

Train inventive engineers for the future
Invention of new products as a basis for studying the method of innovation
and product development for first year Engineering students.

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INTRODUCTION

These are hard days for companies: they have to survive in a market that has been hit by a financial crisis. Many countries in Europe have severe problems trying to overcome this financial crisis. The main remedy applied by governments is to cut back on expenditure, but on the other hand it is said that it is important for a country, and especially for companies, to invest in innovation. Germany is a country that is doing quite well economically due to their approach, among other aspects. German companies are investing in innovation [1]. There is a difference between creating innovation in big companies and in small-and-medium-sized companies (SMEs) [2]. Big companies have more means for innovation at their disposal and have relatively more highly educated personnel to investigate possibilities for innovative activities. On the other hand, SMEs are more flexible to decide to start an innovation development trajectory. After graduation students of Universities of Applied Sciences often start, their careers in SMEs. These highly educated young professionals in those SMEs should be able to help these companies to investigate possibilities to start up innovations [3]. These innovations should lead to innovative products that will lead to profitability turnovers for these companies and, as a consequence, improve the economic conditions in a country. Universities for their part should be aware of the fact that they educate students to a certain level of the professional practitioner. They provide students with engineering competences with which they can show a higher degree of ability to answer complex questions such as how to become players in the market again with the opportunities the company can afford. Universities should always make inquiries concerning the need for new competences of engineers in companies in the region they deliver starting engineers to. They have to modify their curriculum in order to educate students in these new competences [4], [5: p. 162].

Developing the competence innovation for a curriculum is not as deterministic as developing, for example, the competence using mechanics theory well. Innovation is an umbrella term that can be seen as covering a lot of different activities that can be attached to the product creation process. Innovation is not only the creativity process. This creativity process is followed by a development process and an introduction to the market and the decision-making elements in between. The goal of innovation is to create new or renewed products/processes that will be accepted by the market. Defining an innovation competence

should include all the relevant steps of innovation that make a student see the wide-spread implications of innovation to the companies' abilities of achieving their goals. Technical companies, producing technical products, engineers should be asked to find ways to develop meaningful innovations. It is very tricky for companies, and certainly for SMEs, to invest a substantial amount of money in product innovation, because no one knows what will be the efficiency of this investment. And also the competitor could easily copy the ideas of the company. So this prevents the company from making lighthearted attempts to develop new products. Patent laws protect the inventor, and his company, for his effort in finding and creating inventive products and help him to take the step to dare invest in it. There are three criteria for investigating whether an invention is patentable: 1 The idea needs to be new; nowhere in the world should a similar idea already exist [6, chapter IV-9]. 2 The idea needs to be producible [6, chapter IV-5]. 3 The idea needs to be inventive [6, chapter IV-11]. This last criterion is the most difficult to define, because it's an abstract criterion. EPO (European Patent Office) in their document [6, chapter IV-11.7] gives the so-called problem and solution approach for investigating the inventiveness. In this approach an idea is called inventive if it meets three sub-criteria: 1 Determination of the closest prior art. This means that the idea may not affect or have the same purpose as the closest patented idea. 2 Formulating the objective technical problem. In this second sub-criterion for inventiveness the idea is investigated as to what kind of problems it solves. This is compared with the solving of problems the closest patented idea does. 3 The could-would approach, where the possibility is investigated whether there is knowledge and skills in universities or other schools with which it would be possible for a skilled person to solve the same problem that the new idea wants to solve. The idea is called inventive if the investigations of the three sub-criteria show that there is no way with today's state of the art knowledge and skills to be able to do the same as the new idea.

Teaching students to become more innovative engineers, Fontys University of Applied Sciences, Department of Engineering, has designed a curriculum in which students are educated in the competence innovation. An important element in the process of teaching innovation to students is the approach of inquiring into possibilities of patents for a company to find inventions that give possible profitability's in the market. Fontys University is of the opinion that when teaching students to become innovative professionals it is important for these students to be taught the DOs and the DON'Ts of patents. In the second semester of the first year, students can decide to join an innovative project called: 'The invention project'. The basis of this project is that students are given the opportunity to create their own invention and with their previously acquired knowledge and skills they design, calculate, prototype and present their invention. Students in this project are brought in contact with an expert on patents who will discuss with them the potential of their ideas. This makes students feel that they are doing worthwhile work at University and so they become more motivated. They become more innovative in their approach to finding inventions and that is why, when they have graduated, they can help companies to look for new innovative products that help companies to become more profitable. This project will be up-scaled for higher-year students in the next few years. This invention project is an interesting example of a project for which collaboration with other Universities can be set up.

1 THE INVENTION PROJECT

The Invention Project is an optional project for first-year students of Electrical and Mechanical engineering. About 40% of these students decide to do this project. (About 65% of the Mechanical Engineering students and about 20% of the Electrical Engineering students join this project.) The students are taught how to find ideas and to investigate the patent research databanks (ESPACENET) to see if their idea is really new. A patent expert, from the Dutch patent office, gives guest lectures on what patents are and what their potentials are and their dangers for companies. He will also discuss with students if their ideas are possibly

patentable and thus possible inventions. In this project students are given an impression of the process and content of innovation. The way the project is organised helps them to structure their approach to find and build their own invention.

1.1 Perception of the innovation process in companies

Very often innovations result from creative thinking to find ‘nice’ ideas. Many engineers do not see the complex configuration of innovation. It is very hard to give a solid definition of innovation because it is an umbrella term for activities from finding potential ideas towards the real successful selling of the products on the market and everything that is in between that is needed to come that far. In [5, pp. 25-33] an extended description is given of what is to be seen as the content of innovation. Engineers think that innovation is very closely connected to product innovation. But it is important to be aware that there are possibilities for innovation in other areas, too. In [7] 4 different areas of innovation are distinguished: Product innovation, Process innovation, Market innovation and Organisational innovation. Only about 25% of all innovations are technical. In [7] it says that a technical innovation acquires more potential when it can be connected to one of the other three areas of innovations. It is important to show students this perception that, consequently, for innovation projects it is advisable to set up multidisciplinary teams. To give Engineering students a full perspective of what activities should be included in the innovation process, they are given lectures on perception of innovation using *fig 1*. In this picture of a model for the perception of innovation a number of consecutive steps are shown which need to be explored to have a full perception of what the impact of the possible innovation is. In between there are decisions to be made on how to proceed. Engineers need to be prepared to offer a relevant contribution to this decision-making in companies. In this picture it is also obvious that several disciplines are interacting to achieve a good result. This makes students aware that an engineer on his own is hardly able to realize a total process of innovation. It is obligatory for the engineer to work together with other disciplines.

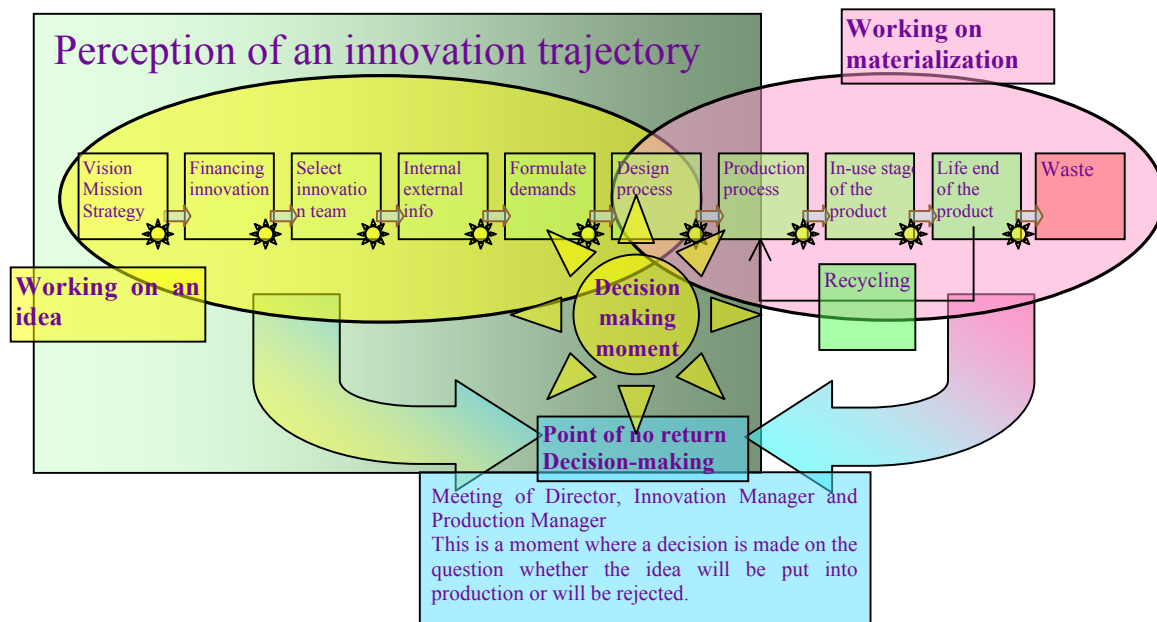


Fig 1: process of innovation

In interviews with companies on their perception of what an innovator could be or must be, most of them, independently, state that for an engineer to become an innovator it is important for him first to be a good engineer in his own field of expertise. Therefore in the Invention Project the knowledge taught in the lectures is strongly related to the development of results. Students need to give arguments, from their disciplinary background, why certain steps are made. Mechanical Engineers need to calculate constructions and their mechanical processes

and Electrical Engineers need to design the electrical features. In the collaboration between Mechanical and Electrical Engineering students, they need to discuss how designs created by the Electrical Engineering students are to be fitted in the construction created by Mechanical Engineering students and the other way around. By showing students the full perception of what is to be seen as the content of innovation they become more aware of the complexity of it all and they will acquire a basic outlook on how to develop innovations in an integrated way, which has been found to be more successful for companies.

1.2 Organisation of the Invention Project

The project starts in the second semester of the first year and ends with a presentation in July. Students are informed about the project in a kick-off session. In this kick-off lecture students see a presentation about innovation and they are shown how the consecutive steps of the project are set up and the goal of the project is explained to them to find and make and present to an audience an invention. Groups are composed of a maximum of 6 students. In each group, students from Mechanical and Electrical Engineering need to collaborate. It is seen as essential that there are at least two students of each discipline in a group, because it is important that two students of the same discipline learn how important it is to help each other. It is also important that students of different disciplines tell each other about their possible contributions to achieve the goal of the project.

For running the project well, a certain number of pre-conditions are given to the students, such as: 1 Students need to make a good plan of approach, 2 The invention needs to be new, makeable and inventive (according to the opinion of the patent expert), 3 Students need to account for their designs in a report, 4 They have to use the engineering design methods of the curriculum, 5 They have to make and test the final result, and 6 They have to present the invention to a audience. The subsequent steps of the project are: 1 Kick-off meeting where they learn what is demanded from them, 2 Creativity stage where they try to find ideas for products for a certain target group, 3 Design stage where they follow the engineering design steps to prepare the idea so that it can be manufactured, 4 Prototype stage where they are really making and testing the invention, and 5 Presentation stage where they present their invention to an audience that has been invited: Students' parents, people from the world of industry and the patent expert mentioned above.

2 RESEARCH LAY-OUT

In a research project, the experiences of students in this Invention Project have been analysed. The goal of this study was to understand what the success factors of this first-year project are and what should be the outline of innovative projects in higher years. The basis of this inquiry is a questionnaire to identify the opinions of students at the start of the project: what is their perception of innovation and of their contribution in the Invention Project. At the start of the project the students give their opinions on: 1 the importance of innovation for companies, 2 the reason why they have decided to do the Invention Project, 3 the student's opinion on his strong and weak points in contributing to in the Invention Project, 4 what the student thinks he will learn and 5 what kind of functions he is aspiring to after graduation. At the end of the project students are asked to fill in the same questionnaire, with questions added about their experiences during the project. In the analysis differences of opinion among students will be seen as indicators, which can be translated to certain success factors for this kind of innovation projects.

3 RESEARCH RESULT

The research was carried out in the spring semester of 2012, from February to July. In total 31 students were involved in this research (27 Mechanical Engineering students and 4 Electrical Engineering students). For each statement in the questionnaire they could select an opinion

varying on a scale of: ‘fully agree’ (5), ‘agree’, ‘in doubt’, ‘don’t agree’ and ‘don’t agree at all’ (1). The weighted average was calculated from the outcome of the opinion of students on a given statement. A high figure (5) shows that students fully agree with the statement and a low figure (1) shows that students do not agree with the statement.

Students were asked to give their opinion on their perception of the importance of innovation for their occupational group. The data clearly showed that there was no significant difference between their opinions at the start and at the end of the project. The average of their scores was 3.4 and the difference between opinions in the several statements at the start and at the end was lower than 0.2. Students have a strong belief that innovation is a driver for companies to stay on course, nowadays, for a healthy profitability.

Students were also asked to give their opinion on what they wanted to learn in the Invention Project. They were given the opportunity to state this in three words. From the total of words used, typical categories were determined. Of course the word ‘innovation’, and related words, were counted the most. But students also indicated that they wanted to learn about: setting up a mechanical design, doing research, working professionally and collaborating, see table 1. Importantly, at the end students state more clearly they have learned how to innovate than they stated in the beginning that they were less able to innovate. In the data on their perception of innovation, working on patents was mentioned 11 times.

Category topics	Counted words at the start	Counted words at the end	Total
Develop innovation	18	27	45
Set up a mechanical design	12	10	22
Doing research	11	11	22
Working professionally	7	13	20
Collaborate	6	6	12
	54	67	121

Table 1: the number of words students mention in a specific category

The data show that students think that learning about innovation is important for becoming a professional in their occupational group.

At the end of the project, students were asked to give their opinion about the set up of the project. Seven topics were presented to the students: 1 the introduction of the project, 2 their own way of organising their work in the project, 3 finding ideas, 4 contact with the patent expert, 5 the design process, 6 the elevator pitch presentation and 7 prototyping. Students were also asked to give their opinion about coaching during the project and to give an overall assessment. In table 2 the outcome is given. The result shows that students are very satisfied about the project. They are less satisfied about the method used for assessing their inventive ideas. This is very relevant because we

<i>Elements of the project</i>	<i>Weighted average</i>
Introduction	3,8
Organisation	3,7
Finding ideas	3,4
Patents used for assess ideas	3,3
Designing the product	3,6
Elevator pitch presentation	3,7
Prototyping	3,8
Coaching	3,6
Total average	3,6

Table 2: evaluation of the project by students

want to give students experiences from the point of view of whether the idea they came up with was patentable. Four sub-statements were formulated for asking students about the

relevance and effectiveness on working with patents: 1 the effectiveness of getting advice from the patent expert, 2 the effect in using the advice on their idea, 3 the effect of using ESPACENET (international Patent databank: <http://www.epo.org/searching/free/espacenet.html>) and 4 the possibilities of using ESPACENET in second-year projects. The conclusion which can be drawn from the data is that students are very satisfied about the contact with the patent expert. This helped them to find ideas that were really patentable, but they were less satisfied about ESPACENET. It was not easy to use.

As a general remark students were asked to give a figure of 1-10 for the quality of the project. They gave the project a 7.1. Of the 31 students 25 said they were proud of their group's results, and 22 of the 31 students said that would use what they learned in this project for projects in the following years.

4 CONCLUSIONS

The results show that there was a high degree of student satisfaction about the Invention Project focused on innovation development. Students see the relevance of this subject to be learned in order to become well-prepared professionals in their occupational group. Students were also satisfied about the opportunity to work on their own invention and to learn all that is involved the total process of creating a new, patentable product. Success factors for this project in the first year of the curriculum were seen: 1 to work on own inventions, 2 development of student's perception of the total product creation process and 3 to make students see the relevance of contacts with real professionals from industry and from the patent office in their own project. Improvements can be made by: 1 helping students more during the creativity stage in the project and 2 to coach them more on the aspect of engineering a successful invention of which they can be proud.

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