Company Assessment in Production Management Education
Graduate Course in Industrial Engineering and Management

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INTRODUCTION

Today's engineers are versatile servants of industry and society [7, 8]. The nature of engineering work has changed from classical engineering expertise and from technology orientation towards communicative expertise [9]. In the knowledge word the problems are not anymore well-defined technical problems but rather vague challenges where technical solution is just a part of the total outcome. To be able to solve these problems, new kind of skills are required.

Rapid changes in working life bring new kinds of challenges to develop engineering education and expertise. Due the practical nature of engineering work, the engineering profession reflects more than most professions within the operation environment [1] causing the challenges for long-lasting education process to be able to react and adapt the needs of industry and society fast.

Industrial engineering and management (IEM) is a profession where problem solving, understanding of large-scale phenomena and complexity has been always requested.

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The starting point as IEM engineer to answer the current settings are well. However, in order to have better capabilities to work as an expert and manager in modern business and society requires new kind of skills alongside the substance know-how. Competences like cooperation, courage to solve new kinds of problems, continuous learning as well as creating and applying new knowledge is emphasized.

Understanding business operations and production management is one core competence of IEM expert. This study aims to show a case example how production management education has been developed at the University of Oulu as part of IEM curriculum to tackle also the new competence requirements. This case show how by developing the learning method we can support the multiple requirements that university education faces today.

1 INDUSTRIAL ENGINEERING AND MANAGEMENT EDUCATION AT THE UNIVERSITY OF OULU

1.1 Industrial engineering and management

Industrial engineering is the engineering discipline that deals with the plan, design, development, knowledge, improvement, implementation, installation and evaluation of the performance of complex processes or integrated systems of people, technology, and information. Finnish Industrial Engineering and Management (IEM) university programs define IEM to *be a discipline to address organizations and their networks as technological, economic and social processes with the objective to create and advance high profitability and sustainability*. Generally the research topics are management science, operations study, and even experimental design in industry [11].

1.2 Industrial engineering and management education at the University of Oulu

IEM education in University of Oulu (UO) includes on B.Sc. and two M.Sc. degree programmes. The number of students are 35 in B.Sc. and around 50-60 in M.Sc. programs. These degree programs aim at improvement of productivity, quality and well-being at work and taking into account the good practices of sustainable development. Students can choose his or her scope of interest within two majors: production management and product management. Students will also select one technical minor subject.

The constructive learning approach can be seen as the backbone of the teaching in IEM UO programs. The major issue is to see students as active participator and knowledge creators and editors. The learning is founded on earlier knowledge against which the new knowledge and experiences are reflected, and new constructions are created.

2 GRADUATE COURSE IN PRODUCTION MANAGEMENT

2.1 Course description and realization

Production Management is a 5 ECTS course organized by the Industrial Engineering and Management (IEM) unit at the University of Oulu. It scheduled to run in the autumn semester and it is planned so that the IEM graduate students should complete the course in their 2nd year of Masters studies. There were 30 registered students. Total of 25 students completed the course

The learning outcome of the course is defined as follows:

> Upon completion of the course the student understands the key concepts of operations and production management. The student should know the essential production strategies. The student should also understand the principles of the

supply chain management, and should be able to apply JIT, Lean and TOC methods in analyzing and constructing development plans for production organizations. Upon completion of the course the student can apply the management methods also in service systems. The student also understands the principles of the sustainable development in production.

The course was realized so that it included 20 hours of lectures, 20 hours of assignment guidance and coaching. 95 hours were reserved for the group work. The group work consisted of the following stages:

1.The students formed 7 teams with 3-5 students each. Within these groups the students had study further from the literature the concepts of Operational Excellence and maturity Models.

2.The teams recruited a suitable production company, where they could analyse the company's operational status as well as they would test the provided tool.

3.The team conducted the company analysis at the site by interviewing key personnel of the company.

4.Students analyzed to results with the tool.

5.Student team compiled the report and submitted to the university for evaluation.

6.Teams presented their work in a seminar and they received feedback of their work.

2.2 Course focus in 2015-2016

The course is defined to contain the following topics: Production strategies, Sustainable development, Just-In-Time (JIT), Theory of Constraints (TOC), Lean, Toyota Production System (TPS), Management of the production of services.

The topic of the supervised group work can vary within the scope of the production management from year to year. In the academic year 2015-2016 the topic was Operational excellence and maturity models related to production management.

2.2.1 Operational Excellence

There are many definitions of Operations Excellence. Texas Instruments created in 1994 what they called TI-BEST, a programme that were meant as a guideline of how to operate the business in the best possible way. This was done through a four step process (Johnson 1997):

1. define business excellence for your business,
2. assess your progress,
3. identify improvement opportunities and
4. establish and deploy an action plan.

The rapid changing in both technology and consumer behaviour across multiple industries constantly generates new demands that are to be met. Some companies believe that using operational excellence is the key factor in keeping and acquiring customers [4]. It therefore means that Operational Excellence is much more than product or process optimization, but also about humans and resources.

Operation Excellence is also about continuous improvements – looking at the current status, analyzing it and taking the steps required in order to fulfil the vision status [6]. It could be everything from Kanban, lean or Six Sigma [2]. A good way of exploring this

process is to create a so-called Operational Excellence Loop, explaining the different steps in the process. It provides a great overview through this illustration.

2.2.2 Maturity Models

There are different types of organizations, when it comes to organisational maturity. Mature organizations do things systematically, create schedules and achieve them and meet their goals almost without deviation. Immature organizations achieve their outcomes as a result of the efforts of individuals, create schedules but miss their goals by wide margins and don't know which goals will be met and neither how long it will take to assign it. Immature organizations often don't achieve the goals that they commit to achieve.

One definition of maturity is that mature organizations have systematic and well-documented processes, while immature organizations get things done due to the heroic efforts of individuals, who are basically using spontaneously created approaches [5]. Maturity models are used to determine the stage of development that the company is currently at, as well as to provide insight on what the company must do in order to reach the next stage [10].

There are two different approaches to maturity models. One approach is based on stages or levels, and the other is called continuous representation [5]. The group works and the tool is based on maturity levels. In this approach, the five states, called the States of Process Maturity [3], are assessed based on six process factors: defining the process, employee skills, process management, process performance measurement, process optimization, as well as IT systems and integration [10]. They are used to understand the overall state and capabilities of the organization [3].

The characteristics of the different States of Process Maturity can be briefly described as follows [3, 10]:

1) Siloed: The organization is immature. Projects are unpredictable, and processes are ad hoc and undefined. No coordination between departments. Individuals are focused on optimizing their own function, but not the organization as a whole.
2) Tactically Integrated: Processes are identified and defined to some extent. Integration of the organization and IT systems has begun, but is still somewhat fractured and built around functions. Data is gathered and analyzed and some metrics exist.
3) Process Driven: Processes are defined and integrated for the most part. Data is collected on process performances and analyzed. Departments responsible for core processes have integrated IT systems. Organization-wide leadership is installed, as well as a supporting team responsible for end-to-end process optimization. Management decisions are enforced.
4) Optimized Enterprise: The organization is committed to continuous improvement and utilizes business-focused metrics to reach new levels of efficiency and effectiveness. Processes are completely defined and standardized. High levels of integration. Departments cooperate and work well together. Performance-related data is gathered and analyzed statistically
5) Intelligent Operating Network: A state of continuous improvement. Processes between different organizations are defined and integrated. IT systems are integrated between the organizations connected to the process. Other

organizations are represented in process teams, and the process team is responsible for measuring performance both ways.

2.2.3 Analysis tool

A tool was developed in a separate research project to analyse the maturity of the operations of manufacturing companies. The tool is based on the maturity models as well as on the definitions of operational excellence. The focus of the analysis is in the following aspects:

- State of the processes
- Employees' skills
- Production management
- Measuring process performance
- Optimization of processes
- Information systems and data transfer.

The students collected the analysis data and recorded them into an Excel -tool, which produced the final scoring of the organization, like in *Fig. 1*.

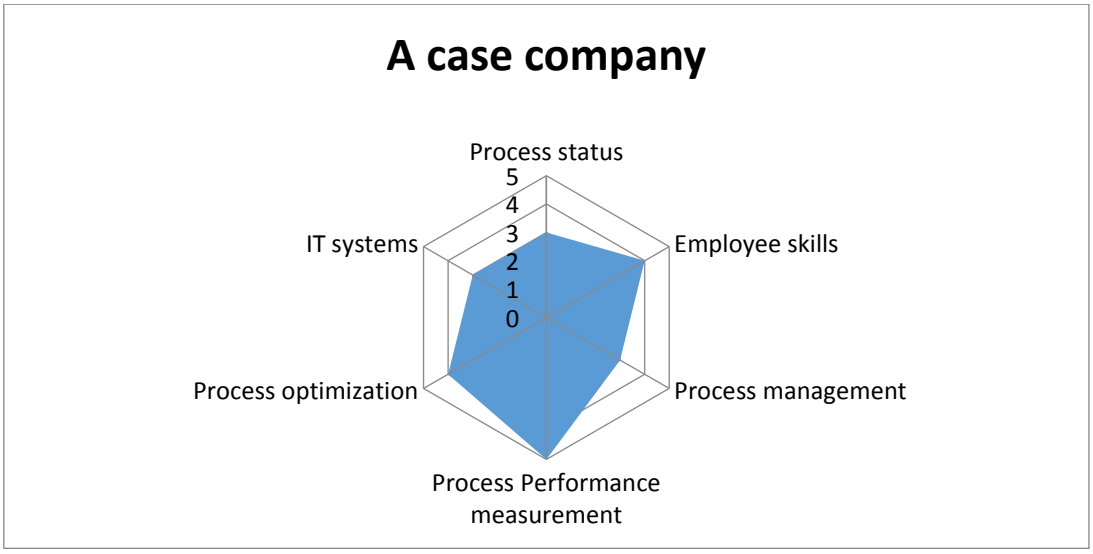

Fig. 1. An example about the outlook of assessment tool.

The analysed functions were in addition to production also the sales and purchases. The aspects under assessment were analysed using the scale that is typically used in maturity models. In this scale, 1 stands for ad hoc, 2 defined, 3 managed, 4 optimized, and 5 continuous improvement.

3 LEARNING RESULTS

The student experiences that they have faced during the course is analyzed. We examine the student experiences on 1) what industry case gives for learning, 2) how the assessment tool and making the assessment affects to learning. The results are examined as group level in the full paper.

3.1 Student experience

3.1.1 Group A

The students found it in the beginning a little bit difficult to identify a suitable case company, but when they managed to contact the case company, it was very rewarding. The students were pleased with the outcome of the exercise. The visit at the company was very interesting and the management of the company welcomed the students very friendly. They were very well prepared for the evaluation meeting and it was delightful that the company had arranged 5 key members of their factory to answer the evaluation questions and to tell the students about their operations and all expectations was filled. The students learned how the company operates and how advanced they are in using automation, IT-systems and process measuring and optimization.

The students felt that making the exercise to an existing company was truly rewarding. They learned a lot about the company and also about maturity level tools and operational excellence also in action.

Making this assignment to a real company was really interesting and gives also contacts to the company for later use. The students felt that it was nice to see how this maturity evaluating tool really works.

3.1.2 Group B

The maturity model and the used Excel tool fit well into the use to develop production operations. The tool was fairly clear and easy to interprete. The tool was not easy to use, because of the way in which it had been built.

The group was pleased about how it had performed with the exercise and the students learned new things about production management. Having a real company case increased the practical value of the exercise.

The assignment as such was easy to complete since there was plenty of material available and the company visit was well organized.

There were some scheduling problems because of the course schedule and schedules of other tasks in the program.

3.1.3 Group C

The expectations for this exercise were not really high in the beginning, as the students believed that there wouldn't be that much interest within the company for this kind of an evaluation tool. However, the students were proven wrong as the company's CEO was keen on filling out the forms of the tool as well as getting some suggestions from the student team after the analysis. Also, it was interesting to see that the CEO actually knew what the students were talking about and why they were doing this exercise in the first place.

The students were quite lucky while choosing this company to interview, as it is possible that not everyone is as interested in these topics as the CEO of this case company was.

The students learned that the evaluation of a company's processes isn't as black and white as it appears in theory. There are a bunch of different aspects to be taken into consideration when evaluating a company and its operations. The interview gave the student team some new ideas about the maturity model as well, how it is quite difficult

to interpret if the analyzing party isn't doing the evaluation together with the case company. If there would be more details within the tool, it would be much easier to analyze exactly what needs to be done inside the company in order to reach the next levels in different areas of operational excellence.

The students were quite happy with the way this exercise was managed. The fact that there was a list of case companies to contact really made it easier to begin working, as it would have been so much more time-taking and difficult to come up with a suitable company to contact.

The team learned to delegate the work between the members for the sake of doing the tasks efficiently. In addition, the students learned a lot about the theory base of both operational excellence and maturity models.

All in all, the students think that this exercise actually exceeded their expectations

3.1.4 Group D

During this exercise, the students gained new knowledge on maturity models and operational excellence. The students visited a real company and evaluated their production processes using the maturity model. The group learned new ways of looking at the production management after researching the theory and using the maturity tool in practice.

However, the students felt that the schedule for this course was too tight, considering that it's a 5 ECTS credit course. They had only approximately one month to complete the group work. Organizing the meeting with the company and rescheduling the meetings extended the time of completion.

However, the students truly feel that they have done their best considering all these circumstances.

3.1.5 Group E

Presenting the tool in the company was interesting and clearly a learning experience. The company representatives were initially rather critical, but a great surprise to the students was how well the tool was received by the company as a useful development tool. The company representatives started even planning some improvements during the evaluation session. The tool was seen as a good 'wake-up call'.

The use of the tool gives a good overview to how well the production process is operating and to the various aspects of optimization. These came very clear during the students' company visit and tour at the factory floor. After some specific improvements in the tool, it would give good picture both to students and the company managers about how different parts in the production process influence in the whole production excellence. The biggest problem with tool was with this student group to really understand what is behind all the questions used in the tool. However, the tool gives a good overall picture of the production operations and the development areas can be clearly identified.

3.1.6 Group F

The students pointed out that it is good to have courses in university that involve cooperation with the local companies. It gives a great chance to make connections and learn more about companies around Oulu. Therefore, visiting the company was a great experience. The students felt that, it was nice to see another production line and hear about the management's view of its' state.

The exercise was easy to understand and it was relatively easy to execute in the case company. The exercise is short enough, so it doesn't take too much time from the company. Besides, it was good practice on contacting companies and convincing them to cooperation.

One improvement for the exercise could be to use English in the introduction of the exercise. The fact that all the instructions and the excel sheets were in Finnish, made the exercise quite hard for the exchange students. Translating the tool completely into English could also be the next step for the tool itself. That would enable its' use in other countries as well.

All in all, the exercise was a good experience, but the students would have liked to have some other exercises to go along with it as part of the Production Management course in order to get a better coverage of the subject.

3.1.7 Group G

For the student team this was the first visit to a food producing company. This brought to the attention of the students the high requirements of hygiene and cleanliness. Especially how precisely these are taken care was noted by the students.

The students were welcomed warmly at the company and this was also a positive point. This was followed by a question and answers session in a very positive mood from both sides making this a real learning situation.

The maturity model was positively received by the company representatives and there were clear signs that using the results will follow some development activities in the company.

3.2 Benefits

The course organized as a case study clearly benefitted several stakeholders. Here we can identify as important stakeholders the students, the faculty members; especially in named education program, and the case companies. The key benefits are listed in *Table 1*. By reporting the findings the experiences can be used also by the IEM colleagues around the world.

Table 1. Key benefits of a case study as a teaching method for different stakeholders.

Benefits for the students - new knowledge on operational excellence, maturity models and company evaluation - deeper understanding on the production operations in the case company - team work, delegation and task sharing - self-confidence increased by contacting companies, acting as a specialist role and gotten professional coaching
Benefits for the faculty - improvements in teaching methods - additions to the teaching/learning materials - contacts to companies - empirical data for scientific articles
Benefits to the participating companies - an improvement tool - new ideas for organisational development - contacts to the university

3.3 Needs for improvement

In this particular course, the case study method was used at the first time including a new tool for company assessment. Some course specific development needs rose during the course that need to be improved for the next time when course is given.

One development need regards the teaching process. The timing for the course and different tasks needs to be improved. The other major improvement areas is for material improvement and a tool development. The tool must be more self-explanatory in order to avoid misinterpretation. Since there is always Finnish and English students in this course, all material needs to be in English. However, when working with small Finnish companies also some key material is required in Finnish.

Also, one open question remains: who should contact and agree with the case companies. There are benefits, if this done by the teacher of the course and benefits if it is done by the student groups themselves. This time the selection and contacting the case companies was on the student side with a little help from the teacher.

4 CONCLUSIONS

IEM UO Production management course were developed by taking Operational excellence maturity assessment in use. The assessment and teacher role as a coach provides a learning method that can answer for the current needs that are currently set for education. This method gives a way to teach the substance but also combine other skills development for the course.

The results were positive. The student not only gathered the new knowledge on operational excellence, maturity models and company evaluation but they also got a deeper understanding on the production operations in the case company. The case study also creates the industrial contacts that can leads to summer jobs, thesis works, etc. In addition students' team work skills and presentation skills were improved. Also the self-confidence about their own know-how and skills was seen increasing since they got a chance to practice professional work in guided environment.

The students are not the only party that benefits new leaning method. The teacher and study program benefits also from this type of method in a way that new contacts to companies are created, empirical data for scientific articles and additions, practical examples to the teaching/learning materials can be collected. The participating companies are also getting new ideas for organizational development and will be able to use assessment tool as well as creating contacts to the university.

This case study needs further testing to validate that we really achieve the desired learning outcomes. Some practical improvement needs regarding course timing, the assessment tool and the study material was recognized. Though, the assessment tool is already used in one other engineering program.

5 ACKNOWLEDGMENTS

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