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Understanding and Evaluating a Business Case and Improving Interdisciplinary Competences among Bachelor of Engineering Students

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ABSTRACT

Being able to prepare and analyze a business case is relevant for most engineers. The engineer’s technical knowledge cannot stand alone, and must be combined with financial considerations. Therefore, interdisciplinary competences are necessary [7-9].

A business case tool was developed in order to analyze and evaluate the financial aspects of a business case. The tool was used for different engineering programs with different types of business cases. In order to ensure relevance for each engineering program the cases were developed in cooperation with the program directors.

During the development phase of the business case tool special attention was paid to user friendliness, the use of traditional economics theory and the possibility of illustrating practical use and understanding of the economics theory.

The development was an iterative process. The first versions of the business case tool were tested and optimized in cooperation with experts with different perspectives and competences.
The four hour workshop starts with a short introduction to basic economics theory and the business case tool. The duration of the introduction depends on the extent and level of the economics prerequisite of the specific engineering program.

During our workshops, we have documented that the tool can be successfully used within most engineering programs. With a limited teaching effort of four hours, it is possible to give engineering students with varying economic prerequisites a good understanding of the business case and how to analyze and evaluate a business case.

Data collection takes place during spring/summer 2019 and will be analyzed and presented at the conference.

1 INTRODUCTION
The aim of this paper is to describe our work and experiences with designing and arranging workshops introducing all DTU Diplom students to the economics tool: The business case. Data from an e-learning workshop mid July will be analyzed and presented at the conference.

2 BACKGROUND
In the companies where our graduates will be working after finishing their education, the single most decisive factor for whether a project will be started or not is how profitable the project is. This is valid for most kind of projects whether it relates to new products, new production processes or other kinds of process improvements. Therefore, being able to analyze and document that there is a business case for the new product, production process etc., is a very important skill for our engineers. DTU Diplom will be offering all students to obtain that skill by participating in business case workshops.

Furthermore, at DTU Diplom business understanding and economics are considered one out of seven constituent elements, which all engineering students should be able to apply after completing their studies. This ensures that the business case activities receive managements support and involvement.

Since 2010 the engineering programs at DTU Diplom have been based on the educational framework CDIO (Conceive-Design-Implement-Operate) [5] and a typical semester for the 10 different engineering programs consists of three to four individual courses (20 ECTS-points in total) as well as an interdisciplinary semester project (10 ECTS-points) where the students apply the knowledge obtained in the individual courses. The semester projects most often are a CDIO Design Build project.
The extent and level of economics course requirements varies among the different engineering programs. Some programs have two to three separate economics classes of 5 ECTS-points each in addition to applying economics concepts in the semester projects as well. Other programs have almost no economics course at all. This makes it necessary to include a short module in the workshop introducing the most necessary basic investment and cost theories, for some of the engineering programs.

By participating in the workshops, the students will be able to use and understand the concept of the business case as well as what companies can obtain by using this structured way to evaluate and choose among different investment projects. The students will have an important tool that can be used in upcoming projects at both DTU Diplom and in the companies after completing their education.

3 GENERAL METHOD

It was our experience that the students at DTU Diplom needed a simple tool for evaluating the profitability of business cases in their semester projects and bachelor projects. We therefore decided to develop this tool.

During the development process, we asked users from the industry with different skills to test the tool in order to improve it further.

When the tool was ready, we wanted to give the students an opportunity to learn about the tool so they would use it in their projects afterwards.

In cooperation with the management at DTU Diplom we decided to implement a workshop for the students at all engineering programs

In order to ensure the greatest outcome for the students we produced course and learning objectives for the workshop:

General course objectives for the workshop:

The students must demonstrate the ability to

- Use the business case tool in order to evaluate the financial consequences of a business case and carry out a financial risk evaluation.
- Present the results of the business case for a decision maker.

Learning objectives:

The student who has met the objectives of the course will be able to

- Identify relevant data for a business case.
- Use the business case tool in order to evaluate the financial consequences of the business case.
• Identify which assumptions that are highly critical for the results of the business case.
• Carry out a risk evaluation on the highly critical assumptions.
• Present a recommendation to the target group based on the business case.

The first two workshops were conducted as pilot workshops in order to achieve experience and to further improve the tool and workshop. The students targeted in the pilot workshops were from the Global Business Engineering Program and the Production Engineering Program. Until now, the workshops have been completed at 5 of the engineering programs at DTU Diplom, and will in the near future be offered to the remaining engineering programs. The business cases are adapted to the specific engineering programs and the results of the workshops in the spring and summer 2019 has been collected and analyzed.

4 THE BUSINESS CASE TOOL

The business case tool is based on Excel. The tool includes a short description of the investment project, critical assumptions, risk evaluation etc.

The students must further add the following input data for each year during the project lifetime into the tool:

• Investment costs.
• Net payments from revenue, variable costs, fixed costs, other incomes and other costs.
• Discount rate.

Based on the input data the tool calculates Simple Payback Time, Dynamic Payback Time, Net Present Value (NPV), and Internal Rate of Return (IRR) of the investment [1][6].

5 THE WORKSHOP

During the workshop, groups of students are working on a business case adapted to their engineering program. The duration of the workshop is four hours.

The workshop is adjusted to the qualifications of the students from the specific engineering program.

For those who have no or only very limited economics knowledge there will be a general introduction to basic economics theory. It will last for approximately 35 minutes and will include the following subjects [1]:

• Understanding of costs and income with focus on the distinction between variable and fixed costs and between cash flow and cost/income.
• Sunk costs and incremental costs.
• Methods for evaluation of the profitability of an investment.

For all engineering programs there will be an introduction to the business case tool (approximately 10 minutes) and a presentation of the specific case (approximately 15 minutes).

Each business case includes a “six steps recipe” which the students must follow during their work. These six steps are the following:

1. A brief description of the project including the suggested solutions.
2. Identify gains and losses related to the suggested solution.
3. Consider how it is possible to monetize the pros and cons.
   a. Which information/data do you need?
   b. How can this information be obtained at the company?
4. Estimate the value of these pros and cons.
5. Identify the most important assumptions and make a risk analysis (most likely, best case and worst case).
6. Complete the business case

The students are working on the business cases in groups, with the lecturer acting as a supervisor. The students must identify relevant data, understand the criticality of the assumptions they use for the evaluation of the business cases, and carry out risk evaluations on the highly critical assumptions by adding different scenarios into the business case tool.

Each group presents their results for all the students in plenum for approximately 30 minutes.

The workshop is also conducted in a mandatory course for Bachelor of Engineering students called Innovation Pilot. The outline for the course is that the students work in multidisciplinary teams with specific real-life challenges offered by the involved companies. The company is the problem owner and the students should involve the context reality of the company in solving the challenges. The students are responsible for finding ways to apply their unique skills and knowledge to create value in the projects.

As there are no traditional lectures in the Innovation Pilot course the business case workshop was developed as an e-learning program. The program consists of 5 videos:

Video 1: An introduction to the workshop
Video 2: A general introduction to investment theory and some basic economics
Video 3: A presentation of the business case tool and an introduction to the 6 steps recipe that should be followed in order to make a business case
Video 4: An introduction to the case the students should work with
Video 5: A discussion of the solution to the case

A Delphi survey [3] has been conducted and both the method and the results will be presented in part 7 and 8 in this paper.

6 DEVELOPMENT OF BUSINESS CASES

The hypothesis was that it is important to adapt the business case to each engineering program in order to ensure the relevance for the students at the specific program.

The first two workshops were conducted as pilot workshops. The students were from the Global Business Engineering Program and the Production Engineering Program. We prepared two different cases, one for each of the two engineering programs. Our hypothesis about adapted cases was correct. It turned out that the students from the two programs had quite different approaches to solving the exercises because their focus and competences were within different areas. The students from the Production Engineering Program rapidly was asking for additional information regarding Operations Management issues, such as whether or not the production process is a bottleneck, or details to the process flow. The students from the Global Business Engineering Program was soon gathering information from different data bases regarding market data for competitive products. In both programs it was clear that the students applied their interdisciplinary competences. The students from the Production Engineering Program used both technological, economics and management competencies. The students from the Global Business Engineering Program used technological, economics and marketing competences.

It was clear that they applied their interdisciplinary competences, as they used both technological, economics, marketing and management competencies.

Based on experience from the pilot workshops it was decided to extend the workshop to additional engineering programs at DTU Diplom. For each of these programs meetings were set up with the program directors to inform about the business case tool, how to use it, and the relevance to the students. Based on this information the program directors appointed a relevant lecturer to help prepare the business case for the specific program. Different topics for the business case were discussed and a business case was prepared.

7 DATA COLLECTION AND ANALYZIS

In order to evaluate the effect of the business case and the workshops data has been collected and analyzed using the Delphi method. Two workshops have been selected to provide data for the analysis. The first workshop was a physical
workshop with students from the Production Engineering Program and the second was an e-learning workshop with students from Innovation Pilot.

After the first workshop with the student from the Production Engineering Program, the students from this program were introduced to three themes and asked to come up with statements regarding the business case and the workshops. The three themes were the following:

1. Usefulness in later projects and in the work life
2. The relevance for an engineer from that specific field the student have, hereunder the necessity of having interdisciplinary competences (management, technology and economy)
3. What was the outcome of the workshop

For each of the three themes the students came up with multiple statements each. Afterwards the statements were grouped after similarity. That ended up with 4-6 statements for each theme:

Theme 1: Usefulness in later projects and in the work life

- Question 1: The business case is an important tool for risk evaluation of an investment project
- Question 2: The business case is an important tool in their job after finished education
- Question 3: The business case is an important tool in later projects in the university
- Question 4: Using a business case results in a larger success rate for my project ideas in the companies after finished education
- Question 5: Using a business case makes the assumption of the investment project more visible
- Question 6: Using a business case visualize how the investment is affected by changes in the assumptions

Theme 2: The relevance for an engineer from that specific field the student have

- Question 7: Interdisciplinary competences are necessary in order to make a business case
- Question 8: The business case is a highly relevant for that specific engineer (the student)
- Question 9: Interdisciplinary competences contributes to ensure that pros and cons for the will be more realistic
- Question 10: In addition to the technical background, it is important to have financial knowledge, as the profitability of a project is essential
Theme 3: What was the outcome of the workshop

- Question 11: The workshop gave a good basis for using the business case tool
- Question 12: The workshop has been fruitful
- Question 13: A better understanding for variations in the project’s profitability depending on different scenarios as a result of changes in assumptions (most-likely, worst- and best case)
- Question 14: By using the tool in the workshop I have gained an understanding of which elements it is important to focus on in order to present an investment project for the management of the company

The students from the Production Engineering Program were then presented to the 14 statements and asked to indicate how much they agreed/disagreed on a scale from 1-5, where 5 is strongly agree and 1 is strongly disagree. Of practical reasons, the survey was conducted two working days after the workshop, which is the reason why only 14 out of the 20 students participating in the workshop responded.

The students from Innovation Pilot were presented for the same 14 statements via the e-learning activities and requested to upload the questionnaire. This resulted in a lower response rate.

8 FINDINGS

8.1 Production Engineering workshop

There were 20 participants in the first workshop and 14 questionnaires were collected.

| Theme 1 | | Theme 2 | | Theme 3 |
|---------|---------|---------|---------|
| Question | Average | Question | Average | Question | Average |
| 1       | 4.5     | 7       | 4.4     | 11      | 4.6     |
| 2       | 4.3     | 8       | 4.9     | 12      | 3.8     |
| 3       | 3.9     | 9       | 4.6     | 13      | 4.4     |
| 4       | 3.7     | 10      | 4.6     | 14      | 4.2     |
| 5       | 4.5     |         |         |         |         |
| 6       | 4.1     |         |         |         |         |
| Theme average | 4.2 | Theme average | 4.6 | Theme average | 4.3 |

Table 1: Scores for the themes
In general theme 2 regarding relevance was receiving the highest scores with an average of 4.6. Theme 1 and 3 also received high scores with averages of 4.2 and 4.3. That means that the students in general agree with the statements. Looking further into the data some variations within each theme can be seen.

In theme 1 especially question 3 and 4 differ with lower values. Question 3 regarding the business case as an important tool in later project in the study received the score 3.9 and question 4 regarding larger success rate for project ideas in companies after finishing education received 3.7. The lower score in question 4 was expected, as it can be difficult to know exactly how decision processes are in companies. However, the score in question 3 was a bit unexpected, as the students have more experience in university projects than in company projects. Comparing to question 2 regarding the use in the work life after finished education this is even more remarkable.

In theme 2 question 8 regarding the relevance for that specific engineer differed with a very high score of 4.9. The exact reason can not be seen, but might be influenced by the use of adapted cases. Question 7 and 9 with a score of 4.4 and 4.6 respectively, shows that the students finds that interdisciplinary competences are necessary for making the business case.

In theme 3, question 12 regarding if the workshop was fruitful received a score of 3.8. Question 12 is a more general question whereas the other questions in theme 3 are more specific and received a higher score (4.2-4.6). This could indicate that the students finds that the workshop has given them a good understanding of using the business case tool. The reason for the relative lower score could be that the students at the Production Engineering Program already have a good understanding of investment theory, but not to the specific business case tool.
REFERENCES


