# Connecting Higher Education, Business and Research to develop a Future Educational Ecosystem

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## INTRODUCTION

The ever increasing technological developments and greater demands from our society for qualitative better, safer, sustainable products, processes and systems are pushing the boundaries of what is possible from an engineer's perspective.

Besides the (local) grand challenges in energy, sustainability, health and mobility the world is getting smaller due to advances in communication and digitalization. The exponential increase of complexity and data driven systems (big data) which are integrated and connected to different networks calls for rethinking and inventing new business models [1].

To stay competitive in the world OEM's and SME's have to develop breakthrough technological, innovative and advanced systems and processes.

These changes have a major impact on engineering education. The industry needs engineers with different competences and skills to fulfil the challenges and demands mentioned earlier. Universities should follow up on these changes and can only deliver and prepare the engineers of the future by close collaboration with the high tech industry.

Fontys University is fully aware of this and developed a Centre of Expertise in High Tech Systems & Materials (CoE HTSM) to close the gap between the university and industry. This CoE is a public-private cooperation where applied research, projects and educational programs for different curricula are being developed and executed.

By making the industry partner and giving them a role within the university, the engineering education programs and the future engineering profile can be better aligned in a faster and more structural way.

# 1 GENERAL

## 1.1 Eindhoven, the heart of the high-tech industry

The Eindhoven region in the south of the Netherlands is the heart of the high-tech industry [2]. The regional companies (OEM and SME) have understood that collaboration in manufacturing, development and innovation with suppliers is key to retaining a competitive position in the world. The Eindhoven area or also known as the Brainport Region have successfully implemented an open innovation eco-system where OEM companies work together with SME companies throughout the whole value chain.

## 1.2 Centre of Expertise High Tech Systems & Materials

Fontys University is fully aware of the dynamics and significant (economic) potential of the high-end and high-tech industry. Fontys plays an important role in the regional innovation system as an industry partner and it is leading the way in higher education in advanced emerging technologies. As such, Fontys has decided to collaborate with regional industry to invest in and develop a new Centre of Expertise focusing on high-tech systems and materials. This new development will boost cooperation and partnerships on many different levels, helping to fulfil our stakeholder's different needs. In general, this model of public-private cooperation will contribute to our government's goals and Brainport human capital agenda [3].

## 1.3 Goals and Business/Research model supported by roadmap

Setting up a Centre of Expertise where the university and the industry play a major role is not something trivial. To make sure that this is going to be a successful and sustainable effort, we decided to design and develop a so called business/research model and a roadmap till 2017 [4]. The output of this centre of expertise should achieve the following goals in a cyclic manner:

- Stronger and intensive cooperation between industry, education and government;
- Partnerships in applied research and engineering projects;
- More and better national and international qualified engineering graduates;
- Up to date and state of the art engineering bachelor programs;
- Custom made open, practical, short and modular courses, workshops and training for the industry;
- National and international curriculum development (bachelor, associate degree, minor);
- Professionalizing of the universities work force (professors, lecturers, etc.);
- A clearer profile of the university in the region.

The business/research model is part of the PDCA (Plan Do Check Act) quality system of Fontys University and is presented schematically in figure 1 below.

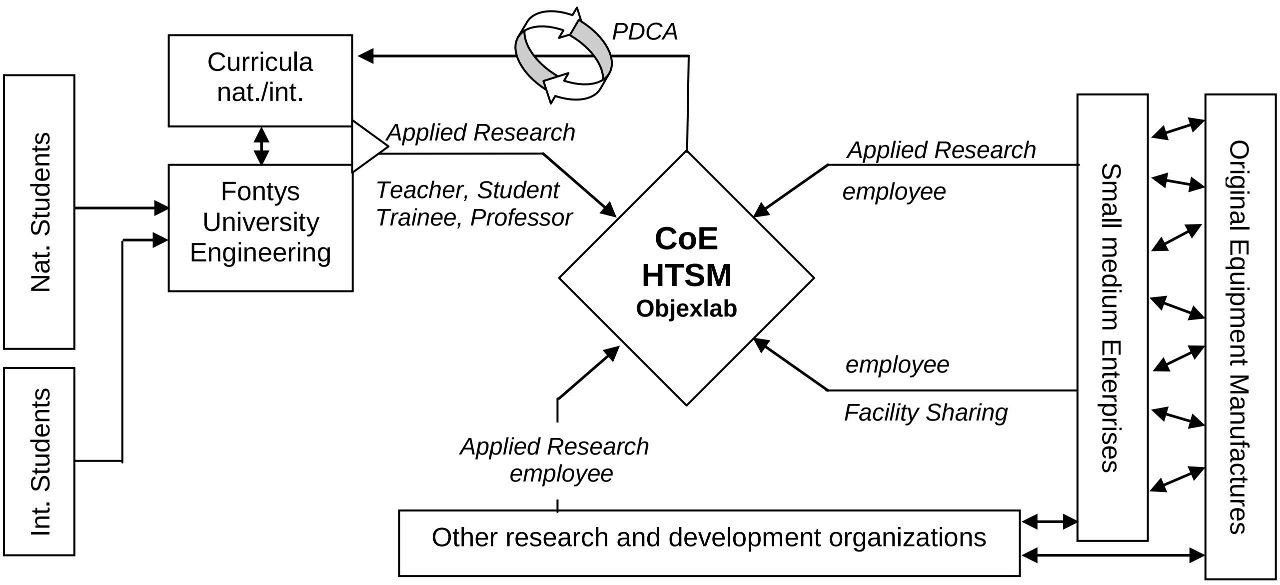


*Fig. 1.* Schematic overview business/research model

## 1.4 Method and way of working

As mentioned earlier, setting up a Centre of Expertise with almost no experience is not trivial. We started with a focus group. After a few meetings it was clear that we needed advice from more experienced and qualified people especially from entrepreneurs and business developers to start a value network of interesting companies willing to participate in and support the idea of a Centre of Expertise. The Dutch government was willing to support us with two (2) external advisors [5]. Together with the focus group and the external advisors we started our journey to find out what the industry needs when it comes to engineering education and human capital and how we could start a sustainable and structural partnership. First of all we started by taking interviews of key players in the industry (sector, OEM and SME). This gave us information about the mission, vision and the short term activities of the companies written in different roadmaps.

## 1.5 Focus points

After studying and aligning the roadmaps and analysing the interviews we found the common needs and focus points of the regional industry for the coming two to three years. These common focus points are: systems engineering, project management, communication skills, multidisciplinary projects, international collaboration and cultural aspects.

Most of the focus points could be gathered under the term non-technical or soft skills. Just to be clear here. From the interviews and roadmaps we clearly understand that the engineer of the future need the basic technical skills. It is not that we should replace the basic technical skills with non-technical skills. Due to the changes and demands as mentioned earlier, companies prefer a future engineer with a T-shaped competence and skill set as presented in figure 2 [6].

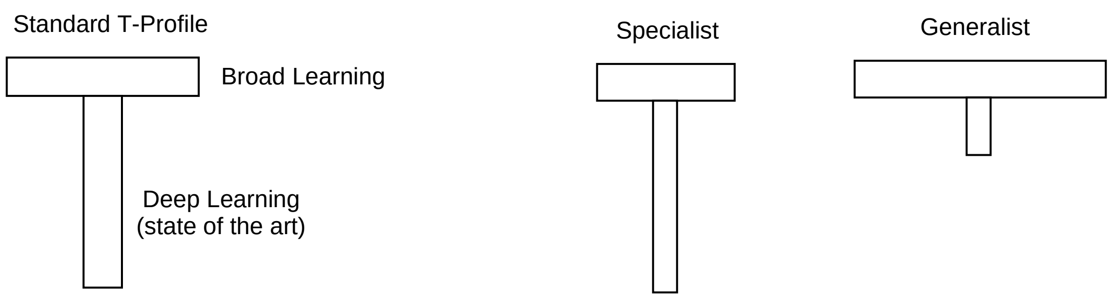


*Fig. 2.* T-shaped competence and skill set

The companies which we interviewed are all active on the international market. Due to lack of qualified personnel (human capital) most companies have foreign knowledge workers on their pay roll. Our research team took two (2) focus points and started a small experiment. The next chapters will go deeper into this research on how to implement non-technical skills by means of applied research and understand international aspects of collaboration.

## 1.6 First experiences and lessons learned

Because we use the PDCA quality circle the focus team evaluated the results of setting up a new centre of expertise and starting to build a value network of partners to achieve the earlier mentioned goals. We learned that it is not possible to start a new organization without the knowledge of business development and entrepreneurship. What we also learned is that the most professors and lecturers are not used to work on projects like these. Companies are organized differently and have another way of working. The dynamics and fast cycle times, project management and collaboration skills are different then what we are used in the university. What we can conclude from all this is that the university has to change and should be organised like a commercial company to keep the pace of developments. The university should invest not only in our future engineers but also in our professional workforce. What is even more important is a change in attitude and mind-set towards emerging technologies and developments.

# 2 EMBEDDING NON-TECHNICAL SKILLS IN ENGINEERING EDUCATION THROUGH APPLIED RESEARCH.

## 2.1 Introduction

As mentioned before, even though the need for engineers is growing, there are still more engineers than jobs available on the market. To stand out from a crowd with similar technical education and backgrounds one needs to draw attention of employers in a different way. What tools can our education provide to students to improve their position on the labor market and especially in the engineering field?

Scientific research and popular websites like Forbes are trying to find the ultimate formula for the employer skill-sets of 2014. Because of the enormous amounts of competences and skills being researched to find out their impact on job opportunities, it is hard to find out what really matters. One thing is becoming clearer: soft skills matter! Nearly every study finds that the era of focusing on facts and knowledge is over. The new skill is to find our way through the web of data and use skills to get to the information or product we are looking for.

One of the skills or skill sets to take us further are personal skills. Especially when it comes to finding a first job, a starting engineer often needs to dig in a whole different area than he is used to. They need to focus on who they are, not only what they learned. The problem is, during their four years of study, they are so busy with learning for their exams, they forget or don't have time left to develop themselves as persons. They lose focus on themselves and forget what they like because of what they have to do to receive their study points (ECTS).

At Fontys University of Applied Sciences we give third year international students the opportunity to spend time to concentrate and develop their strongest selling point for the starters: *themselves*. We even reserved ECTS in our curriculum because we are convinced that developing one's personality is part of our education purposes. Educating young engineers how to profile themselves and stand out from the crowd is at least as important as teaching them mathematics and dynamics, especially in times of economic crisis. That is why in our education at Fontys Engineering, we also pay attention to non-technical skills like communication, project management, cultural tolerance and much more to give our engineering students non-technical tools to benefit their own non-technical potential as engineers of the future.

## 2.2 Introducing the WORT module

At Fontys University of Applied Sciences we like to challenge our students to work on their workplace readiness skills and to answer to the requirements of nowadays employers: young professionals who are ready to participate in their existing teams. This requires professional and personal skills like flexibility, fast learning, efficiency, productivity and more. We introduced the module *Work field Orientation (WORT)* where students research the topic of non-technical skills to practice their research skills and at the same time practice and become more aware of non-technical skills. The purpose of this module is to broaden awareness about the non-technical skills useful at the start of their careers in the near future. It is inspired by Workplace Readiness Skills [7].

As mentioned earlier, literature states an enormous amount of non-technical skills. For practical reasons we divide these skills into two classes: personal skills and project management skills.

- Personal skills: taking initiative, social skills, application, imagery, competitiveness, flexibility, productivity, positive work ethics, professional ethics, speaking and listening skills, reading and writing, critical thinking, problem solving skills, creativity, ingenuity, (nonverbal) communication, self-reflection.
- Project management skills: planning, teamwork, diversity awareness, cultural tolerance, reasoning/problem solving, qualitative and quantitative research, analytical skills.

We are aware this classification is a rough and general one and that in practice these skills are interrelated as well. Moreover we understand this list is not exhaustive but it gives an idea of what lies ahead of us to focus and embed in our curriculum. Our first challenge was to find a method to embed as much personal and project management skills in our Engineering curriculum in a natural way that interests the engineering student.

## 2.3 Method

We developed a practical 1 ECTS module as a way to invite students to create awareness and at the same time practice their non-technical skills through doing desk research and field research on the topic 'non-technical skills' itself. The students were introduced to qualitative data collection (desk research) and quantitative data collection (questionnaires). Topic of the data collection: the importance of non-technical skills for starting engineers.

## 2.4 Participants

101 semester 7 regular and exchange and students from various different countries: China, Indonesia, Brazil and European countries were taking this 10 weeks course from November 2013 until January 2014.

## 2.5 Goals of the module

The goals of this modules are threefold. First, we want to teach students to find good and reliable information through desk research on the internet and search engines: how to recognize reliable information of reliability sources, how to use internet search engines and searching databases and how to read scientific articles: grasping the core of the article. Second, we want to create awareness of the importance of non-technical skills for engineers: actively search for information on the topic, discuss the topic in teams to create involvement, awareness and attitude, and discuss the topic in cross-cultural teams to create awareness of cultural influences. Third, we introduce students to personal branding based on the found information: using the knowledge about non-technical skills to stand out from the crowd, reflect on development on own non-technical skills during the module, exploring what the engineering fields ask and expect from starting engineers.

## 2.6 Power of this module

The combination and playful use of the research skills to get more knowledge about the topic is the power of this innovative module. Both skills and knowledge are explored and practiced at the same time. As 'non-technical skills' are the topic of the research, students need to think and discuss about what they are actually researching. This differs this module of most other modules where student get lost in the making of a technical product. The third part is to apply the knowledge and skills on oneself.

First, students execute a desk research to get acquainted with the subject 'non-technical skills' and practice their research skills. They are introduced to several search methods using Google and Google Scholar, a search engine of Fontys and hardcopy papers or articles (found in the Eindhoven library or Mediatheek TU/e). This desk research can be seen as a project because the assignment is done by a multicultural team of students, which provides them a multicultural learning environment to practice intercultural and interpersonal skills. Second, students develop a questionnaire based on findings of the desk researches. Group decisions should be made about: which subjects? Which demographic information? Which research question would you like to answer? What hypotheses are possible? How do we get the answer on our research question? How to analyse the data? Teams will think about these questions and will give their input during class. Based on these sources students wrote an introduction for their final paper about the most important findings. Third, a guest speaker from a job agency – specialized in technical personnel - will explain more about the practical importance of non-technical skills in finding a job. Based on their own (theoretical) research and the practical advices from the guest speaker student wrote a reflection paper and a personal development report on how their current and desired state of their non-technical skills.

## 2.7 Conclusion

In general students are positive about the WORT module as a preparation for internships and career start-up in (regional) companies. Especially the combination of doing research on a new kind of subject than they are used to, working together in a multicultural team and the guest speaker's presentation were seen as positive and valuable to their learning process and education. In their reflection and personal development reports students repeatedly confirmed the importance of non-technical skills for their career leaving us satisfied with the idea that awareness had been created during the module. Especially students who emphasized the switch from being sceptical in the beginning of the course and eventually being quite enthusiastic to find more and more information about the topic gives us more reason to extend and embed this topic more in our engineering education.

During the module, we also found some resistance of some students towards the content of the course. Most heard comment was: ‘the module does not fit in the curriculum as it is not technical’. Another comment was ‘for 1 ECTS we have to do a lot’. There’s something to say for both comments. We understand this module has a different load in topic and effort than most students are used to from previous and other courses, but we are surely seeking to embed and fit the module more into the curriculum and mingle topics with e.g. projects to blend in more smoothly. A third heard comment came from students who already were working in the field. For them the modules was less interesting because they are not really the starting relatively young engineers we focus on in this module.

*What we think of the module*
Certainly this module needs more improvement on defining and refining explanation of the most important topics. The module is now credited with 1 ECTS (28 hours study load) in the curriculum. Taking into account the growing importance of these skills and knowledge gained in this course, we think this course at least deserves consideration to be incorporated at a higher scale in Engineering Education, credited with more that only 1 ECTS. To enable students to not only focus on a detailed scale on engineering skills but lift themselves and each other to a helicopter view on skills and topics that are mostly unseen and go unnoticed but can unintended leave a footprint or influence a situation. It turns out that students have much to learn when it comes to developing a critical and research view on things and especially themselves.

# 3 THE INTERNATIONAL ASPECTS OF COLLABORATION

## 3.1 Introduction

A side effect of collaborating with the industry to develop CoE seems to be attracting more international students and knowledge workers, this gives the collaboration an international aspect. The question is, is it a side effect or is international collaboration an essential part to prosper and remain competitive, and drive economic growth. This paragraph will elaborate in lessons learned concerning the cultural aspects of international collaboration. The lessons learned are perceived by using a theoretical model from Hofstede, the five (5) cultural dimensions and an article on key success factors for international collaboration according to G. Handley.

### 3.2 Theoretical model of Hofstede

One of the ways in which cultures differ is in their underlying value systems. Peoples' values are expressed through what they say and what they do. Therefore people working together from different cultural backgrounds may find that they approach and execute tasks differently because of differences in their cultural values. Too often differences in style are simply seen as problems to be solved (usually by encouraging everyone to work in the same way). Understanding differences in value systems helps us to understand how and why individuals may behave differently to ourselves. This can help us work more effectively together and make the most of the benefits that those differences offer. A number of models have been proposed to explain how the value systems of countries differ. The most frequently cited model is that proposed by Hofstede (Geert Hofstede, 2010). He suggests five fundamental dimensions to national culture.

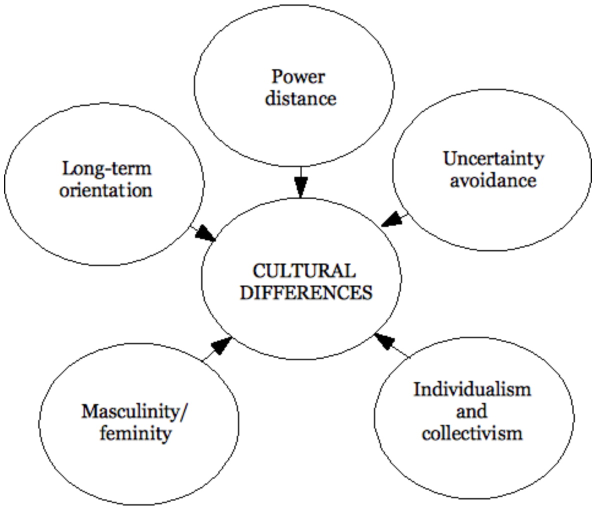


*Fig. 3.* The 5 cultural dimensions (Hofstede 2010)

The 5 dimensions can be summarized as:

*1. Hierarchy* – Hofstede calls this dimension 'power distance'; it relates to the extent to which individuals within a culture accept unequal distribution of power. At one end of this continuum are cultures that value hierarchy. In these cultures, the emphasis is placed on leader status; individuals will expect the team leader to provide direction and make decisions. Individuals within these cultures tend to be accepting of rules and questioning authority may be discouraged.

At the other end of the continuum are cultures that place a lot of emphasis on team involvement, with wide consultation and group decision-making being common. Questioning authority is likely to be accepted or even encouraged in these cultures.

*2. Ambiguity* - This dimension, labelled by Hofstede as 'Uncertainty Avoidance' deals with the degree to which individuals feel comfortable with ambiguity. At one end of the continuum are cultures that encourage risk taking; in these cultures individuals are likely to feel very comfortable trying new and different ways of approaching things. At the other end of the continuum are cultures that place more value on routine, regulation and formality. Individuals in these cultures are likely to prefer tried and tested ways of doing things rather than taking risks with unknown methodologies.

*3. Individualism* - This dimension relates to the extent to which the individual values self-determination. In an individualistic culture people will place a lot of value on individual success and the need to look after oneself. At the other end of the dimension are collectivist cultures in which individuals will place more value on group loyalty and serving the interests of the group.

*4. Achievement-orientation* – Hofstede describes one end of this dimension as masculine and the other end as feminine because it relates to values that have traditionally been associated with gender in western society. A culture at the masculine end of the continuum will be very achievement-oriented, valuing things such as success, achievement and money. At the other end of the continuum are cultures that place more value on aspects such as quality of life, interpersonal harmony and sharing.

*5. Long-term orientation* – This dimension was a later addition to Hofstede's work. At one end of the continuum are cultures that focus on long-term rewards; at the other end are cultures that are more concerned with immediate gain.

The value of Hofstede's framework is that it provides a useful tool for thinking about culture and how values impact upon behaviour. It is interesting to think about where the collaboration sits in view of Hofstede's dimensions. As the values of individuals within the collaboration are likely to be aligned, to some extent, with the values of the organisation, it is likely that for each of Hofstede's dimensions one extreme will be more prevalent within the collaboration than the other, irrespective of the nationality of members. Nevertheless, it is interesting to consider the dominant value systems of the countries that colleagues are based in and to consider how these may impact on their behaviour.

However, perhaps the biggest learning point one can gain from reviewing research into value systems is a better understanding of one's own personal values and how those values impact on the working style and working relationships.

## 3.3 Successful international collaboration

During the annual meeting of the American Association of the Advancement of Science, which took place in Boston February 2013, the workshop called "Responsible Professional Practices in a Changing Research Environment was given by G. Handley (Pain, 2013). G. Handley is the associate director for international research affairs of the National Institute of Allergy and Infectious Diseases at the National Institutes of Health (NIH). He explored international research collaborations and what makes them successful or dooms them to failure. G. Handley recommended 13 principles for successful collaboration. For the purpose of this article 7 of the 13 principles will be researched on.

*Table 1:* 13 principles for successful collaboration (Pain, 2013)

| |
|---|
| 1. Make sure that it is a true collaboration: take into account the missions of the partner organizations; pursue interests that are shared among all investigators and relevant to local needs; verify that there is a good, common understanding of the field among all partners; make sure that everyone involved will benefit. |
| 2. Establish a relationship of trust and openness. It needs to be a two way street so that they will tell you when things don't go well but they also need to trust you to tell them when someone is not doing things well on your side of the collaboration. |
| 3. Seek support from the host government and local community. Otherwise, you may suddenly find that your results are being compromised just because you haven't been engaging all the people that could have an influence on whether this study can go forward |
| 4. Be willing to invest a lot of time, money, and other resources into the collaboration, including travel, building research capacity, and training staff members overseas. Have continues contact. |
| 5. Be prepared to justify to your dean, funding body, and reviewers why you are spending time and money abroad rather than domestically. Keep the stakeholders informed. |
| 6. Effective communication across languages, cultures, and scientific fields can be especially difficult. Some cultural differences, such as how much and how openly woman scientists are empowered to contribute – are very much an issue in some cultures- also need to be appreciated. Hay: course workshop cultural differences. A country that is very rude in this case The Netherlands. In Finland people are less direct. |

7. Depending on the country, be prepared to face a complex and seemingly arbitrarily changing bureaucracy, long delays, and corruption.

## 3.4 Empirical description on international collaboration at Fontys University

At Engineering, a department of Fontys University of applied science, there are different international activities, from strategic to operational activities. What follows now is an empirical description on these activities.

The international office department of Engineering has contacts with international partner universities. The contacts have two targets: one is to acquire exchange students and the other is to enrol international students. There are no significant challenges concerning international collaboration, because the contacts are structural contacts and the activities are operational. The only difficulty of the target is the contact with non EU universities. It is hard to establish the level of education at these type of universities. On paper the level seems adequate but the reality might differ. Point 6 effective communication is a principal that is applicable for this challenge.

The next activity is the contacts between the international universities held by lecturers. These contacts come to exist because of mutual interests between the international universities. The 7 principals all apply to these types of activities. From these 7 principals two of them are a challenge for the involved lecturers. One of the challenges is getting more colleagues interested and motivated to get involved. There are only a couple of lecturers willing to invest in these type of collaboration. Principle 4 is about investment. Moneywise and time wise this has not been an issue on individual level. Getting colleagues motivated is a challenge. The second and major challenge for the lecturers is the lack of a specific strategy formulated for Engineering concerning international collaboration. Principal 4 is again the principal that needs attention. The lack of willingness to commit is coherent with the lack of the strategic choices Engineering makes on this matter.

## 3.5 Conclusion (lesson learned)

The 7 principals for successful collaboration seem to be principals applicable to collaboration on strategic level, with exception of principal 6. Sadly Engineering has no written policy on strategic international collaboration. The fact that there is an informal strategic collaboration is because of the goodwill, of the interest of the individual lecturers. On the other hand, Engineering does facilitate financially these collaboration.

The problems, challenges posed in the previous paragraph can be explained by Hofstede model of 5 cultural dimensions. The first challenge mentioned is knowledge on the level of education at non-EU universities. The difficulty in effective communication is the core of this challenge, principal 6. According to Hofstede working on effective communication is part of dimension 4 *Achievement – orientation*. It is advisable to find out what kind of culture the university displays. Is it masculine or feminine? Knowing what drives the university, is it success, achievement, money or quality of life, interpersonal harmony and sharing, will help the communication process.

The next challenges mentioned is getting colleagues motivated to participate in international collaboration. Principle 4 the willingness to invest is the issue at hand. Mapping this with de dimension of Hofstede one can conclude that dimension 2 *Ambiguity* gives insight in the core of this problem. This dimension deals with the degree to which individuals feel comfortable with ambiguity. Engineering culture is one that values routine, regulation, formality. The unknown of the international collaboration is for the colleagues probably a risk they are not willing (accustomed) to take.

Hofstede 5$^{th}$ dimension is *long-term orientation*. Engineering has the culture of short-term orientation. This agrees with the fact that there is no strategic orientation on international collaboration. Engineering is also an *individualist*, dimension 3. Which means that its primary motivator is Engineering and not the community or the economic growth.

A global college education is increasingly becoming a crucial part of being competitive in today's job market, and international collaboration can help prosper and remain competitive, and drive economic growth. Being competitive is not a luxury but a necessity. The need for a culture that is open for change and innovation is an important factor in successful international collaboration.

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