

INTEGRATING ENTREPRENEURSHIP IN DBT PROJECT COURSES AT LINKÖPING UNIVERSITY

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ABSTRACT

An example of how entrepreneurship can be integrated into Design-Build-Test (DBT) project courses is presented. The example is taken from the engineering program Applied Physics and Electrical Engineering at Linköping University, where entrepreneurship has been introduced in ten different DBT project courses related to the specializations of the program. The purpose of the entrepreneurship part is that the students shall acquire knowledge and abilities within the general area of entrepreneurship with particular focus on business planning for new ventures. The organization and execution of the entrepreneurship activities are described in detail together with a summary of the experiences from the first year. The results of the entrepreneurship activities within the project courses are positive and will be further developed, with emphasis on the connections between the project ideas and technical contents of the courses.

KEYWORDS

Entrepreneurship, idea development, coaching workshop, design-build-test course, project based learning

INTRODUCTION

Entrepreneurship is today seen as a highly relevant skill to be provided through lifelong learning. Fostering an entrepreneurial mindset as well as providing training and educational activities among people – starting from basic education – will greatly contribute to economic growth. Therefore we see initiatives focusing on promoting entrepreneurship in the European countries growing extensively over the past decade [1, 2]. In this paper we argue that a key research goal in entrepreneurship is explaining the development of venture ideas or – as they are often called – ‘opportunities’ [3]. A key aspect is that entrepreneurial discovery and exploitation are not simply events where the complete venture idea is found. Rather, entrepreneurship is a process that includes the identification, evaluation, elaboration and modification of ideas leading to business emergence [4]. Over the years we have also witnessed a widening of the entrepreneurship concept not just focusing on encouraging new start-ups but other businesslike situations i.e. in the academic system and public sector. The importance of entrepreneurship is also emphasised in the CDIO Syllabus, see [5], where Section 4.2 states a number of aspects of entrepreneurship. The aim of this paper is to present experiences from a pilot study carried out during 2009 where entrepreneurship has been introduced in ten DBT project courses, with

approximately 200 students, within engineering programs at Linköping University. The paper starts by presenting the program and course framework. Then the organization and execution of the entrepreneurship part is described in detail. Finally some observations and conclusions are presented.

PROGRAM CONTEXT

This section gives an overview of the overall program structure and describes the place and role of the project courses in the curriculum of the program

Program structure

Linköping University is one of the four original collaborators in the CDIO Initiative. During the first years of the CDIO Initiative the main efforts were spent on the program Applied Physics and Electrical Engineering Program. Some of the results of these efforts are presented in [6] and [7]. The CDIO ideas have gradually been disseminated to other engineering programs at Linköping University, and some implementation examples are given in [8]. The Applied Physics and Electrical Engineering program is one of the largest engineering programs at Linköping University. It admits 150 students (120 in the regular program and 30 in the international version) each year. In agreement with the Swedish system the nominal time of studies is five years, corresponding to 300 ECTS credits, i.e. 60 ECTS credits/year. The program has a strong emphasis on mathematics, physics, and electrical engineering, and it is considered to be one of the most demanding engineering programs in Sweden. During years four and five the students choose one out of twelve specializations.

Project courses

One main development of the Applied Physics and Electrical Engineering program is that a sequence of DBT project courses has been developed and implemented. The sequence is illustrated in Figure 1, and further details can be found in [6] and [7].

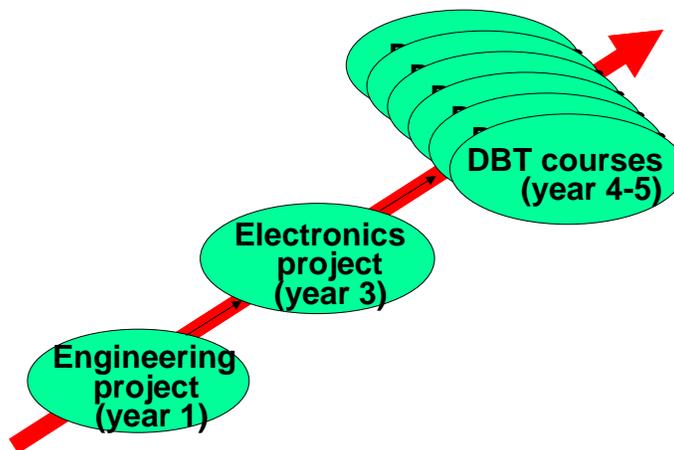


Figure 1. Sequence of project courses in the program.

The third stage in the sequence is a set of courses offered during the fourth and fifth year of the program. The courses are connected to the specializations of the program, and currently ten different courses are offered:

- VLSI design
- Mixed-signal processing system
- System design
- Project – Applied mathematics
- Images and graphics - Project course
- Project course in computational physics
- Design and fabrication of sensor chip
- Automatic control – Project course
- Biomedical engineering – Project course
- Communication systems – Project course

Course structure

All courses involved have the same size, 12 ECTS credits, and the entrepreneurship part corresponds to 3 ECTS credits. The courses run over an entire semester, and the VLSI design course is given during the spring semester of year four, and the other courses run over the fall semester of year five. Even though the courses cover different subjects they have a number of common learning outcomes related to both the expected result of the project and the process needed for reaching the goal. There are also learning outcomes related to the presentation of the results in terms of written and oral communication. It is also specified that the projects are expected to be carried out using the project model LIPS, which has been used in the project courses in year one and year three.

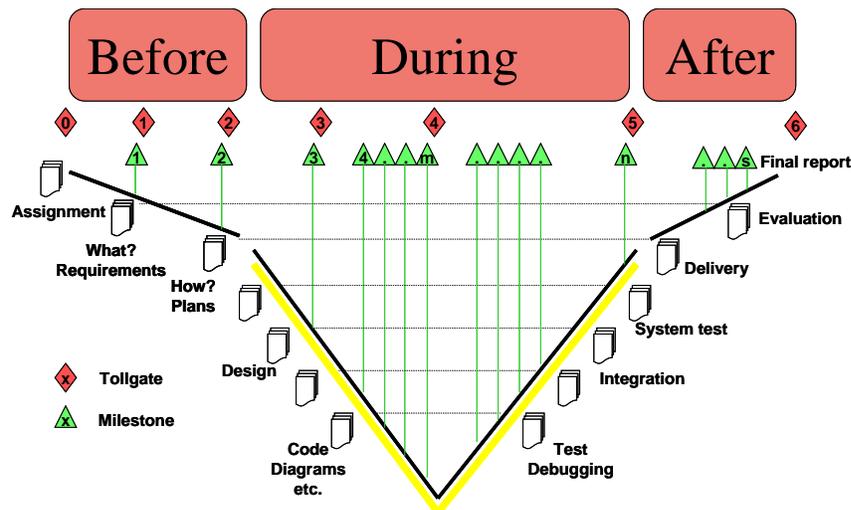


Figure 2. The LIPS project model.

The courses in list above are primarily given for the students within the engineering program Applied Physics and Electrical Engineering, but they are also available for students from other

programs. For example, in the courses within the electronics field the majority of the students are international students following master's programs in this field. This implies that the projects in many cases are carried out in groups of students from different programs and with different background. In some situations this leads to additional challenges, but it can also be a useful experience for the future career.

ENTREPRENEURSHIP EDUCATION AND TRAINING AT LINKÖPING UNIVERSITY

Entrepreneurship education at Linköping University (LiU) dates back to the early 1990s. Since then, a number of courses have been developed which are offered primarily to students at engineering programs, but also to some programs at the Faculty of Arts and Sciences. This organisation of entrepreneurship education reflects the broad perspective on entrepreneurship adopted by LiU. The LiU perspective of 'entrepreneurship' is based on a process view, where the realisation of ideas through venture creation and development is in focus, regardless of whether this takes place within new start-up companies or established organisations (private or public). In this process, we emphasise in particular the need to understand the 'business' side of venture development in terms of creating value for customers/users and other stakeholders and capturing part of that value in order to meet the goals of the new venture, be they economic, social, environmental and/or cultural. Since the beginning of the 1980s, LiU has been a forerunner both when it comes to new spin-off firms and supporting entrepreneurship through various education, training and networking activities. Today LiU has a world class support system including activities dealing with pre-start issues (i.e. inspiration, information and attitude change), start-up (entrepreneurship programs and incubator facilities) and growth programs (development programs and management groups), as well as networking activities for the spin-off firms.

ENTREPRENEURSHIP IN CDIO PROJET COURSES

The purpose of this section is to present the aim and overall structure of the entrepreneurship part and describe how it has been carried out during 2009.

Aims and overall structure

This entrepreneurship part was first introduced during the spring semester 2009 and since then about 200 students (a spring respectively an autumn class) have participated. The overall purpose is for students to acquire knowledge and abilities within the general area of entrepreneurship, and with particular focus on business planning for new ventures. The learning outcomes of the course state that after the course, students should be able to account for:

- and critically discuss models that describe what it takes for a new venture to have a stable basis for further development and to assess the level of development of ventures using such models; and
- the information and analyses needed to evaluate a development project from a business point of view and have the ability to collect and analyse relevant information for that purpose and communicate the results orally and in writing.

A crucial aspect is that the course will inspire the participants to take – whenever it happens – a step into the entrepreneurship world. The entrepreneurship part is structured around plenary

sessions dealing with entrepreneurship and business development issues, e.g. new venture formation, analysing the idea, market analysis and planning, financing, entrepreneurship support structures and intellectual property rights (see Table 1). All the plenary lectures and the recommended course literature give the students a frame and a platform to work from. A written and very basic 'knowledge-test' is executed to briefly check that the students have achieved the learning outcomes. The most important part of the entrepreneurship activities and a major foundation for examination is however a business planning group work. Here, the students are supposed to write a short business plan (maximum 10 OH-slides) based on an 'own' idea. In the end of the course the students orally present the business plan and get direct feedback. The project work is supported by three coaching workshops centred on major themes such as formulating and presenting the idea and estimating the commercial prerequisites and potential for the idea. The organization and implementation of these coaching workshops will be described in the following section.

Table 1
Structure of the entrepreneurship part of the project courses.

Week 1:	Course introduction, guest lecture by an entrepreneur (Presentation of content and participants, formation of groups, workshop instructions and get practical insight from a real case)	2 hrs
Week 3:	The Business Platform (Entrepreneurship and business planning in early stages; the business platform model and its eight cornerstones, case analysis, classifying and judging ideas)	2 hrs
Week 4:	Coaching workshop 1	2+2 hrs
Week 5:	Market analysis and planning (Marketing and selling new ideas; marketing versus selling. Who is the customer? What am I selling? How to sell? Why would someone buy from me?)	2 hrs
Week 6:	Intellectual property rights (How to protect your idea? - patenting and trademark issues)	2 hrs
Week 7:	Analysing new ventures ideas (The venture idea, different type of ideas and consequences for the new venture development process)	2 hrs
Week 11:	Coaching workshop 2	2+2 hrs
Week 13:	Coaching workshop 3	2+2 hrs
Week 15:	Financing and supporting entrepreneurship (The support structure of innovation and entrepreneurship at the university; policy and roles, teaching and training initiatives and financing schemes) Knowledge test Project presentations (groups)	1 hr 1 hr 2+2 hrs

Coaching workshops: organization and implementation

Organization and implementation

The project coaching during the first year was organized in the form of three thematic workshops, each lasting one hour. The workshops were given for groups of 4-5 project groups (i.e. about 20-25 students). In the first year, a total of 30 project groups participated in the workshops, which implies that each workshop was repeated two times in the spring semester and four times in the fall semester.

The main idea was that the coaching workshops should allow students to develop their final presentations step-by-step. For each workshop, they should prepare a set of transparencies that, towards the end of the course, could be combined to form the final presentation. The content and organization of each workshop will be described more in detail in the following.

Coaching 1:

The purpose of the first coaching workshop was to introduce the students to the entrepreneurship project assignment, help them form project groups and make sure each group had formulated an idea to work with during the project.

The workshop started with a brief introduction to the project task and the intended outcome, which, as described above, was a set of 10 overhead slides describing their venture idea and its commercial viability, which should be presented at the end of the course. The students were also introduced to the overall coaching idea, i.e. that the coaching workshops and the preparations for them would help them develop their presentations in a step-by-step fashion.

The students were then asked to form groups of 5-6 students. They were expected to work in basically the same groups as in the technical part of the project course. Next, the formed project groups were given the task to generate a venture idea that they would work with during the entrepreneurship project. Most groups were expected to work with their technical projects, but as it was evident that some of the projects were not suitable as business projects (for example some within Applied Mathematics), the students had an option to choose other ideas as well. The project groups were then allowed some time to prepare a 2-3 minutes "pitch" of their ideas, i.e. a brief presentation of the idea including a description of the main product (or service), the intended customers and the main customer benefit of the product. All groups had to present their pitch orally in front of the other students, after which they received feedback and questions from the coach and their fellow students.

Finally, the project groups were given "homework" to complete for the next coaching workshop. Their task for coaching two was to formulate and present their idea in the form of three transparencies that answered the questions outlined in Table 2, i.e. basically an extension of the first pitch with the addition of the issue of their own driving forces with regards to the project.

Table 2
Homework for coaching workshop 2 (original course design)

1. Describe the idea	<ul style="list-style-type: none">• What is new with the idea (“state-of-the-art”)• Are there any substitutes?• What about competition?• Formulate your idea in two sentences!
2. Who could benefit from the idea (i.e. customers)?	<ul style="list-style-type: none">• What is the content of the offer?• Which customer ‘problem’ could the idea solve?• Who could the first reference customer be?• What about competition?
3. What is your driving force behind the venture?	<ul style="list-style-type: none">• What is your way of commercializing the idea (a new firm or other way)?• How do you see your role as entrepreneurs?• What are your current goals for the project?
4. Are there any specific issues (problems) that must be dealt with to make progress when developing the idea further?	

Coaching 2:

The purpose of the second coaching workshop was to develop the venture ideas further along the same dimensions as the first idea pitch developed during coaching 1. The workshop was organized as a presentation seminar, where all groups got about 10 minutes each to present their venture ideas, including comments and questions from the coach and their fellow students. Due to the strict time limitation, the use of computer presentations was banned and all groups had to bring their presentations with them on transparencies. After the presentations, the main common problems and questions raised during the presentations were summed up by the coach, who also introduced the homework for coaching workshop 3. This consisted of preparing yet another set of transparencies, this time focusing on questions related to the market potential and commercialization of the venture idea (see Table 3).

Table 3
Homework for coaching workshop 3 (original course design)

1. Estimate the market through a simple market survey	<ul style="list-style-type: none"> • What market information did you get? • What is the market potential?
2. Describe the market and the primary target customer segment	<ul style="list-style-type: none"> • Draw a product/market matrix! • What is the customer value? • How could your offer be developed into a product?
3. Try to get feedback from potential customers!	<ul style="list-style-type: none"> • What feedback did you get? • Consequences?
4. Which exploitation model is suitable for commercializing the idea?	<ul style="list-style-type: none"> • Get patent? • Sell a license? Start a new firm? Continue to develop the idea within an established company?
5. Will the chosen exploitation model require any co-operation with, e.g., industrial partners?	
6. In what way will you as researchers/entrepreneurs be involved in the further development of the idea?	
7. Are there any specific issues (problems) that must be dealt with to make progress at this stage?	

Coaching 3:

The purpose of the third coaching workshop was to discuss issues related to market and commercialization strategy. For each part of the analysis (the market survey, the market segmentation and/or product/market matrix or the exploitation model), the coach let one or two project groups volunteer to present what they had done with respect to that part. In that way, all groups got to present some of their work and all parts were covered, but without too much overlap between presentations. This outline also allowed students the opportunity to choose either to present the strong parts of their analysis (for others to learn from), or to raise issues for discussion they themselves had found difficult to handle (to further their own work). Towards the end of the workshop, the coach summarized the main common issues to consider before the final presentation and reminded students of the presentation guidelines.

REFLECTIONS ON EXPERIENCES FROM THE FIRST-YEAR COACHING WORKSHOPS

A lot of experiences have been gathered from the coaching workshops during the first year and the most important ones will be discussed in this section.

Workshop organization and implementation

In the first year, we came to realize that the second coaching workshop did not work as intended. The students had already described the product and the customer benefit in the first workshop and found it difficult to elaborate on the questions about competition without having an understanding of the market (one of the topics for workshop 3). Thus, they did not do much work between the first and the second coaching workshop, which reduced the value of the second workshop and also left the students with too much work for the third workshop and the final presentation.

For the second year, we therefore changed the workshop agendas. The first two coaching workshops are now dedicated to product and market issues, with two main tasks for the students. The first task is to formulate the idea in two sentences, answering four questions: What is the content of the offer? What is new with the idea? Who could benefit from the idea? Which customer 'problem' could the idea solve? The second task is to describe the market for the idea and develop a market strategy. This task includes estimating the market size and potential through a simple market survey, describing the market in terms of customer segments, selecting a primary target market using a product/market matrix, identifying a potential first reference customer, identifying substitutes and competitors and discussing how the offer could be developed into a differentiated product that delivers value to target customers. In the first workshop, students quite naturally focus on the first task and make a preliminary formulation of their idea, which they work further on and refine before the second workshop. The market analysis is presented and discussed at the second workshop.

The third workshop is dedicated to the issue of commercialization strategy. Students are asked to discuss (i) which exploitation model is suitable for commercialization of the idea; (ii) what type of co-operation is needed to implement the chosen model, what the incentives are for potential partners to co-operate and how a potential co-operation could work; and (iii) how the students as entrepreneurs will be involved in the further development of their idea and what their current goals are for the project.

At the time of writing, the new outline has just been implemented and we cannot therefore assess the outcome yet, but we believe that the more evenly distributed workload will allow students to advance the development of their venture ideas further

Student participation and commitment

The level of ambition and commitment to the task differed between the project groups, which also affected the workshops. Workshops in which most project groups were well-prepared and committed to participate actively of course became much more dynamic and contributed more to student learning than workshops in which most project groups had not done their home-work or remained silent for other reasons. To some extent, this was related to the issue of workshop organization as described above – since students felt that they did not have to do that much between the first and the second workshops, some of them seem to have decided not to take the assignment very seriously. However, it was also a matter of internal driving force; a number of groups went beyond the given task for the second workshop and had already begun to

analyse the market. How such driving force can be stimulated and, in an ideal world spread, between groups is an interesting question for future courses.

Here, the workshop format can actually provide an advantage over more traditional project group coaching. In one of the workshop groups, one group had hardly prepared at all for the second workshop. This became evident as it presented its work, which could best be described as sloppy. It stood quite clear that the students in this group had not taken the assignment seriously but were rather trying to make fun of it. However, before the workshop coach even got the chance to say something about it, the other students started asking very critical questions that made it clear to the group that they had rather made fools of themselves than of the assignment. Thus, some kind of 'peer pressure' emerged, which stimulated the group to prepare much better (actually among the best) for the third workshop, perhaps to redeem themselves in the eyes of their fellow students.

Coordination with the technical project

As described above, the original idea of the entrepreneurship project was that students should work in the same groups as in the technical project and with the same ideas, in order to integrate the business and technology sides of the project. The first part of these expectations was met: with few exceptions, students chose to stay in the same groups. However, when given the opportunity to choose ideas freely, none of the project groups chose to pursue their technical project ideas also in the entrepreneurship project. Instead, a large variety of other venture ideas were generated. These included, for example, a new high-quality HDTV concept, a laundry delivery service, a car-pooling internet service, a bug trap, a solar energy system and bicycle tracking system. Few of the ideas were related to the students' main area of study.

In hindsight, students commented that they felt that it would have been better if the projects had been more closely related to their program and future career opportunities, but they did not provide any explanation of why, then, they had not chosen to pursue their technical project ideas. One reason may be that the technical projects, which were provided by the staff of each project course, had been selected primarily based on technical merits and without much consideration of business potential. Perhaps this made it difficult for the students to see how they could develop a sustainable business venture based on these ideas. Another reason could be that students thought that it would be easier to develop a venture based on a rather simple product or service than developing their technical project ideas, especially considering that they did not have any previous experience of entrepreneurship.

Mandatory versus elective entrepreneurship education for engineering student

Our previous experience of entrepreneurship education for engineering students primarily concerns elective courses, i.e. courses that students at our engineering programs may include in their program curriculum if they want to. By contrast, in this case the entrepreneurship is part of a mandatory course. This implies that the students who take the course are not necessarily very interested in entrepreneurship issues, which might explain differences in driving force as describe above. Moreover, the students are more heterogeneous than students in elective entrepreneurship courses with respect to their ability and readiness to present and promote themselves and their ideas; in elective courses there is a form of "self-selection" of students in that only those who feel reasonably comfortable with oral presentations etc. will choose courses in which such activities are required This is of course both a strength and a weakness of mandatory courses – on the one hand the average student is probably less interested in the topic and probably starts from a lower level in terms of competences and abilities, but on the

other hand the self-selection bias is overcome and, thus, more students are given the chance to try on a new subject and improve their abilities so that they in the future may feel more comfortable with the idea of pursuing further entrepreneurship education or perhaps even a career in entrepreneurship.

GENERAL OBSERVATIONS AND CONCLUSIONS

In this section some observations and conclusions will be summarized from student, faculty member, and program management perspective.

Observations from student perspective

Since a number of years Linköping University uses a web based system for evaluation of courses. It is not mandatory for the students to fill in the course evaluation, which implies that the response rates can be different for different courses, depending on where in the program the courses appear. In the setting of the courses that was used during 2009, i.e. to let the entrepreneurship be a part of the project course, the course evaluation system does not allow a separate evaluation of that particular part, and instead an overall grade was given. The students grade various aspects of the quality of the course using a scale from 1 to 5, where 5 is the highest grade. For 2009 the following overall grades were given:

- VLSI design: 4.8
- Mixed-signal processing system: 4.6
- System design: 4.1
- Project – Applied mathematics: 2.8
- Images and graphics - Project course: 4.2
- Project course in computational physics: 4.0
- Design and fabrication of sensor chip: 3.6
- Automatic control – Project course: 4.3
- Biomedical engineering – Project course: 3.8

(The project course in Communication Systems was not given during 2009.) As can be seen the grades are high in most of the cases. In general, a grade 4.2 and higher is considered to be very good, and such a grade also leads to that the examiner for the course receives a letter of recognition from the Dean. In the project course in Applied mathematics, which got a rather low grade, about half of the students belonged to a master's program in mathematics. For them the project course format and entrepreneurship was not found to be so relevant for their education. This is an example where there are disadvantages having students with too different background in the same course. In addition to grading the course from different perspectives the students have possibility to write comments on the course. Concerning the entrepreneurship part both positive and negative comments could be found. Positive and encouraging comments were also given spontaneously directly or via e-mail to the faculty members responsible for this part of the course. Several students found this part interesting and relevant for the education. The comments concerning things to improve were mainly about that the students would like to have a stronger connection between the technical contents of the course and the idea to evaluate in the entrepreneurship part, and that the credits for the entrepreneurship were somewhat "easier" to obtain than the ones for the technical part. Some improvements concerning the scheduling were also suggested.

Observations from faculty perspective

The main observations from the perspective of the faculty members that have been responsible for the entrepreneurship part are the following.

- (1) It's possible with rather small resources to implement entrepreneurship education for students who normally would not choose to participate in such courses.
- (2) Bridging attitude gap – i.e. convincing students that entrepreneurial skills will be needed in their future careers as engineers (e.g. in development projects in larger companies or as a team member as a start-up company) – is necessary to get the students “on the hook” and increase their commitment. This should preferably be done before the course starts.
- (3) Course content and organization has to be adapted to the students' prior knowledge, which in this case implies a practical, hands-on perspective rather than a theoretical approach.

Observations from program management perspective

In terms of number of credits the integration of the entrepreneurship part into the program is a minor change, but in terms of number of courses and faculty members involved it is a non-trivial task. Meetings with the faculty members responsible for the various courses have been arranged in order to inform about the new ideas and motivate the role of entrepreneurship in an engineering program. These meetings were arranged rather long time before the actual execution of the courses, and one observation from 2009 is that it would be valuable to have such a meeting in close connection with the execution of the course. It is also important to arrange such meetings after the courses have been finished in order to collect experiences and discuss possible improvements. One important aspect for the overall success is whether the examiners of the courses have their own experiences of entrepreneurship. When this is the case it also has a positive influence on the attitudes of the students.

Another important practical issue from program management perspective is the scheduling of the various courses. During the fall semester of 2009 eight courses ran in parallel, and the lectures, coaching sessions and other activities related to the entrepreneurship part had to be scheduled in a way that suited these eight courses. This worked out well, but the complexity of the task shall not be underestimated.

A positive consequence is also that the work has encouraged cross disciplinary contacts between faculty member from different engineering fields and faculty members specialized in the entrepreneurship area.

Conclusions

The main conclusions from can be summarized as follows:

- It is possible to integrate entrepreneurship in courses of mainly technical character.
- The success of implementing entrepreneurship is due to several factors such as e.g. practical orientation of the learning activities. The learning activities have to be designed based on the fact that the most of the students have no, or very limited, experience of the field before the course.
- It is important to motivate the students as well as the faculty members that entrepreneurship is important for engineers, to present examples of successful entrepreneurs as role models, and work for a creative and positive atmosphere in the student group.

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Biographical Information

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