10	joint	Master´s Degree in Micro and Nano Technologies for Integrated Systems	EPF Lausanne (Switzerland) Grenoble INP (France) Politecnico di Torino (Italy)	Engineering	3	3	http://www.master-nanotech.com/
11	triple	Coastal and Marine Engineering and Management	City University London (United Kingdom) NTNU (Norway) TU Delft (the Netherlands) Technical University of Catalonia (Spain) University of Southampton (United Kingdom)	Engineering	3	5	http://www.tudelft.nl/live/pagina.jsp?id=99f642a4-6c91-4766-a2c0-90f459ff143f&lang=en
12	double	Double master degree in Computational Engineering from University of Erlangen-Nuremberg and Kungliga Tekniska Högskolan Stockholm (KTH)	FAU Erlangen (Germany) KTH Stockholm (Sweden)	Engineering	3	2	http://www.ce.uni-erlangen.de/m-sc-program/double-degree-in-computational-engineering/
13	double	Double Degree Master Program in Engineering Science	Tomsk Polytechnic University (Russia) TU Berlin (Germany)	Engineering	2	2	http://mechanik.tu-berlin.de/popov/ddmpes/ddmpes.htm
14	double	Double Degree master program Flight Dynamics & Control and Avionics	Instituto Superior Técnico Lissabon (Portugal) TU Delft (the Netherlands)	Engineering	3	2	http://www.dem.ist.utl.pt/aero/html-en/Duplo_en.html
15	double	European Masters in Engineering Rheology	Catholic University Leuven (Belgium) Grenoble INP (France) Huelva University (Spain) University of Calabria (Italy) University of Ljubljana (Slovenia) University of Minho (Portugal)	Engineering	4	6	http://beta3.capsule.com.pt/
16	double	Advanced Master´s in Structural Analysis of Monuments and Historical Constructions	CTU Prague (Czech Republic) Technical University of Catalonia (Spain) University of Minho (Portugal) University of Padova (Italy)	Engineering	3	4	http://www.msc-sahc.org
17	double	KIT DeFI: deutsch-französische Initiative am KIT	Karlsruhe Institute of Technology (Germany) École Polytechnique de Paris (France) ENSAM (France) Grenoble INP (France) INSA (France)	Engineering	3	5	http://www.kit.edu/fzk/idcplg?IdcService=KIT&node=5123&document=ID_065598
18	double	KIT DeFI: deutsch-französische Initiative am KIT	Karlsruhe Institute of Technology (Germany) École Polytechnique de Paris (France) Grenoble INP (France) UJF Grenoble (France)	Physics	3	4	http://www.kit.edu/fzk/idcplg?IdcService=KIT&node=5123&document=ID_065598
19	joint/multiple	Joint European Master in Nuclear Fusion Science and Engineering Physics	Ghent University (Belgium) KTH Stockholm (Sweden) Universidad Carlos III de Madrid (Spain) Universidad Complutense de Madrid (Spain) Universidad Polytécnica de Madrid (Spain) Universität Stuttgart (Germany) Université Henri Poincaré (France)	Physics	3	7	http://www.em-master-fusion.org
20	joint	International master of industrial management	KTH Stockholm (Sweden) Politecnico di Milano (Italy) Universidad Politecnica de Madrid (Spain)	Economics	3	3	http://www.imim.polimi.it
21	double	Master's Programme in Security and Mobile Computing	Helsinki University of Technology (Finland) KTH Stockholm (Sweden) NTNU (Norway) Technical University of Denmark (Denmark) University of Tartu (Estonia)	Informatics	3	5	http://www.tkk.fi/Units/CSE/NordSecMob/index.html
22	double	Joint Erasmus Mundus Master of Science program in Photonics	Free University of Brussels (Belgium) Ghent University (Belgium) Heriot-Watt University (United Kingdom) KTH Stockholm (Sweden) St Andrews University (United Kingdom)	Engineering	3	5	http://www.master-photonics.org/index.php?id=10

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23	double/triple	Joint Masters of Science in Management and Engineering of Environment and Energy (ME3)	BME (Hungary) EMNantes (France) KTH Stockholm (Sweden) Queen´s University of Belfast (United Kingdom) Universidad Polytécnica de Madrid (Spain)	Engineering	3	5	http://www.mastereurope-me3.org/spip.php?rubrique5
24	?	International Master in Materials and Sensor System for Environmental Technologies	Universidad Politécnica de Valencia (Spain) KTH Stockholm (Sweden) University of Bologna (Italy)	Engineering	3	3	http://erasmusmimmsset.webs.upv.es/index.php?home
25	double	Global software engineering European master	Mälardalen University (Sweden) University of L'Aquila (Italy) VU University Amsterdam (the Netherlands) Westminster University (United Kingdom)	Informatics	4	4	http://www.gseem.eu/index.html
26	double	European Masters Course in Aeronautics and Space Technology	Cranfield University (United Kingdom) ISAE (France) TU Munich (Germany) Universidad Politécnica de Madrid (Spain) Università di Pisa (Italy)	Engineering	4	5	http://www.aerospacemasters.org/
27	joint	European Masters in Materials Science	Aalborg University (Denmark) Hamburg University of Technology (Germany) Universidade de Aveiro (Portugal)	Engineering	4	3	http://www.tu-harburg.de/eciu-gs/pro_joint_mat.html
28	joint	MSc. in Global Innovation Management	Aalborg University (Denmark) Hamburg University of Technology (Germany) University of Strathclyde (United Kingdom)	Engineering	4	3	http://www.globalinnovationmanagement.org/index.html
29	double	Joint Master Programme in Communication and Information Technologies	Aalborg University (Denmark) Hamburg University of Technology (Germany) Politecnico di Torino (Italy)	Engineering	3	3	http://www.tu-harburg.de/cit/about.htm
30	triple	European Master in Management	Aston Business School (United Kingdom) EMLYON Business School (France) Ludwig Maximilian University, Munich (Germany)	Economics	4	3	http://www.european-master.com/index.aspx
31	double	Erasmus Mundus Master of Mechanical Engineering	INSA de Lyon (France) Trinity College (Ireland) Universitat Politècnica de Catalunya (Spain)	Engineering	2	3	http://www.emmme.com/index.php?Rub=179
32	triple	Masters of Environmental Sciences, Policy and Management	Lund University (Sweden) University of the Aegean (Greece) University of Manchester (United Kingdom) Central European University (Hungary)	Economics	4	4	http://www.mespom.eu/
33	double	Functionalised Advanced Materials and Engineering	Aveiro University (Portugal) Bordeaux University (France) Grenoble INP (France) Liège University (Belgium) Louvain University (Belgium) Technical University of Darmstadt (Germany) University of Augsburg (Germany)	Engineering	3	7	http://www.fame-master.com/94238902/1/fiche___pagelibre/&RH=FAME_UnivPartners?RF=FAME_PRES
34	triple	International Master in Management of Information Technology	Tilburg University (the Netherlands) Turku School of Economics (Finland) Université Paul Cezanne Aix-Marseille III (France)	Economics	4	3	http://www.immit.eu/default.htm
35	triple	European Master in International Management	Hochschule für Technik und Wirtschaft Dresden (Germany) ESC Lille (France) REA Moscow (Russia)	Economics	4	3	http://www.htw-dresden.de/dfn/24.german.screen.guide.html
36	double	Master in Mechatronic and Micro-Mechatronic Systems	ENSMM (France) HsKA (Germany) Universidad de Oviedo (Spain)	Engineering	3	3	http://www.uniovi.es/eu4m/EU4M_site/index.php
37	triple	EMIN - Economics and Management of Network Industries	TU Delft (the Netherlands) Universidad Pontificia Comillas (Spain) Université Paris Sud XI (France)	Economics	5	3	http://www.upcomillas.es/emin/Default.aspx?Opcion=Introduction
38	double	ATOSIM - Atomic Scale Modelling of Physical, Chemical and Biomolecular Systems	Ecole Normale Superieure of Lyon (ENS) (France) University of Amsterdam (the Netherlands) University of Rome "La Sapienza" (Italy)	Engineering	4	3	http://www.erasmusmundus-atosim.cecam.org/
39	double	EMARO - European Master in Advanced Robotics	Ecole Centrale de Nantes (France) Warsaw University of Technology (Poland) University of Genova (Italy)	Engineering	4	3	http://emaro.irccyn.ec-nantes.fr/
40	double	EMMEP - Erasmus Mundus Minerals and Environmental Programme	RWTH Aachen (Germany) TU Delft (the Netherlands) University of Exeter, Camborne School of Mines (United Kingdom) Helsinki University of Technology (Finland) University of Miskolc (Hungary) Wroclaw University of Technology (Poland)	Engineering	3	6	http://www.emmep.org/
41	joint	EURO-AQUAE - Euro Hydro-informatics and Water Management	University of Nice Sophia Antipolis (France) Brandenburg Technical University Cottbus (Germany) Budapest University of Technology and Economics (Hungary) Technical University of Catalonia (Spain) University of Newcastle upon Tyne (UK)	Engineering	5	5	http://www.euroaquae.org/jahia/page5097_de.html
42	?	FUSION-EP European Master in Nuclear Fusion Science and Engineering Physics	Ghent University (Belgium) KTH Stockholm (Sweden) Complutense University of Madrid (Spain) Technical University of Madrid (Spain) University Carlos III of Madrid (Spain) University Nancy I Henri Poincare (France) University of Stuttgart (Germany)	Engineering	3	7	http://www.em-master-fusion.org/index.asp?p=115&a=115

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43	double	International Master "Vintage" : Vine, Wine and Terroir Management	Higher Agricultural Education Institute (ESA) of Angers (France) Technological Education Institution (T.E.I.)of Athens (Greece) Technical University of Valencia (Spain) University of Bologna (Italy) Catholic University of the Sacred Heart (Italy) University of Tras-os-Montes and Alto Douro (Portugal) Corvinus University of Budapest (Hungary)	Engineering	5	7	http://www.vintagemaster.com/accueil118.html
44	joint	JEMES - Joint European Master Programme in Environmental Studies	Aalborg University (Denmark) Universidade de Aveiro (Portugal) Universitat Autónoma de Barcelona (Spain) Technische Universität Hamburg-Harburg (Germany)	Engineering	4	4	http://www.jemes.eu/
45	double	MaMaSELF - Master of Materials Science exploiting European Large Scale Facilities	University of Rennes1 (France) University of Torino (Italy) TU München (Germany) LMU München (Germany)	Engineering	4	4	http://etudes.univ-rennes1.fr/mamaself
46	?	Master of Science in Computational Mechanics	Universitat Politècnica de Catalunya (Spain) University of Wales Swansea (United Kingdom) École Centrale de Nantes (France) Universität Stuttgart (Germany)	Engineering	4	4	http://www.cimne.com/cm-master/default.asp
47	joint	MATHMODS - Mathematical Modelling in Engineering: Theory, Numerics, Applications	University of L'Aquila (Italy) University of Nice - Sophia Antipolis (France) Autonomous University of Barcelona (Spain) University of Hamburg (Germany) Gdansk University of Technology (Poland)	Engineering	4	5	http://www.mathmods.eu/
48	joint	MEEES - Master's in Earthquake Engineering and Engineering Seismology	University of Pavia (Italy) University of Patras (Greece) University of Grenoble Joseph Fourier (France) Imperial College London (UK)	Engineering	5	4	http://www.meees.org/index.php?option=com_frontpage&Itemid=1
49	double	MERIT - European Master of Research on Information and Communication Technologies	Technical University of Catalonia (Spain) Technical University of Turin (Italy) Catholic University of Louvain (Belgium) University of Karlsruhe (Germany)	Engineering	3	4	http://www.meritmaster.org/
50	?	M.E.S.C. - Materials for Energy Storage and Conversion	University of Picardie Jules Verne (France) University of Toulouse 3 Paul Sabatier (France) University of Provence Aix-Marseille I (France) Warsaw University of Technology (Poland) University of Cordoba (Spain)	Engineering	2	5	http://www.u-picardie.fr/mundus_MESC/
51	double	MONABIPHOT - Molecular nano- and bio-photonics for telecommunications and biotechnologies	Ecole Normale Superieure of Cachan (ENS) (France) Complutense University, Madrid (Spain) University of Wroclaw (Poland) Wroclaw University of Technology (WUT) (Poland)	Engineering	4	4	http://www.ens-cachan.fr/monabiphot/
52	double	OPSCITECH - Optics in Science and Technology	TU Delft (the Netherlands) Friedrich Schiller University Jena (Germany) Imperial College London (United Kingdom) Université Paris-Sud 11 and Institut d'Optique Graduate School (France) Warsaw University of Technology (Poland)	Engineering	4	5	http://www.master-optics.org/index.php?id=1
53	joint	SEFOTECH.nut - European MSc in Food Science, Technology and Nutrition	Catholic University of Applied Science Sint-Lieven (Belgium) Dublin Institute of Technology (Ireland) University of Applied Science Anhalt (Germany) Portuguese Catholic University (Portugal)	Engineering	5	4	http://www.sefotechnut.org/
54	joint	VIBOT - European Master in Vision and Robotics	Heriot-Watt University (United Kingdom) University of Girona (Spain) University of Burgundy (France)	Engineering	4	3	http://193.52.242.6/?page=home
55	double	ALGANT - Algebra, Geometry and Number Theory	University of Bordeaux I (France) University of Paris Sud 11 (France) Leiden University (the Netherlands) University of Padova (Italy)	Mathematics	4	4	http://www.math.u-bordeaux.fr/ALGANT/
56	double/triple	CIMET - Color in Informatics and MEdia Technology	University Jean Monnet of Saint Etienne (France) University of Joensuu (Finland) Gjøvik University College (Norway) University of Granada (Spain)	Informatics	4	4	http://www.master-erasmusmundus-color.eu/
57	double	EuMI - European Master in Informatics	University of Trento (Italy) RWTH University Aachen (Germany) University of Edinburgh (United Kingdom)	Informatics	3	3	http://www.eumi-school.org/edu/eumi/home.xml
58	double	European Masters Course in Software Engineering	Universidad Politécnica de Madrid (Spain) University of Kaiserslautern (Germany) Free University of Bozen-Bolzano (Italy) Blekinge Institute of Technology (Sweden)	Informatics	4	4	http://emse.fi.upm.es/index.php
59	double	European Masters Programme in Computational Logic	Dresden University of Technology (Germany) Free University of Bozen-Bolzano (Italy) Vienna University of Technology (Austria) New University of Lisbon (Portugal) Technical University of Madrid (Spain)	Informatics	4	5	http://european.computational-logic.org/
60	double/triple	IM in NLP & HLT - International Masters in Natural Language Processing and Human Language Technology	University of Franche-Comté (France) University of Wolverhampton (United Kingdom) Autonomous University of Barcelona (Spain) University of Algarve (Portugal)	Informatics	5	4	http://mastermundusnlp-hlt.univ-fcomte.fr/

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61	double	Master of Industrial Mathematics	Eindhoven University of Technology (the Netherlands) University of Kaiserslautern (Germany) Johannes Kepler University Linz (Austria)	Mathematics	3	3	http://www.win.tue.nl/esim/
62	double	QEM - Models and Methods of Quantitative Economics	University of Paris 1 Pantheon-Sorbonne (France) Autonomous University of Barcelona (Spain) University of Bielefeld (Germany) Ca' Foscari University of Venice (Italy)	Economics	5	4	http://www.univ-paris1.fr/index.php?id=111297
63	joint	EMSRHS - European Master in Sustainable Regional Health Systems	Vilnius University (Lithuania) Corvinus University of Budapest (Hungary) University of Verona (Italy) University of Deusto (Spain)	Economics	5	4	http://erasmusmundus.tprs.vu.lt/
64	double	Europubhealth - European Public Health Master	National School of Public Health (France) University of Copenhagen (Denmark) University of Rennes 1 (France) Jagiellonian University (Poland) Andalusian School of Public Health (Spain) University of Sheffield (United Kingdom)	Economics	5	6	http://www.europubhealth.org/us/accueil/
65	triple	MSPME - Masters in Strategic Project Management	Heriot-Watt University (United Kingdom) Technical University of Milan (Italy) Umea University (Sweden)	Economics	4	3	http://www.mspme.org/
66	joint	ASC - Master of Science: Advanced Spectroscopy in Chemistry	University of Sciences and technologies of Lille (France) Alma Mater Studiorum University of Bologna (Italy) University Complutense of Madrid (Spain) University of Leipzig (Germany) University of Bergen (Norway) University of Helsinki (Finland) Jagiellonian University of Krakow (Poland)	Natural Sciences	5	7	http://www.master-asc.org/
67	multiple	EMAE - European Master in Applied Ecology	University of Poitiers (France) Christian Albrechts University in Kiel (Germany) University of Coimbra (Portugal) University of East Anglia in Norwich (United Kingdom)	Natural Sciences	5	4	http://www.master-emae.org
68	?	EMBC - Erasmus Mundus Master of Science in Marine Biodiversity and Conservation	Ghent University (Belgium) University Pierre et Marie Curie - Paris 6 (France) University of Oviedo (Spain) Klaipeda University (Lithuania) University of Bremen (Germany) University of the Algarve (Portugal)	Natural Sciences	5	6	http://embc.marbef.org/index.asp
69	double	EMM-Nano - Erasmus Mundus Master of Nanoscience and Nanotechnology	Catholic University of Leuven (Belgium) Chalmers University of Technology (Sweden) Delft University of Technology (the Netherlands) Leiden University (the Netherlands) Dresden University of Technology (Germany)	Natural Sciences	4	5	http://www.emm-nano.org
70	joint	EMQAL - European Joint Master in Quality in Analytical Laboratories	University of Algarve (Portugal) Gdansk University of Technology (Poland) University of Bergen (Norway) University of Barcelona (Spain) University Of Cadiz (Spain)	Natural Sciences	4	5	http://cursos.ualg.pt/emqal/
71	joint	EUMAINE - European Master of Science in Nematology	Ghent University (Belgium) University of Jaén (Spain) Bielefeld University (Germany) University of Évora (Portugal)	Natural Sciences	5	4	http://www.eumaine.ugent.be/index.asp
72	joint	Master of Bioethics	Catholic University of Leuven (Belgium) Radboud University Nijmegen (the Netherlands) University of Padova (Italy)	Natural Sciences	5	3	http://med.kuleuven.be/education/Bioethics/index.html
73	double	SpaceMaster - Joint European Master in Space Science and Technology	Lulea University of Technology (Sweden) Cranfield University (United Kingdom) Czech Technical University in Prague (Czech Republic) Helsinki University of Technology (Finland) Bavarian Julius-Maximilians University of Wurzburg (Germany) University of Toulouse 3 Paul Sabatier (France)	Engineering	3	6	http://spacemaster.se/
74	double	MUNDUS URBANO - Interdisciplinary Erasmus Mundus Master Course International Cooperation and Urban Development	Technical University Darmstadt (Germany) International University of Catalunya (Spain) University Pierre Mendez France (France) University of Rome Tor Vergata (Italy)	Economics	5	4	http://www.mundus-urbano.eu/start.htm
75	double	MSc in Network and e-Business Centred Computing	University of Reading (United Kingdom) Aristotle University of Thessaloniki (Greece) University Carlos III of Madrid (Spain) Trinity College Dublin (Ireland)	Engineering	4	4	http://www.reading.ac.uk/sse/pg-taught/sse-pgtadvancedEuropeanErasumsMundusMSc.asp
76	joint	European Joint Master in Water and Coastal Management	University of Algarve (Portugal) University of Bergen (Norway) University of Cadiz (Spain) University of Plymouth (United Kingdom)	Engineering	5	4	http://cursos.ualg.pt/eumscwcm/index.htm
77	double	GEM - Geo-information Science and Earth Observation for Environmental Modelling and management	International Institute for Geo-information Science and Earth Observation (the Netherlands) University of Southampton (United Kingdom) Lund University (Sweden) Warsaw University (Poland)	Engineering	4	4	http://www.gem-msc.org/

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78	joint	IMRD - International Master of Science in Rural Development	Ghent University (Belgium) Humboldt University of Berlin (Germany) University of Cordoba (Spain) National Higher Agricultural Education Institute (Agrocampus) of Rennes (France) University of Pisa (Italy) Wageningen University (the Netherlands) Slovak Agricultural University in Nitra (Slovakia)	Economics	5	7	http://www.imrd.ugent.be/index.asp
79	joint	Master of Science in Geospatial Technologies	Westfälische Wilhelms-Universität Münster (Germany) Universitat Jaume I Castellón (Spain) Universidade Nova de Lisboa (Portugal)	Engineering	4	3	http://geotech.uni-muenster.de/index.php?option=com_content&task=view&id=1&Itemid=2
80	joint	CoDe - Joint European Master in Comparative Local Development	University of Trento (Italy) Corvinus University of Budapest (Hungary) University of Ljubljana (Slovenia) University of Regensburg (Germany)	Economics	5	4	http://www.unitn.it/mastercode/
81	double	European Master in Law and Economics	Erasmus University Rotterdam (the Netherlands) Ghent University (Belgium) University of Hamburg (Germany) University of Aix-Marseille 3 Paul Cezanne (France) University of Bologna (Italy) University of Vienna (Austria) University of Manchester (United Kingdom)	Economics	5	7	http://www.emle.org/_EMLE_Main_rubric/index.php?rubric=Home&PHPSESSID=e4abad029c755dfe4a3cd
82	double	IMESS - International Masters in Economy, State and Society	University College London (United Kingdom) Helsinki University (Finland) Charles University (Czech Republic) Jagellonian University (Poland) Corvinus University (Hungary) Tartu University (Estonia)	Economics	5	6	http://www.imess.eu/
83	joint	M.A. Degree in Economics of International Trade and European Integration	University of Antwerp (Belgium) Free University of Brussels (Belgium) Staffordshire University (United Kingdom) University of Cantabria (Spain) University of Bari (Italy) University of Science and Technology of Lille (France) Prague University of Economics (Czech Republic)	Economics	4	7	http://webhost.ua.ac.be/eitei/
84	single + diploma supplement	CBU - Information and Communications Technology (ICT)	University of Helsinki (Finland) University of Kuopio (Finland) Lappeenranta University of Technology (Finland) St. Petersburg State University (Russia) St. Petersburg State Polytechical University (Russia) Petrozavodsk State University (Russia)	Engineering	4	6	http://www.joensuu.fi/cbu/Studies/ITbrochure.pdf
85	single + diploma supplement	CBU Master's Degree Programme in Forestry and Environmental Engineering	University of Helsinki (Finland) Lappeenranta University of Technology (Finland) Petrozavodsk State University (Russia) St. Petersburg State Polytechical University (Russia)	Engineering	5	4	http://www.joensuu.fi/cbu/Studies/FEEbrochure.pdf
86	double	Environmental Science - Soil, Water and Biodiversity	University of Copenhagen, Faculty of Life Sciences (Denmark) Swedish University of Agricultural Sciences (Sweden) University of Natural Resources and Applied Life Science (Austria) Universität Hohenheim (Germany)	Engineering	5	4	https://www.uni-hohenheim.de/enveuro.html
87	single	European Master in Object Oriented Software Engineering	Free University of Brussels (Belgium) Ecole des Mines de Nantes (France)	Engineering	4	2	http://www.emn.fr/x-info/emoose/
88	joint	Geoscience of Subsurface Exploration Appraisal and Development (GeoSEAD)	Heriot-Watt University (United Kingdom) University of Edinburgh (United Kingdom) Newcastle University (United Kingdom)	Engineering	5	3	http://www.geos.ed.ac.uk/masters/sead_info/
89	?	Industrial Design and Manufacturing (IDM)	University of Dortmund (Germany) University of Twente (the Netherlands)	Engineering	4	2	http://www.mastersportal.eu/students/browse/programme/1211/industrial-design-and-manufacturing.html
90	joint	Materials and Processes of Sustainable Energetics	Tallinn University of Technology (Estonia) University of Tartu (Estonia)	Engineering	2	2	http://www.sustainableenergetics.eu/index.php?id=10540
91	joint	MEi:CogSci Cognitive Science	Comenius University of Bratislava (Slovakia) Eötvös Loránd University Budapest (Hungary) Budapest University of Technology and Economics Hungary) University of Ljubljana (Slovenia) University of Zagreb (Croatia)	Engineering	4	5	http://www.univie.ac.at/meicogsci/
92	single	Process Engineering (MPE)	University of Applied Sciences Offenburg (Germany) University of Olsztyn (Poland) University of Applied Sciences of Western Switzerland (Switzerland)	Engineering	4	3	http://fh-offenburg.de/uportal/en/graduate-school/mpe/courses/overview
93	double	Applied Economics, Finance and Operations Research	Bilkent University (Turkey) Tilburg University (the Netherlands)	Economics	4	2	http://www.bilkent.edu.tr/~economics/tilburg.htm
94	double	International Financial Management	University of Groningen (the Netherlands) Uppsala University (Sweden)	Economics	4	2	http://www.rug.nl/feb/onderwijs/masteropleidingen/mscibandm_ifm/index
95	double	International Technology and Innovation Management (MITIM)	Lappeenranta University of Technology (Finland) St. Petersburg State University (Russia)	Economics	4	2	http://www.lut.fi/en/business/major/mitim/Pages/Default.aspx
96	double	MBA International Business and Management	Hanze University Groningen, University of Applied Sciences (the Netherlands) Anglia Ruskin University in Cambridge (United Kingdom)	Economics	4	2	http://www.hanze.nl/home/International/Schools/International+Business+School/Programmes/Master+Prog
97	double	The Duke Goethe Executive MBA Program	Duke University's Fuqua School of Business (USA) Frankfurt University's Goethe Business School (Germany)	Economics	4	2	http://www.mastersportal.eu/students/browse/programme/1065/the-duke-goethe-executive-mba-program.h

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98	double	Master's programme in Production Systems	Chemnitz University of Technology (Germany) University of Technology Brno (Czech Republic)	Engineering	4	2	http://www.tu-chemnitz.de/verwaltung/inter_stud/fulltime/prod_sys/prod_sys.html
99	double	Master in Supply Chain and Purchasing Management	Audencia Nantes School of Management (France) MIP Politecnico di Milano (Italy)	Economics	4	2	http://www.audencia.com/fileadmin/images_site/PDF_WORD/Masters_Internationaux/Audencia-MIP-2009.j
100	double	Dual Degree Master Program in Computer Science	Warsaw University of Technology (Poland) Technische Universität Berlin (Germany)	Engineering	4	2	http://www.eecs.tu-berlin.de/fileadmin/f4/fkIV/dokumente/doppelabkommen/DualDegreeMasterInfWarschau
101	double	Harvard Law School and the University of Cambridge J.D./LL.M. Joint Degree Program	Harvard Law School (USA) University of Cambridge (United Kingdom)	Law	5	2	http://www.law.harvard.edu/academics/degrees/special-programs/study-abroad/joint-degree-program.html
102	double	Dual-degree program of the University of Konstanz and of the Shanghai Jiao Tong University	University of Konstanz (Germany) Shanghai Jiao Tong University (China)	Mathematics	4	2	http://www.math.uni-konstanz.de/fb_seiten/contrib/studium/dualprogramm/shanghai/index_s.html
103	double	International Double Degree Program (IDDP) in both Aerospace Engineering and Business Adminstration	Kasetart University (Thailand) Royal Melbourne Institute of Technology (Australia)	Economics and Engineering	4	2	http://iddp.eng.ku.ac.th/home/index.php
104	double	T.I.M.E. double degree	ETH Zurich (Switzerland) Ecole Central Paris (France)	not specified	5	2	http://www.mobilitaet.ethz.ch/outgoings/programs/programme_students/time/index
105	double	Double Degree Master in Business and Economics (major strategy), and International Economics & Business	BI Norwegian School of Management, Oslo (Norway) University of Groningen (the Netherlands)	Economics	4	2	http://www.rug.nl/feb/informatievoor/internationalprospectivestudents/doubledegreeprogrammes/oslobifeb/
106	double	LLB/JD Double Degree	Law School of Columbia University, New York (USA) University College London (United Kingdom)	Law	5	2	http://www.ucl.ac.uk/prosp-students/2008-prospectus/laws/law/degree/double-degrees/index.shtml
107	joint	International Joint Master's Degree Sustainable Development	University of Graz (Austria) Ca' Foscari University Venice (Italy) Leipzig University (Germany) Utrecht University (the Netherlands) Basel University (Switzerland) Hiroshima University (Japan)	Engineering	4	4 + 2 associated partners	http://www.jointdegree.eu/index.php?id=161&lng=1
108	joint	MA in Contemporary European Studies: Politics, Policy and Society Euromasters & Euromasters with Trans-Atlantic track	University of Bath (United Kingdom) Free University Berlin (Germany) Humboldt University Berlin (Germany) Universidad Carlos III de Madrid (Spain) Institut d'etudes politiques de Paris (France) Charles University Prague (Czech Republic) Università degli Studi di Siena (Italy) University of Washington (USA)	Economics/Politics	3	8	http://www.bath.ac.uk/esml/em/index.html
109	joint	Polymer science	Free University Berlin (Germany) Humboldt University Berlin (Germany) Technical University Berlin (Germany) University of Potsdam (Germany)	Engineering	4	4	http://www.polymerscience.de/
110	double	Global Studies	London School of Economics and Political Science (United Kingdom) Universität Leipzig (Germany) Universität Wien (Austria) Uniwersytet Wroclawski (Poland)	Politics	4	4+4 non-European associated partners	http://www.uni-leipzig.de/zhs/emgs/index.php?option=com_frontpage&Itemid=1
111	double	Master on Work, Organizational, and Personnel Psychology	Universitat de València (Spain) Universitat de Barcelona (Spain) Université René Descartes Paris 5 (France) Alma Mater Studiorum-Università di Bologna (Italy) Universidade de Coimbra (Portugal)	Economics	5	5	http://www.uv.es/erasmuswop/
112	double	International Master's Degree in Horticular Sciences	University of Bologna (Italy) TU Munich (Germany) University of natural ressources and applied life sciences of Vienna (Austria)	Engineering	4	3	http://www.agrsci.unibo.it/dicabo/imahs/index.htm
113	double	MIEX "International Executives" - Master in International Management	University of Bologna (Italy) ICN Business School (France) ECUST (China) Universidad Lasalle (Mexico) MGIMO (Russia) Uppsala University (Sweden)	Economics	4	6	http://www.eng.unibo.it/PortaleEn/Academic+programmes/Masters/2008-2009/MIEX.htm
114	double	Master of Arts in Asian-European Management	University of Hamburg (Germany) ECUST (China) University of Aalborg (Denmark) National Economics University/Foreign Trade University Hanoi (Vietnam)	Economics	3	4	http://www.wiso.uni-hamburg.de/index.php?id=2068&no_cache=1&tx_ttnews[tt_news]=1091&tx_ttnews[bac
115	double	Master of Science in Water & Coastal Management	University of Groningen (the Netherlands) University of Oldenburg (Germany)	Engineering	3	2	http://www.wcm-master.eu/
116	double	International Business and Management	University of Groningen (the Netherlands) Uppsala University (Sweden)	Economics	3	2	http://www.rug.nl/prospectiveStudents/degreeProgrammes/mastersProgrammes/jointProgrammes/masterI
117	double	Master's programme in Production Systems (German-Czech)	Leipzig University (Germany) VUT Brno (Czech Republic)	Engineering	3	2	http://www.tu-chemnitz.de/mb/studium/sg_ps.php
118	double	Goethe Executive MBA	Goethe University Frankfurt am Main (Germany) Duke University (USA)	Economics	3	2	http://www.gbs.uni-frankfurt.de/index.php?option=com_content&task=view&id=73&Itemid=104
119	double	Masters Programme in Public Policy	Central European University (Hungary) Barcelona Institute of International Studies (Spain) Institute of Social Studies, the Hague (the Netherlands) University of York (United Kingdom)	Politics	3	4	http://www.mundusmapp.org/cons/cons.htm
120	double	European Master's Program in Distributed Systems Engineering	Dreden University of Technology (Germany) Universidad Politécnica de Madrid (Spain) University of Naples "Parthenope" (Italy) National technical university of Ukraine (Ukraine) Ecole Internationale des Sciences du Traitement de l'Information (France)	Engineering	3	5	http://wwwce.inf.tu-dresden.de/doubledegree.html
121	double	International Business Management	Universität Marburg (Germany) Grande Ecole INSEEC Business School (France)	Economics	3	2	http://www.uni-marburg.de/fb02/studium/studiengaenge/internationalBusinessManagement

	Degree type	Programme name	Involved universities	Thematic orientation	Thematic relevance (1 high, 3 low)	No. of involved universities	Website
122	double	Double-Degree-Program in Mathematics and Physics	University of Trento (Italy) University of Tübingen (Germany)	Natural Sciences	3	2	http://www.pit.physik.uni-tuebingen.de/grabmayr/dopplalaurea/index.php?h=main&l=e
123	double	International Project Management	Chalmers University of Technology (Sweden) Northumbria University in Newcastle upon Tyne (United Kingdom)	Economics	3	2	http://www.chalmers.se/en/sections/education/masterprogrammes/programme-descriptions/ipm
124	joint	Biotechnology	Universität Basel (Switzerland) Albert Ludwigs-Universität Freiburg (Germany) Eberhard Karls-Universität Tübingen (Germany) Université Marc Bloch Strasbourg (France)	Engineering	3	4	http://www.biologie.uni-freiburg.de/LauxLab/ESBS-Dateien/ESBS%20Flyer.pdf
125	joint	Nordic Master in Innovative and Sustainable Energy Engineering (ISEE)	Technical University of Denmark (Denmark) Chalmers University of Technology (Sweden) Aalto University in Helsinki (Finland) University of Iceland (Iceland) KTH Stockholm (Sweden) NTNU (Norway)	Engineering	3	6	http://www.nordicmaster.eu/nordic_master.htm 4
126	double	Transnational ecosystem based Water Management	Radboud University Nijmegen (the Netherlands) University of Duisburg-Essen (Germany)	Engineering	3	2	http://www.ru.nl/master/vm_archief/vm_oud_masters/english_master%27s/master_transnational/
127	double	Environmental and Infrastructure Planning	University of Groningen (the Netherlands) Institut Teknologi Bandung (Indoesia)	Engineering	2	2	http://www.rug.nl/prospectiveStudents/degreeProgrammes/mastersProgrammes/jointProgrammes/croho66
128	dual Bachelor	Business Information Systems	Kemi-Tornio University of Applied Sciences (Finland) University of Massachusetts Dartmouth (USA) University of Massachusetts Boston (USA) Frankfurt University of Applied Sciences (Germany)	Economics	3	4	http://www.tradis.info123.org/
129	dual Bachelor	Atlantis Bachelor/The International Mechanical Engineering / Materials Science Dual Degree	Lulea University of Technology (Sweden) Oregon State University (USA) Saarland University (Germany)	Engineering	3	3	http://matsci.oregonstate.edu/osu-atlantis/index.html http://matsci.oregonstate.edu/osu-atlantis/index.html
130	double	Engineering Mechanics and Materials Engineering Program (EMME)	University of Nebraska-Lincoln [UNL] (USA) Lulea University of Technology [LTU] (Sweden) University of Rouen [UR] (France)	Engineering	2	3	http://engm.unl.edu/grad07/doublemaster.shtml
131	double	Dual master's degrees in electrical and computer engineering and computer science	University of Trento (Italy) University of Technology Munich (Germany) Politecnico di Torino (Italy) Georgia Institute of Technology (USA)	Engineering	2	4	http://www.gatech.edu/newsroom/release.html?id=1793
132	double	Automotive Systems Engineering/Production Engineering	RWTH Aachen (Germany) Tsinghua-University Beijing (China)	Engineering	1	2	http://www.rwth-aachen.de/go/id/ifj/
133	double	MMM Program	Kellogg School of Management (USA) Mc Cormick School of Engineering (USA)	Economics and Engineering	4	2	http://www.mmm.northwestern.edu/

Annex V Case protocol

Educational cooperation in the European automotive sector

The following questions were the guideline for the case study. Internet and interviews were used to collect the information.

General information:

1. What exactly is the specialisation of the programme?
2. What universities are involved?
3. What is the background of these universities?
4. Do they work with other foreign partner universities?
5. Are the universities also involved in other joint programmes?
6. When did the Master's programme formally start?
7. How did the Master's programme come into being?
8. What was the initial motivation to start the Master's programme?
9. How many students are currently participating in the Master's programme?
10. How many students have successfully finished the Master's programme?
11. Are there set targets for the Master's programme regarding the amount of students and the number of partner universities?
12. Are the participating micro-clusters located in a micro-cluster?

Cooperation with the other educational institutions offering the programme:

13. What is the nature of the cooperation (what kind of programme is offered)?
14. Is it a one or a two year Master,s programme and how many ECTS credits are being given?
15. Is it possible to acquire a double degree?
16. Is it compulsory for students to exchange with students from the partner universities or is it compulsory for students to interact in a different way
17. Are there any effects, positive/negative, of the cooperation.?
18. If so, can you name them?
19. Have there been unexpected profits for the university from the cooperation?
20. Does educational cooperation have a positive effect on research cooperation?

Education offered in the programme:

21. What subjects are part of the programme?
22. What is the rationale for these specific subjects?
23. Is education on innovation theory part of the curriculum?
24. Is teaching staff from industry involved in the Master's programme? If so, how many ECTS can be gathered through Master's programmes given by teachers from industry?
25. Is there a part in the curriculum that instructs students to be more entrepreneurial? What part is this?
26. Are students being taught to be more creative or self-confidently or to take more initiative?
27. What are the acquired competencies?
28. What are the learning outcomes?

Annex VI Positive and negative effects: lessons learned

During the interviews more questions were asked about the cooperation and the lessons learned from setting it up and running it that could possibly be of use for other universities. These lessons can be found in this Annex

Case 1
According to Mr. Simeonov the most negative part about the cooperation is that it is time consuming. You need a flexible mind set and a small team to set up a programme like the MSc-ITS and this team has to invest a lot of time and effort in the cooperation without guarantees. There is no certainty about the amounts of students applying and about the intentions of the other universities. This again makes it difficult to get time and approval from the university to set it up. In the beginning a lot of your own time has to be invested. When its set up you have to continue to invest time to keep it running.

Positive effect of the cooperation is the built up of a good and strong network of contacts to exchange ideas. The MSc-ITS project meeting of June 2010 was an excellent example of this, where a constructive debate helped to discuss the future of the MSc-ITS.

Case 2
As with the first case, the interviewees mentioned the difficulties to start a joint programme. First of all, because it's very difficult to tune two different programmes from different countries. Every country has different laws regarding education that make it sometimes hard to come to a solution that works for both countries. That's why this case is constructed in a way that students have to finish the first two semesters at CTU before they can go to the other countries. Secondly, the level of the students from the other institutions is difficult to assess, because of all the differences. Only at the moment that the first students start with the programme you really know whether the students have the right level of knowledge or not. If this level is too low, then students go back and even cooperations end. Mr. Vooren mentioned that this happened with an Indian university with which HAN University had started an educational cooperation.

A positive effect of the cooperation was the international notoriety of the university. Other universities from a diverse set of countries heard about the MSc programme and the universities involved and started negotiations about other joint programmes with HAN and CTU. A good example of this is the actual agreement with an Indian university to start an international English bachelor programme with HAN. The increase in the amount of international projects is positive for the university as well. The last positive effect, and actually an important reason to start the cooperation, are the additional students that the programme attracts that would not have been studying at the university if it had not cooperated with the other institutions. These students want international experience and use the programme to get this.

Mr. Vooren mentioned that the industry appreciates the cooperation between universities because of the international character of the automotive sector The cooperation introduces future employees to the international environment and helps them to be able to understand and work with the different cultures.

Annex VII List of Subjects MSc-ITS

CURRICULUM STAGE 1 (1st and 2nd semester)

Modules	Czech Technical University in Prague	ECTS credits	UAS Technikum Wien	ECTS credits	Linköping University	ECTS credits
Module 1 Transportation Systems	Analysis and Prevention of Traffic Accidents	2	Transportation Systems	3	GIS for Transportation	6
	Energy Analysis of Land Carriage	2	Public Transport	1,5		
	Safety and Reliabilty in Transportation	2	Technologies in Transport	1,5		
Module 2 Intelligent Transport Systems	Telematic Systems and Services	3	ITS in Rail, Water and Airborne Transportation	4,5	Intelligent Transport Systems	6
	Systems Analysis and Design of ITS	2	Traffic Telematics	1,5		
Module 3 Automated Data Acquisition and Processing	Pattern Recognition	3	Sensorics	3	Traffic Demand Modelling	6
	Data Processing	3	Algorithms and Data Structures, Soft Computing	3		
Module 4 ITS Management Skills	Economy and Manage-ment of ITS Projects	3	Management and Leadership Training	3	Project Management (takes place in the 3rd semester)	6
	Technological Aspects of Quality	2	Law	3		
Module 5 Mathematical Tools	ITS Mathematical Tools	3	Discrete Mathematics	3	Optimization	6
	Theoretical Physics in Transportation	3	Operational Research	3		
Module 6 Required Elective Module	Tutorial in Informatics	2	Required Elective Module	6	Computer Networking	6
	Compulsory Facultative Course I	2				
	Risk Analysis and Management/Intelligent Vehicle and Safety	2				
Module 7 Traffic Modelling and Simulation	Traffic Simulation	2	Transport Modelling and Simulation	6	Traffic Planning and Simulation	6
	Traffic Flow Theory	3				
	Numerical Modelling	2				
Module 8 Telecommunication	Telecommunications in ITS	3	Telecommunications	3	Mobile Communication	6
	Signals and Codes	4	Mobile Telecommunication and Network Technology	3		
Module 9 Specialisation in ITS 1	Control System Theory	2	Embedded Control Systems	4,5	Data Communication and Internet	6
	Information Security	2				
	Artifical Intelligence and Expert Systems in Transport	2	Distributed Systems	1,5		
Module 10 Specialisation in ITS 2	Master's Project 1	2	ITS Project I (Select one of the following: Autonomous Driving, Intelligent on Board Sensors for Vehicles, Traffic Data Acquisition, Cooperative Systems)	6	Human Systems Interaction/ Road Safety Audit	6
	Master's Project 2	4				

ECTS credits Credits according to the European Credit Transfer System

CURRICULUM STAGE 2 (3rd semester)

Modules	Czech Technical University in Prague	ECTS credits	UAS Technikum Wien	ECTS credits	Linköping University*	ECTS credits
Module 11 GIS, Positioning, Navigation and Identification Systems	Geographical Information Systems	2	Positioning, Navigation and Identification Systems	3	Positioning Systems	6
	Identification Systems	2	GIS	3		
	Localization and Navigation Systems	2				
Module 12 Complex Systems	Systems Engineering	4	Advanced Driver Assistance Systems	1,5	Traffic Engineering and Management	6
			Cooperative Systems	1,5		
	Stochastic Models and their Applications	2	Logistics and Fleet Management	1,5		
			ITS System Architecture	1,5		
Module 13 Human and Environmental Impacts, Safety and Sustainability	Transport and Environment	2	Safety and Sustainability	3	Traffic Safety Management	6
	Road Safety Audit	2	Traffic Psychology and Human Machine Interface	3		
	Modelling of HMI	2				
Module 14 Specialisation in ITS 3	ITS Effectiveness Assessment / Safety Critical Applications in Transport / Special Materials and Technology	2	Dependable Systems	3	Applied Optimization	6
	Advanced Telematic Applications / Railway Interlocking Systems / Vehicle Control Systems	2	Transport Economy	1,5		
	Mathematical Models in the Economy	2	ITS Project II	1,5		
Module 15 Specialisation in ITS 4	Master's Project 3	4	ITS Project III	6	Analysis of Communication and Transport Systems	6
	Compulsory Facultative Course II	2				

*The curriculum stage 2 for students moving from UASTW and CTU to LiU comprises the modules 6 (see stage 1), 11, 12, 13 and 15.

CURRICULUM STAGE 3 (4th semester)

Any university of the consortium depending on availability

Modules	Czech Technical University in Prague	ECTS credits	UAS Technikum Wien	ECTS credits	Linköping University	ECTS credits
Module 16 Master's Thesis	Master's Project 4 and Thesis	26	Master's Thesis	18	Master's Thesis	30
	Applied Informatics	2	Graduate Seminar	6		
	Designing of Advanced ITS Systems and Services	2	Supervision – Master's Thesis	6		

Annex VIII Agenda of attended workshops, meetings, congresses and interviews

Date	Subject	Location
8 October 2008	EC Workshop 08C23 - Partnerships, networks and clusters in the automotive sector	Brussels
4 November 2008	GAST project meeting	Frankfurt
6 November 2008	TWA meeting “Innovative Technologies for road transport and personal mobility” at the Eindhoven University of technology	Eindhoven
13/14 November 2008	EARPA Workshop on European automotive research	Brussels
7 January 2009	Consultation with Dr. Mom	Eindhoven
4 February 2009	Consultation with Prof. van Vught about measuring tools	Brussels
17 February 2009	Consultation with Dr. Mom	Eindhoven
26 February 2009	GAST project meeting about European clusters	Frankfurt
2-3 March 2009	Conference about regional competitiveness clusters and economic development organised by the University of Liège	Liège
17 March 2009	Automotive cluster meeting	Helmond
23 March 2009	Meeting about clusters at the High Tech Automotive Campus (HTAS)	Helmond
23 March 2009	Consultation with Dr. Mom	Eindhoven
26 March 2009	GAST project meeting	Frankfurt
2/3 June 2009	International cluster meeting / Opening of the HTAS Helmond	Helmond
1/2 October 2009	GAST project meeting	Helmond
9 February 2010	Consultation with Prof. van Vught	Brussels
2 March 2010	Consultation with Prof. Schot and Prof. Vleuten	Eindhoven
15 March 2010	Consultation with Prof. Schot	Amsterdam
30 June 2010	Electro-mobility forum, organised by the European Association of Automotive Suppliers (CLEPA)	Brussels
15 September, 2010	Interview with Dr. Simeonov (by Telephone)	Vienna
24 September, 2010	Interview with Mr. Vooren	Arnhem
2/3 December 2010	Workshop about the role of the EIT in the education	Leuven

	landscape	
9 December, 2010	Interview with Dr. Achtenová (by Telephone)	Prague
16 February 2011	Entrepreneurship Forum organised by the TU Delft	Delft
12 January 2012	Consultation with Prof. Schot	Eindhoven