Opportunities and Challenges in the Implementation of the Knowledge Triangle

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1 THE KNOWLEDGE TRIANGLE (KT)

Introduced by the Lisbon Agenda at the dawn of this century in order to enhance Europe's competitiveness (mainly from a University viewpoint), the "Knowledge Triangle", as shown in *Figure 1*, links together Research, Education and Innovation (the "poor relation" of many European universities), with special platforms and processes on its three sides. It replaces the traditional "one way" flow of information, from research to education and from educators to students, by a "both ways" circular motion between the three corners of the triangle.

As explained by GOOSSENS & SJOER [2], it results of the superimposition of two triangles – one for education and one for research – each having a "Model" corner (M), an "Activity" corner (A) and a "Utility" corner (U) : see *Figure 2*. They also showed that any industrial company is actually working according to a similar triangle. The reason of that similarity can be found in the framework proposed by the American psychologist Ulrich NEISSER, generally referred to as "*Neisser's Perceptual Cycle*" [3]. It consists of a circular relationship between the models of the world that we have in our brain, the exploratory activity that we lead in a

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part of the world around us in order to find a satisfaction to our needs, and the available information that we can derive from the object(s) selected in our environment, information that in turn can modify our models.

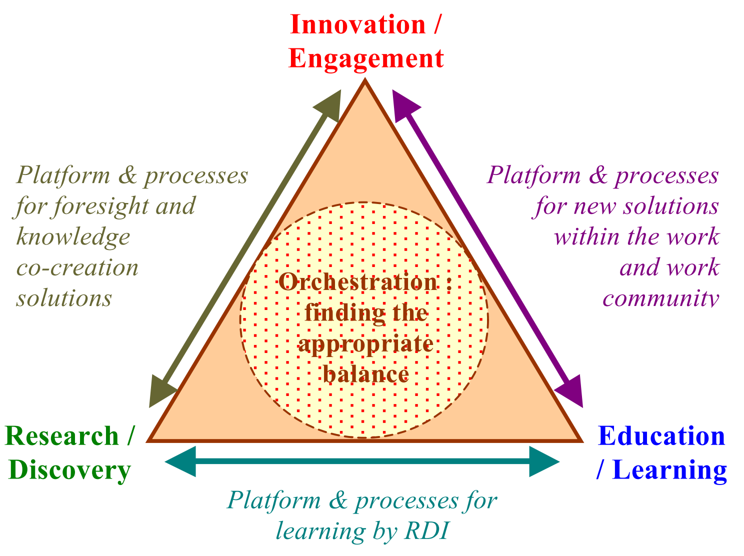

Fig. 1 – The Knowledge Triangle (adapted from [1])

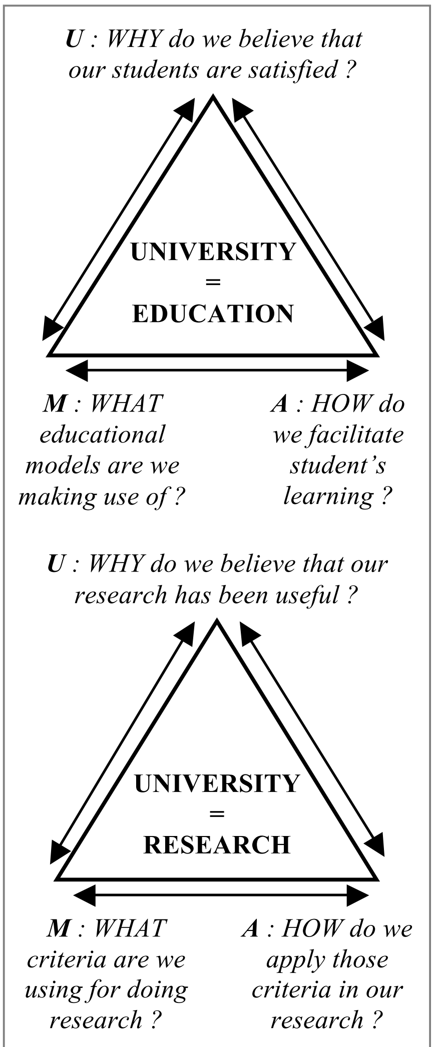

Fig. 2 – The two triangular components of the Knowledge Triangle

Taking time into account and relying on the concept of "*loose coupling*", in the meaning defined by Karl WEICK [4], they explained how the same form of cognitive process can be extended from individuals to their organizations.

Following on what we presented one year ago at the SEFI Annual Conference in Lisbon [5], we propose to extend the aforementioned approach to the innovation process itself and use it to explain the drivers and barriers met when implementing the KT in real life practice. The main research question is : " *What are the central issues in implementing the KT ?* ".
We shall share the points of views of three different target groups of the KT, namely regular students (in section 2), academic teachers (in section 3) and PhD graduates working in industry (in section 4), and then try to link their experience and difficulties with the three anchorage points of Neisser's perceptual cycle : M for the various models, A for the activities that should be led in common, and U for the utility (which is different for all parties).

2 THE POINT OF VIEW OF STUDENTS (by Delft University of Technology)

2.1 Introduction to the case

Delft University of Technology has a long tradition in cooperation with industry. Students get acquainted with industry via internships, (graduation) assignments, games, guest speakers. In this case, we collected and analyzed the viewpoints of regular Bachelor's and Master's students on the following question : " *What do they consider as the central issues in implementing the KT* ? ". For our data collection, we used an orchestration tool called Barter, which is an online platform for promoting information exchange using an internal knowledge market scheme [6]. It consists of several parallel markets that have been designed with MIT for trading different types of knowledge. Students trade their knowledge and share their expertise via a price mechanism. At the beginning, one of the "teachers" uploaded the aforementioned SEFI 2011 paper [5] into the "market", with the following request :

> *« This paper was written for the SEFI Conference in September 2011. Its purpose was to start a discussion on how to make the Knowledge Triangle (KT) a reality. The KT concept – the interplay between research, education and innovation – has been introduced in 2000 as part of the Lisbon Strategy. The idea was to make a better "use" of research and education (researchers, PhD's, teachers, students), in order to be more innovative as a European economy and society. Furthermore, as you can read in this article, the role of industry as a partner is important. Please submit your ideas on how to make the KT a reality. All other comments and suggestions are also welcome. At the end, we shall report your ideas and suggestions back to Brussels » (teacher)*

All users (≈ 280, mostly students) could respond and were rewarded for their input. At the end of the semester, 77 users had visited the track : 18 of them had given extensive online responses, 21 had voted positively ('thumps up') and none negatively. As their contributions were not anonymous, a follow-up conversation with some of them, and with some groups of students, could be scheduled. We give in sections 2.2 t/m 2.4 a summary of three discussions : quality of education, ideas for implementing the KT and students contribution to innovation.

2.2 To what extent does the implementation of the KT effect the quality of education ?

One important discussion point, on which students very much disagreed with each other, dealt with the effect that the implementation of the KT would have on the quality of education :

« I think that incorporating industry into university studies in order for the economy to benefit would be a step backwards in terms of educational quality (and thus student development). Universities and industry operate on a different level, for they serve different purposes. While industry is stubborn, hard to change and far too complex to cope with, university environments are very broad, but still quite flexible, which allow for a more focused and thorough study, which is thus of more educational value. Fundamental research is a common practice in universities, which constructs a steady base to innovate upon, although not at all interwoven with the industrial sector. What would be the place of fundamental research after the application of the knowledge triangle concept ? Perhaps I might be a little too conservative in this case, but I really fear commercial specialization in contrast to holistic education. » (student)

Many students were convinced that there is much to learn in and from industry :

« Rather than seeing it as a step backward, I think this will help bridging the gap in some aspects. For one, educational quality will not be a let down, if anything the students have FAR more to learn from what could await them in actual corporate life. » (student)

The same student also reacts to the role of fundamental research after deploying the KT :

« I fully agree with your statement - Universities and industry operate on a different level, for they serve different purposes. But I think, unless you are look at major scientific breakthroughs, we will find fundamental research can happen while still being part of the university intersection industry. Many companies spend finances at places like MIT, Harvard, etc and I think it gives a chance for specialization to happen. » (student)

2.3 How could the Knowledge Triangle become a reality ?

In accordance with the online request, students posted ideas on the implementation of the KT, mostly about organizing events, internships or projects :

« I would say one of the key features of making this triangle a reality is to actually start holding conferences and meetings with companies and universities. A university is clinging on to "I need academically relevant research" and industry is mainly looking at "How can I increase revenues" - the link we can look is innovation and students are the bridge here. […] This also would help with grants for projects and having a good industry recognition – in turn students being beneficial in both cases (either because they chose to pursue PhD or join a company). » (student)

Though most students are in favour of a fruitful relationship between university and industry, some of them don't consider that a closer relationship is a good idea:

« Companies already 'steal' highly skilled people from university, usually the ones that are indeed looking for such an opportunity. I see no need to encourage these processes. » or *« Why not ? In the end, at least part of the job of universities is to deliver (high skilled people) to the market (companies). »* or *« […] those who are*

anyway not attracted by industry cannot be "stolen" - they would be passionate about continuing research and stay at university. And not necessarily all those at companies do not come back to do PhD's (post working or while working) or do not innovate at all. » (students)

2.4 To what extent do students consider themselves able to contribute to innovation ?

What could we expect from our ordinary students ? The answers are divided between those who think that contributing to innovation is "too difficult" (see first answer below) and those who think that it is "possible" – if it is not too complex – (see second answer).

« First of all, I'll reflect back to my own faculty, which is Aerospace. Obviously it is important to teach the students what they are learning for. In the end, you want them to produce innovation and do useful research. But I think it would be very difficult to get the students to produce something really useful for this entire branch. I think personally I could not yet design or develop an airplane that I would grant more then a 50% chance of flying reliably. It's just too difficult to produce something useful for this branch early on. Something that could help is sending the students on internships earlier on. This gets the students more in touch with the actual environment, and it bring them to do something useful for a company at this stage already, although unlikely. »

« When I look at technical management, I see a lot of ground ready for improvement by students. When our group came up with concurrent engineering for transportation hubs, we figured this was just another useless idea, as were most ideas we came up with while being students. This of course because we lack a lot of critical knowledge yet, and many things we come up with have already been tried, tested and dropped. But when we took the idea a project manager to review it, he indicated instantly that he had been trying to get people to work in this way for years. The biggest issue, he claimed, was to get the companies behind your idea, as concurrent engineering had not been proven to work in the civil engineering sector yet. In this area, students could help out. You can easily have a student do an analysis on a hundred projects for a company, and point out to them that they could improve using a certain method. When we pointed out to the PM [project manager] that ESA had been using concurrent engineering successfully for years now, he grew even more enthusiastic. Concluding, I think it would be a good idea to try to bring faculties and the real world together, as the work the students will do later will most likely be in the industries. These industries however seem set in their ways, and here students could help out. The matter at hand should not be too complex though, as students could not help out here yet because of missing knowledge. » (student)

2.5 Conclusion of the case

As anyone, students have in their mind some model of the world and of what innovation is (M-corner of the triangle), but that model is short of practical information about their future work in industry : " *The industry is stubborn, hard to change and far too complex to cope with* ". Also, based on their previous experience, they have some idea of how education should look like (M-corner) and of how the various parties could contribute. Furthermore, those who reacted in some way to this discussion showed that they wanted to contribute to innovation (A-corner). Finally the previous paragraph revealed that the characteristics of the industrial sector for which they are trained and success experiences make them feel capable or not to contribute to innovation : " *I could not design or develop an airplane that I would grant more than a 50% chance of flying reliably. It's just too difficult to produce something useful in that field at the very start* ". The feedback they get from the academic staff of their faculty about their possibility to contribute to innovation will also be a determining factor.

So, on the bases of the discussions in this case, our recommendations would be :

1. In order to change the mental models that students have of the world in which they will have to operate and innovate, we must introduce other forms of education and learning methods, based on a successful cooperation with their future professional world.
2. In order to make this first recommendation possible and fruitful, we must apply the concept of the KT in the various faculties of technical universities and foster a positive attitude of the academic staff of those faculties towards the KT.

3 THE POINT OF VIEW OF THE ACADEMIC STAFF (by Aalborg University)

3.1 Introduction to the case

Aalborg University has a long tradition of collaboration with the surrounding society, mostly in connection with student projects and its pedagogical model – the Aalborg PBL (Problem Based Learning) model – strongly encourages such an action. The results given hereafter have been obtained in the framework of a European funded project in developing tailor-made continuing education in the northern part of Denmark.

Therefore, inspired by our experience in that field, we introduced a slightly modified PBL model in continuing education (CE), for engineers working in local companies : we simply replaced our usual students by engineers from those companies. It seems very simple, but, without didactics purposes and curriculum, it is not that simple : identifying the needs of the company and designing a course based on those needs is a process that should require more research but, in this paper, we shall merely consider the viewpoints of the academic staff involved in the project : how do they think of the experience of facilitating the learning process of engineers working in a company instead of their usual students ?

3.2 Opinions of the academic staff

We already mentioned the lack of support form the university system to the CE activities, because they are not seen as likely to improve academic career opportunities. In other words, there is no incentive for the academic staff getting involved in CE activities and, therefore, we often got answers like the following ones :

« Unfortunately, I don't have time to get involved in this very exciting course at the moment » or *« Unfortunately, it is not possible to organise such a course at the moment »*

Lack of time is another important issue for the academic staff involved in CE, as they are full-time employed doing research and teaching their university students : so, their possible involvement in CE activities is considered as unpaid overtime, or a duty, which generally does not interest them, even if some of them like to work in cooperation with companies for their research work. They usually answer something as :

« I think my answer will be : " I would like to be involved in in-house continuing education with ECTS – but I will not deliver consultancy for discount price " ! »

The university system cannot handle the payment of "normal" fees for CE activities : what they receive is much less than their fees for courses within the university system and this of cause is not conducive to CE activities ! Besides, CE courses only run once, unlike the in-house university courses, which normally are repeated more that once, and with slight changes only. Spending time in developing in-house courses is obvious a much better investment, and it also represents stability and security for the academic staff, which is not the case of CE courses.

3.3 Conclusion of the case

The results are very clear : though they know very well the PBL-model and how to facilitate learning processes, the academic staff cannot find a good enough reason for getting involved in CE activities, which may very well be due to the lack of incitement structure towards those activities. As already mentioned, there is a tradition for cooperating with the surrounding society, but it is mostly through student projects introduced by the academic staff in order to solve the company problems, and not through developing CE courses – although it is possible to have these CE courses developed within the existing in-house frame.

We can explain this by using our triangular (M-A-U) approach, as in *Figure 3* :

- A common CEE activity (A) has to be implemented, implying some academic staff of a given university on the one hand, and some engineers of a given company on the other hand. The first ones have a certain idea (Ma) of what they could do in that way, but they are linked with a university, which has a much stronger operating model (Mu) ; the loose coupling between those two models works practically one way : the academic staff do not have the power to change (Uu) the university model, and therefore they do not find a strong enough motivation to apply his model to the considered CE activity.

- There is of course (even if it was not the aim of this case) a similar process going on the company's side : the engineers interested in the CE activity do not have the power to change the stronger company's operating model (Mc).
- Finally, there is a loose coupling both loose-coupled models (Mu-Ma on the one hand and Mc-Me on the other hand), which results in a weakening of an offer and a demand that could have been stronger otherwise.

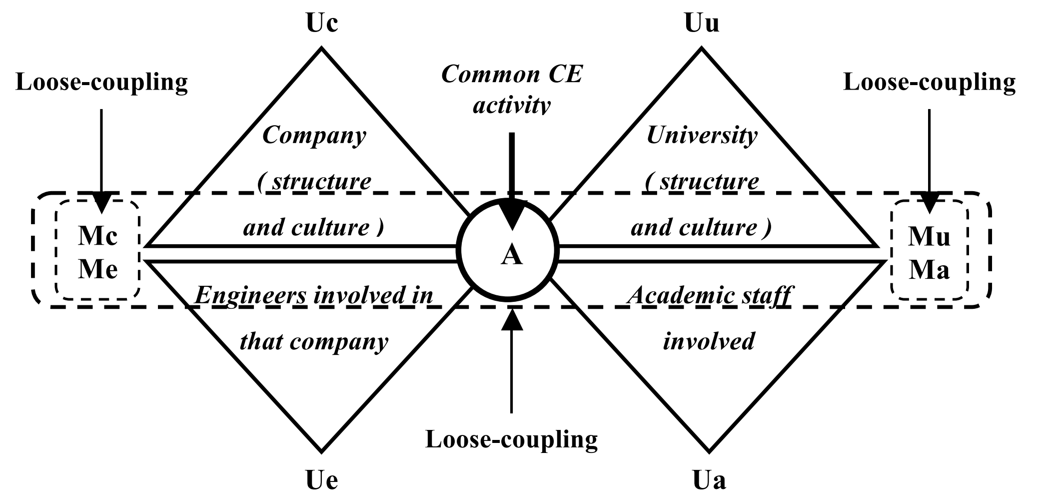

Fig. 3 – Explaining this second case with our "triangular" cognitive process

Nevertheless, though the structure and the culture of Aalborg University do not encourage academic staff towards CE activities, many of them are willing to get involved in external collaborations. There are many good reasons for such a willingness : the duty to cooperate with local companies, the possibility to get input to their research work or to get case material to in-house courses, etc. But there is no doubt that their interest in CE activities would be much stronger if, somehow, they could receive higher fees and greater recognition in return.

4 POINTS OF VIEW ABOUT PhD GRADUATES IN INDUSTRY (by SEII)

4.1 Introduction to the case

One year ago, CLAIU-EU asked SEII to make a survey of the career perspectives that are presently offered by European industrial companies to PhD graduates in engineering. The results of this survey were presented at their last Annual Conference in Madrid [7].

4.2 Findings of the survey

Most opinions that were found (one from the journal "Nature" [8], one from an OECD survey [9] and one from the newspaper "The Economist" [10]) were not in favour of doctoral studies in science and engineering. Here are a few selected sentences :

« *In much of the world, PhD graduates in science and engineering may never get a chance to take full advantage of their qualifications, with a dwindling number of academic jobs and an industrial sector unable to take up the slack* »

« *In OECD countries, a non-negligible share of doctorate holders seem to be employed, either in non-related or in lower qualified occupations* »

« One thing many PhDs have in common is dissatisfaction ... There seem to be genuine problems with our system, which produces an oversupply of PhDs ... Many PhDs find it tough to transfer their skills into the job market ... But universities have discovered that PhD students are cheap, highly motivated and disposable labour, as they do much of the university research these days »

On the other hand, one of the best argued opinion in favour of PhD graduation has been given by Georg WINCKLER, Rector of the University of Vienna [11] :

« PhDs are strategic tools and a vital resource in a knowledge-based economy, and Europe needs 700,000 researchers more to enhance its competitiveness. Universities must provide Europe with a new generation of highly adaptive experts. But, in order to achieve that, University-Industry cooperation is more than ever necessary, as a vehicle to enhance knowledge transfer ».

At first glance, it seems that those two sets of opinions are completely antinomic and by no way reconcilable. Yet, when looking carefully at them, it appears that they actually do not conflict with each other, because they do not relate to the same thing : WINCKLER speaks of a desirable situation, of something he hopes universities could do, through their PhDs in engineering, to foster innovation capacity and the competitiveness of European industry, of what the concept of Knowledge Triangle could achieve, if it was correctly applied ; while the other evidence is about the present situation of PhD graduates, namely their difficulty to integrate into professional life. In other words, both sides are speaking with different models in their mind, with different maps of the world in which they place their opinion, present and pragmatic on one side, future and slightly idealistic on the other side.

In order to find out where such a gap is coming from and how it could be filled, we have interviewed some managers working in industry.

4.3 The point of view of industry

The policy of industrial companies about the recruitment of PhD graduates in engineering tends to be more or less the same everywhere in Europe. In large industrial groups – and to a lesser extent in SMEs – this recruitment is linked with their volume of R&D, as those graduates are particularly prepared to work in R&D. But, besides the question of volume, Human Resources Managers have to take the following points into account :

- PhD graduates' career is generally going to move from research work towards more managerial tasks for which they have not been sufficiently prepared.
- Taking on PhD graduates to have them work in a position for which they are overqualified is risky : they could leave the company within a few years, or stay and be unhappy (and probably not very much motivated).
- As a more or less important part of the R&D work can also be tackled by engineers at Master level, the standard of " soft skills " may be a more discriminatory criterion.
- New industrial processes and practices are usually created by groups, while PhD students are often alone in front of their thesis subject.

4.4 The origin of the gap : first approach

It is true that a number of PhD students are not very clear in their mind what the reasons of their choice were, that they don't imagine what is waiting for them in industry, and that they don't possess a high enough level of "soft" skills, which are highly searched for in industry. But it is true also that many universities have made important progresses in the way they are preparing their PhD graduates for working in industry.

Therefore, it is quite probable that the point of view of industry is slightly distorted and outdated. But, if we want the approach symbolized by the Knowledge Triangle to be efficient in improving the competitiveness of European Industry, there is another point that has to be considered, namely the volume of private R&D in Europe.

4.5 Second approach : volume of R&D in Europe

A recent OECD report [12] made it appear that the position of European countries, with regard to R&D, is far to be good, as compared with their main competitors. In 2011, R&D intensity was estimated to be of 1.8 % for Europe, compared to 2.7 % for the United States, 3.3 % for Japan, 3.2 % for South Korea and already 1.6 % for China : this is even less than the average value for the whole world, which turns around 1.9 % !

But we can still go further and compare R&D intensity in the public sector (mainly universities) and in the private sector (mainly industry), as derived from a recent report of the European Commission [13]. It is very interesting to notice that if, globally, Europe stands comparison with the United States, Japan and South Korea concerning the public R&D intensity, it is not the same relating to the private R&D intensity, for which Europe – globally - is laying while behind those competitors (even if some countries as Finland, Denmark, Sweden and Germany stand comparison).

"*Where does this come from ?*" is a very difficult question to answer. There is, of course, a difference of mindset, but this is probably not the only explanation.

4.6 Conclusion of the case

As in both previous cases, let us try to explain those differences with the help of our triangular (M-A-U) approach, as illustrated in *Figure 4*. Actually, there are three "main" gaps between the models that the various stakeholders –University professors, students applying for a PhD in engineering, and managers of industrial companies – have of what PhD graduates in engineering, when working in industry, could do in order to foster the innovation capacity of their company :

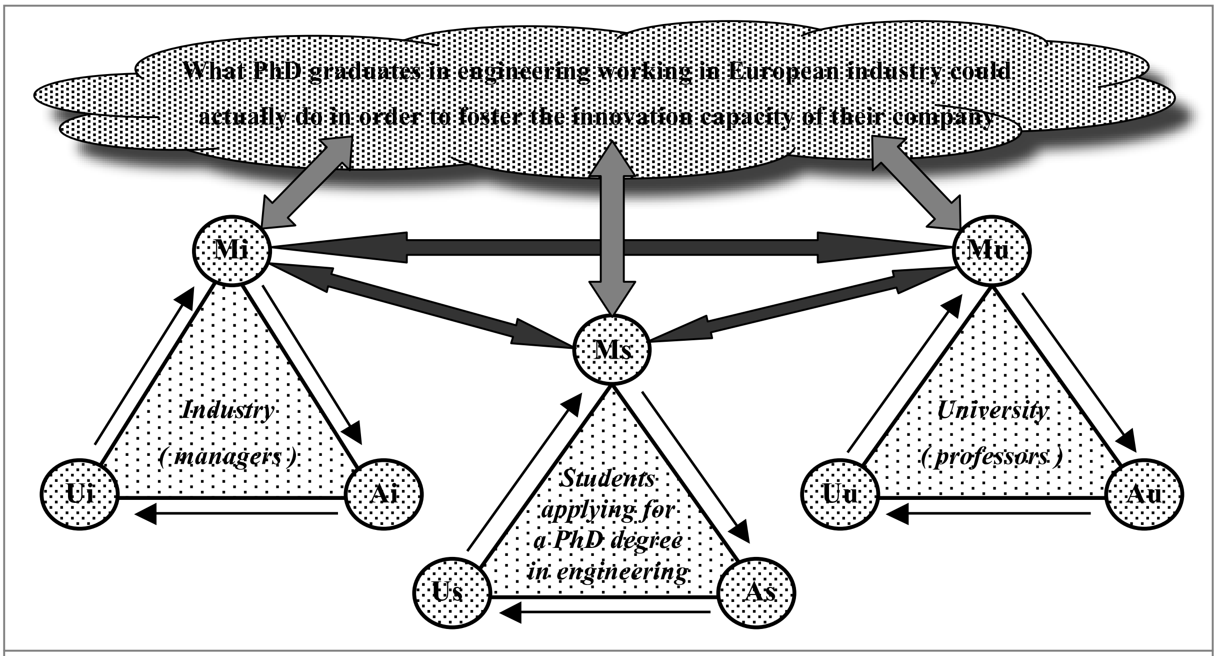

Fig. 4 – Explaining this third case with our "triangular" cognitive process

- The first gap – quite important – is the difference between the model of University professors (Mu) and the model of managers of industrial companies (Mi) ; this is quite noticeable through the opinions presented in section 4.2.
- The second gap – not very large – is the difference between the model of University professors (Mu) and the model of students (having gained a degree in engineering at Master level) applying for a PhD degree (Ms) ; we will underline the fact that this gap is in line with the gap illustrated by our second case (Aalborg University).

- The third gap - also very large – is the difference between the model of the students applying for a PhD in engineering (Ms) and the model of managers of industrial companies (Mi) ; it is connected with the gap illustrated by our first case (TU Delft).

But there are also three "secondary" gaps, which are the gaps between those three models (Mu, Mi and Ms) on the one hand, and an "ideal" reality on the other hand, that is " *what PhD graduates in engineering could actually do for the innovation capacity of the industrial companies in which they work if they had been 'ideally' educated for such a task* ".

One question remains to be tackled : "*Can those gaps explain the aforementioned differences of investment in R&D between most European countries and our main competitors?*". It is difficult to give a straightforward answer to that question, but the results of a survey made by INSEAD for the European Business Summit [14], in which they analyzed the relevant skills of graduates from European countries and from some non-European countries according to their capacity to foster growth and competitiveness, when plotted versus the R&D intensity as given by the EC [13], showed that there is some relationship between both variables : in *Figure 5*, the ellipse delimits the zone within standard deviation for the 29 analyzed European countries, while the inclined broken straight line expresses the linear correlation. This of course does not mean that there is a cause and effect relationship.

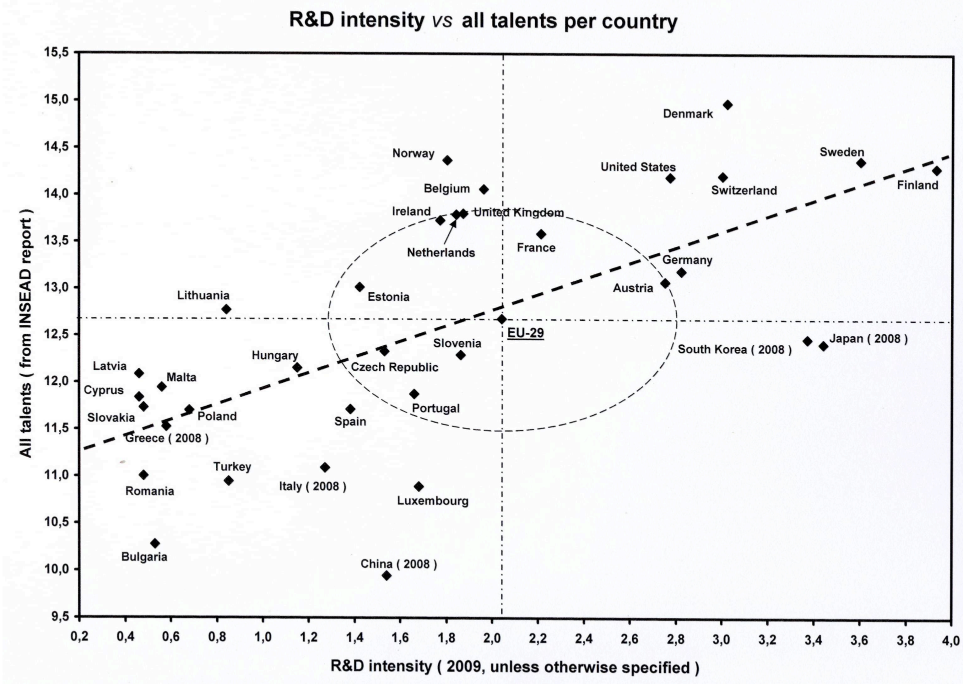

Fig. 5 – Relationship between the R&D intensity and the skills level as measured by INSEAD

5 CONCLUSION : OPPORTUNITIES AND CHALLENGES

Our main research question was : « *What are the central issues in implementing the KT ?* ». We answered it on the basis of three cases linked with its three corners. Through their analysis, we believe that the main barriers to implementing the KT lie in the gaps between the different mental models that people and their organizations have of their respective and reciprocal tasks, objectives and working processes :

- In some instances, as in our 2nd case, the strong loose coupling between an organization (here a university) and its staff (here academic staff) influences more or less consciously the members of the staff in their view of what they want or have to do.

- In other instances, as in our 3rd case, the absence or weakness of loose coupling between two different types of organizations (here, university and industry) prevent them to adjust their respective offers and demands.
- And, as in our 1st and 3rd cases, the situation is more challenging for engineering students (at any level, but maybe worse at doctorate level) going to work in industry, as they have to change a mental model shaped by university into a mental model adapted to industry.

The Knowledge Triangle aims at fostering innovation, which means "*A change in the thinking process (M) that aims at executing (A) a new – and supposedly beneficial (U) – action* ". We recognize in that definition the three corners of our concept.

The KT is directing to a 'commitment' of all stakeholders, so that they should carry through more successful innovation with different partners. This in turn should better satisfy their needs and induce them to change their mental models. But, in order to initiate the process, it is necessary to raise among them the awareness of the need of implementing the KT (drivers) and of the dangers of not implementing it (barriers). Of course, we are perfectly aware that it cannot resolve all the problems that are linked with innovation.

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