

## **International collaboration in engineering projects on product innovation.**

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## **1 INTRODUCTION**

The speed of economic life is increasing all the time. The life cycle of the products always gets shorter. Quick development of information technology and general globalization has also left small and medium sized enterprises (SME's) facing international competition. All this makes that there is strong need for new products that succeed each other in an ever-quicker fashion. This is a challenge for businesses. People realize plans and activities for a new product. It means that it is crucial to know which knowledge, skills and attitudes they possess. The unification of Europe has made it easier for companies to work together over borders and cultural regions. In many cases there is also need for cooperation over these borders to strengthen the global competitiveness. The businesses that have their own products need new technical solutions to achieve new products. However, not only the technology is important. It is also important to consider what kind of products is suitable to develop and produce.

To achieve new products there is a need for activities to find ideas, design, to produce the product and to carry out marketing activities. All parts of this chain have to be in place and they have to be produced properly in the right time. The first step in this process is to generate a good idea for a product.

To be competitive in the market the business needs real new products that competitors lack. If the product is technically new, it can be an invention. Even better, if the idea is so new and special, it can be patented. When patented, the company has protection against copying by competitors. The question to answer is how engineers, who are employed by the company, are able to achieve good inventions that can be the base for a competitive and profitable business. The better education and experience they have, the better inventions and products they can achieve.

It is possible to find new solutions that can solve existing problems or fulfill needs. Thus it is possible to produce inventions and still achieve economic benefit from the effort. In the patent register there are plenty of new inventions. Unfortunately a big part of those never comes to a usable phase. Much energy, time and money is lost as a result and it can be argued that a lot of that energy has been lost in vain. It would be better to find ideas, which finally come to widespread use in a market or somewhere else in the society. Only then can we talk about a successful innovation. To be able to do this in effective way an

engineering student needs to know how to use a method on how to proceed. The role of technical universities is crucial. They have to be able to offer suitable knowledge and methods to achieve good ideas and products based on them.

In next paragraphs the phenomenon of what happens when a person tries to find a solution to a problem to make an invention is discussed. It handles the knowledge that is stored in the brain of a person and provides the methods on how to find it out both need to be combined to solve the problem. When a solution has to be found quickly and there is need for diverse knowledge, it is better to have a group of different persons having a different set of knowledge and skills. Additionally these people need to be capable to work efficiently together helping each other to do their best.

There are good possibilities to make good results, if there is available knowledge, mastering of the method and the ability to work in a team. Still practical arrangements like time, place, tools and resources have to be arranged. Beside all of this participating people need to have a will to carry out the new product process. When all earlier mentioned is available, the action can start. It means that people will communicate a lot. It will happen between the participants and with stakeholders outside of the team. When people are close to each other and they are reacting positively each other, the process is progressing well.

The action to find and develop a new product is a creative process. Professor Jorma Tuomaala [1] from department of mechanical engineering in University of Oulu has written about the creativity in design work. He made his life's work mostly as practical designer and the last ten years as professor of mechanical design at Oulu University. His writing deals with the unconscious mind. Main focus is that there are knowledge centers in the brain. They are storages for all the information that a person has received during his/her life. This information consists of very different art of knowledge that has been collected because of all experiences and studies. Collecting and using the knowledge is rather much concerning the communication in and out of the brain. There are methods to activate the subconscious mind and accelerate the phenomenon to find good solutions for any purposes.

Because of a strong communication flow, the communication methods, arrangements and tools have to be available and there has to be skills to use them. This is the more important the more far from each other the partners of the team are locating. Also the cultural differences between team members put demand for understanding about how people appreciate and express different matters. In this connection we can mention the language. If all members don't use same native language, there is danger for difficulties in communication.

Normally a new product process is carried out as a project and so the mastering of time is essential. In that case the preplanning and following of the schedule is important. If the members are first time participating in a new product process, the attitude towards the schedules is perhaps not serious enough.

Development work in a group where are present different kind of members requires good communication. Extra important is it, if the members come from different professional or cultural areas. When people are working in close contact the speaking is primary. It is quick and interactive method. Sometimes drawings are needed, if there is a complicated

issue to be discussed. "One picture tells more than thousand words". Technical matters, schedules etc. are most effective to communicate by way of drawings. Writing is needed in sharing different kind of information like documenting plans, action instructions, reports, etc.

When the members are working in different locations, the modern communication means are used. Such are e.g. e-mails, digital communication software that are used over the Internet and mobile phones. These are handy tools when they are used efficiently. Still one issue is technical reliability. There are differences in software and hardware depending on products, producers, type of technology or technical level. The software can include many different possibilities to transmit information, but you have to be routinized to use them to get efficiently the best benefit of the system. If the use of these communication means is not every day action, there can be difficulties to arrange the physical place like videoconference rooms with cameras and microphones in the right time.

One side of the communication is psychology. It is important to know the personalities of partners. After that the digital and remote communication is much easier. Understanding of the unwritten, unspoken messages is possible and don't cause unnecessary confusions and misunderstandings. In international co-operation the language is an issue. There is need for more time, repetition and multifold mutual checks that the information transmitted is understood, as the sender has meant it. The skills in teamwork, negotiation and presentations are important as well. There has to be communication enough between the members of the group. The same need exists both locally and internationally. That means that there has to be clear scheduling for the communication actions. If people don't meet regularly each others physically or over the digital means, the communication channel is closed. The missing clear scheduling of the communication causes also that people don't know when a certain task has to be ready and presented to the others.

Businesses would like to employ engineers who are able to start, plan and carry out processes that lead to profitable innovations. Because of this the role of universities of technology is important. At universities students are guided to the world of physics, mathematics, technics and only in limited measure to the business life. They don't have experience of the complex world connected to the chain from an idea to market wherefrom the product brings money. Suitable young persons should be trained effectively to carry out processes for inventions, which can lead to innovations. There is obvious need to offer engineer students well prepared circumstances to learn and make practice according to their knowledge and time pressure caused by studies.

## **2 DESCRIPTION OF THE INVENTION PROJECT, WHICH HAS BEEN RESEARCHED**

A joint invention project for second year students from universities of applied sciences in Oulu and Eindhoven has been run in the first half of 2013 for the first time. The goal was to find an invention in an international team of mechanical engineering students and as such the invention needed to be new, producible and inventive. This last element, the 'inventiveness', has proven to be the most problematic requirement. In two groups five students from Oulu and six students from Eindhoven worked together in the invention project during a period from January to May of 2013. The two groups worked towards two possible inventions: the first being a transistor splitter to separate a ground plate made of copper; the second, a steering system for shopping cars. For the start a lecturer from

Eindhoven went to Oulu to start up the student groups in Oulu together with a Finnish colleague. During the project the teachers helped the students with the creativity stage and setting up the communication by means of Adobe Connect Pro, a communications platform provided by Oulu. Students arranged their design activities according to the professional method of professor van de Kroonenberg [3] and chose the final design concept to lead into a prototype. Students did preliminary calculations and made a final design in proper mechanical drawings that were needed to manufacture the prototype. Every Thursday, the project groups met by means through Adobe Connect Pro to discuss the project progress. The teachers held weekly meetings by means of Skype's communication software. Teachers/coaches provided students with advices to find common acceptable agreements. At the end of April students presented their products to an audience. Students in Oulu participated in the presentation through Adobe Connect Pro. The project ended at the first of May 2013.

### **3 DATA GATHERED DURING THE PROJECT CARRIED OUT**

There were three stakeholders in this project: the students from Oulu and Eindhoven, the teachers in Oulu and Eindhoven and eight companies in Oulu and Eindhoven which were interviewed on their perception of educating engineering students in innovation skills. In the beginning of the project it was important to measure the opinion of students regarding their perceptions on innovation, seen as a final stage of developing a meaningful invention. Students filled in a questionnaire in which three main questions were asked: What is your perception of the importance of innovation for industry?; What do you want to learn from the invention project?; What kind of position do you aspire in your future job? The outcome of the questionnaire gave similar results for both groups. Students from Eindhoven as well as those from Oulu have the same opinion: innovation is an important element for companies to improve their business efficiency. Students have stronger doubts if their education gives them sufficient learning elements to professionalize their capabilities on developing innovation. They have a strong belief that they will be confronted in their first job with an innovative product development task. Students said they have too little experience and too few skills in setting up a project for innovating product development. They said they do have enough skills to manufacture prototypes. Students were asked to show their opinion about what they want to learn in the project. They could give three keywords that were typical for what they want to learn and the words were then categorized. The outcome was that students want to learn how to innovate, learn how to work in a team and, especially, how to work in an international team. The students were also asked to give their perception about to what kind of job they aspire. For this question there was not a clear answer. There were no typical professions they clearly preferred. In analyzing the data further, showed they liked the jobs typically related to mechanical engineering. The manager jobs were, to the opinion of the students, not that attractive. It can be concluded that the students that chose to enroll in the project aspired to be a technical executer rather than a manager.

Overall it can be stated that the students who joined this project were well aware that innovation is an important aspect for companies to raise the profitability of a company. Additionally, students stated they are well equipped to do mechanical tasks in the project but they were not that prepared for organizing tasks. Students were eager to learn about how to work and organize an invention project. After the project the students wrote an evaluation on their experiences in the project. Students said they learned a lot from working with students with a different cultural background as well as learning more about

working towards collective decisions when the half of the group is 3000 km away. But they were confronted with the communication about achieving an agreement that was accepted on both sides. They learned to always confirm agreements. Student's opinion is that they learned what it means to have a good project plan and to stick to the project plan in order to manage to achieve a product as it was expected. Students felt that they would need more experience in setting up a meeting and have a structured communication that will lead to constructive development reaching the tasks of the project. In addition to positive feedback, students stated that things were not always functioning properly. The first point of critique was that it is essential for a constructive collaboration in the very beginning to get to know each other in an informal way. Because students cannot physically meet it is important to have proper communication tools. They noted also that, as an improvement, teachers must help them setting up the teams. The Adobe Connect Pro software was seen as a good and helpful aid in setting up communication. Apart from this there is need for a special conference room which was available in Oulu but not for the students in Eindhoven. Also, the students indicated that in an invention project it is of utmost importance that teachers are coaching students in the creativity stage to reach good results. In this project they were confronted with finding their own inventive ideas and it was very difficult for them. In Geraedts [2] this inventiveness is explained more in detail. The same phenomenon came up in the earlier years. The students also had to research the patent databank 'ESPACENET' for which students noticed they needed to have received additional tutoring. Teachers should press students more to strictly follow the milestones of the project plan. Students were urged to hold the line of methodical design for mechanical engineers. They mentioned that it would work better if they could apply a clear protocol on how to use the method effectively and efficiently.

In the regions of Oulu and Eindhoven eight key persons in companies were interviewed to have a better perception what would be needed in educating an engineer to improve the abilities to achieve good innovations in a professional setting. They acted as graduation coaches in companies for students who did their graduation project during the same time the invention project took place. The results showed that the opinions could be categorized into 3 main domains. The subdomains give more specific view of their opinions. These three domains are: the conditions in companies in order to be innovative, what should be the goals of innovation, specific features of persons on innovation development.

1. Conditions in the company
  - a. Company culture need to be changed to have employees to take effort in innovation development.
  - b. Having manpower for this development is needed.
  - c. Work narrowly together with other companies.
2. Goals of innovation
  - a. New products but also new production methods.
  - b. Commercial interesting. See what is needed on the market
3. Features of persons being innovative
  - a. Be expert in your profession.
  - b. Think out of the box, be inventive
  - c. Employee must see the strategy of the company and extract this strategy.
  - d. Future driven.
  - e. Having an own ambition
  - f. Be able to participate in scientific research

- g. Collaborative, being a team player.
- h. Communicative in discussions. Disputing debater and able to convince.
- i. Be able to organise innovative projects

From this information we can extract conditions for this education, and especially for the invention project presented in this paper. 1 Present students with conditions that can raise a company's level of innovation. 2 Show students, especially engineers, that innovations will be successful only if you are able to gain a profit out of it. That is why it is important to include managerial and economic elements in the education directed to new product development. 3 Learn to use the information of patents to achieve better inventions. 4 Students have to know the perception of companies of what they see as capabilities of persons that make them key persons for innovation development. So they see what is needed in proper engineering work beside the technological aspect. Important are also the opinions and experiences of the teachers about the project. In the preparing stage it was hard to harmonize the curriculum in Oulu and Eindhoven. There were major differences in the curricula so it was difficult to find a time trajectory that was suitable to give students the opportunity to collaborate. During the startup it clearly showed that it was important to have a professional conference room. Communication of an entire group by way of only one computer was not optimal. Communication between the two teachers was easier. The creativity stage proved to be most difficult for students. Teachers arranged contact with the patent bureau for advice. This was running quite well. The final ideas of the students were not perfect. They had new ideas but did not always produce a real, inventive product. The process was inventive, the product itself not so much. It was seen that it was hard for students to have contact with each other because the time schedule in the one place didn't enable the students to have time to collaborate properly. At the end the students gave presentations, one group in Eindhoven and the other in Oulu. The quality of this presentation was not up to the standards that should be expected.

What can be learned from the teachers' point of view? Firstly, they have to take a strong position in the project. They have clear perception of what kind of engineers are needed in the companies and know from experience what is required from a young engineer to realize their work in the proper, successful way. On the other hand the teacher is able to see in what way students need to grow to become young professionals. During the execution of the project the teachers kept in contact by Skype on a weekly basis. By way of this communication, they could discuss effectively how the groups were proceeding in their projects. The groups in Eindhoven and Oulu sometimes had different opinions about how they would like to approach the results of the project. After the Adobe Connect Pro-meeting the students often were discussing the inconvenient outcome of the meetings. Because teachers were present during the student's meetings and were also quite aware of what was going wrong during the meetings, they could discuss with each other in what way to overcome the problem in the following meetings. The teachers were getting aware what was really going on behind the scenes in the projects both in Eindhoven and in Oulu. This was seen as strong benefit of the teacher's meetings.

#### **4 DO'S AND DON'T'S STARTING UP AN INTERNATIONAL PROJECT**

This paragraph presents the important do's and don'ts which are worth to take into account when arranging a well functioning international student project. The following issues will be presented: preparing the project, harmonization of mutual educational strategies, declaring the goals and joint activities of the project, international

communication and the resources of the teachers involved.

### 1 Preparing the project

At the very beginning it is important for teachers from each institute to declare which are the important outcomes of the common project and they have to see the benefits of the collaboration. When teachers are motivated to work with colleagues from international universities, it will be much easier to overcome the different challenges. Finding a space in both time schedules, attracting students to the project, finding weekly time for meetings, having enough means for doing the project, organizing proper communication tools, goals of the project, a joint time schedule of activities in the project, organizing collaborations with patent bureaus and attracting regional companies to the project are issues to be organized beforehand.

### 2 Harmonization of mutual educational strategies

Each university has his own strategy in organizing the education. There often is need for an inventive fit to make this possible. Both institutes must make changes in the current curriculum in order to be able to let students find time to communicate with each other and to have enough time to work in the project.

### 3 Declaring the goals and joint activities of the project

It is important that universities see the meaningful contribution of the international project in the teaching of their students. Therefore it is important to organize consultations of the teachers of each participating institute when organizing the project in order to find desirable final decisions for the international collaboration.

### 4 International communications

Setting up an international collaboration proved to be more difficult than one inside an own institute. This is partly caused by cultural differences in communication and by the technology used in communication. In the beginning the students used a simple computer and the Skype software. Very quickly it became clear that this is not the way to carry out professional communication. Student-like chatting is different than communicating professionally in a team.

Also the behavior of the students during the meeting sessions caused problems. It was difficult to make decisions and to know for sure if the other party understood what was the mutual made decision. A protocol for these meeting sessions could be a good way to have better results of the communication and thereby better function of the team members in the project. Teachers need to provide more guidance in such situations.

### 5 Competences of the teachers involved.

Teachers must understand what is needed to achieve good results. They must be able to guide students to find by their own an idea for an invention, in a way that is suitable and interesting for the students. The teachers need to be experts in idea search and in the field of designing products. They must recognize when a project group is running well and when it is not. They must know how to improve collaborations in order to let the students know what they did wrong and how to improve upon their efforts. Students will encounter problems that they cannot solve on their own. The teacher must be able to show how it is done in business practice in order for students to truly say *"Now I know how the procedure of inventive projects should be carried out in the engineering practice"*.

## 5 SUMMARY AND ACKNOWLEDGMENTS

This paper discusses how to educate students of engineering in the skills to run an international project aimed at invention and innovation in the mechanical engineering sector.

The research environment was an invention project realized between the universities of applied sciences in Eindhoven, the Netherlands and in Oulu, Finland. The two universities started a project where two groups of students in Eindhoven and two groups in Oulu performed a research on how to generate two ideas for a product. The students carried out the design project and built up the prototypes over a period of four months. They learned about carrying out an international invention project. The core of the learning and the experience were searching and agreeing together solutions, use of communication methods and tools. Also the experience of the differences in working and behaving cultures were significant.

After the project the students commented on how they had learned about following the schedules and about teamwork in a group locating in different countries. They also noticed that they need more training in project management and in working creatively. They noticed the differences of the working arrangements in different organizations.

The role of teachers in both organizations came up clearly. In close co-operation with each other they can control and help the students to realize a complicated project in which the need for independent, demanding and creative work is present and where the cultural differences influence the outcome.

Parallel to the project a questionnaire among key persons in SMEs was conducted to find out what companies expect from an education to prepare students to work in a product projects. Based on the results obtained from the invention project as described here, a further developed international project will be organized between the two universities.

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