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A Chain is only as Strong as its Weakest Link: Managing Change in the Curricilum of Industrial Management Education

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Abstract

In this paper we discuss the process of designing a new Industrial Management Master Program given by the department of Industrial Economics and Management at Royal Institute of Technology (KTH) in Stockholm, Sweden. The foundation of the IM-master program lies in the notions of authenticity and change. We decided early on in the design process, that our aim was to teach the skills of real world change management and to "mould" our students into industrial managers able to master complex industrial change processes. But we realized that we also had to "mould" our own pedagogical tools, examination forms, and not the least, faculty, to reach our goals. These insights lead us to emphasize a Systems perspective, both in regards to program and course design and in regards to the actual management skills we wanted to teach.

The objective of this paper is to present and discuss our explicit use of a systems perspective in designing the Industrial masters program. We have identified four major parts of "our system" where changes had to be made: Premises – Learning activities – Examination – Program management. These four system parts are divided into ten subsections – "systems components". We discuss all four system parts in relation to our goals to enhance authentic skills in change management.

Key words: *Systems perspective, authentic case methodology, industrial management, university education, master program*

1. INTRODUCTION

In this paper we discuss the process of designing a new Industrial Management Master Program given by the department of Industrial Economics and Management at Royal Institute of Technology (KTH) in Stockholm, Sweden. The Industrial management two-year master program (launched in 2010) admits 80 engineering Bachelor degree students per year (e.g. Mechanical Engineering, Computer Science, Material Design). Students come from BSc programs at KTH (as parts of six 5-year Engineering program) and through an international admission (as a stand-alone Master program).

There were two reasons for the department to initiate a new master program. First, and most importantly, KTH had to adapt to the Bologna model of 3+2 years (BSc + MSc). The traditional Swedish 4.5 year Engineering degree did not include a bachelor level. Second, industry as well as KTH and the Swedish University administration encouraged novel ways of educating engineering students to better fit into a modern industrial landscape, i.e. CDIO (see below). It is fair to say that we used the necessity to change the structure of our MSc-education as a window of opportunity for major alterations.*

The foundation of the IM-master program lies in the notions of *authenticity* and *change*. We decided early on in the design process, that our aim was to teach the skills of *real world change management* and to "mould" our students into industrial managers able to master complex industrial change processes. But soon enough we realized that it wasn´t enough to change only the content of the curriculum. If we wanted to teach change management we needed to change ourselves. We had to "mould" our pedagogical tools, examination forms,

* In this article we will not discuss the actual change from the old to the new master program or the process of getting a new structure and a new pedagogical paradigm accepted in a rigid institutional environment like KTH. We hope to return to these questions in a later paper: *Turning a necessity into an opportunity. Change management in higher education* (working title)

and not the least, faculty, to fit a master program focusing on *authentic skills* in *change management*.

Heavily inspired by the pedagogical framework of *Constructive alignment* [1] we recognized that in order to incorporate these activities along with fundamental requirements in higher education, such as critically evaluate theory and individual assessment, *all* parts of the teaching toolbox and curriculum must be reconsidered. These insights lead us to emphasize a *Systems perspective*, both in regards to program and course design and in regards to the actual management skills we wanted to teach. By a "systems perspective" we mean, quite trivially, that all parts of the "system" i.e. our master program, had to be scrutinized when attempting to build something new. We use the concept of system in two ways in this article. We describe the actual master program as a system of mutually dependent components and we use the systems perspective as a pedagogical tool in educating our student in Industrial Management.

Thus, the objective of this paper is to present and discuss our explicit use of a systems perspective in designing the Industrial masters program. We have identified four major parts of "our system" where changes had to be made: *Premises – Learning activities – Examination – Program management*. These four system parts are divided into ten subsections – "systems components". We discuss all four system parts in relation to our goals to enhance *authentic skills* in *change management*.

The four system parts and their system components are:

A: Premises

1. Student background
2. Demands from academia
3. Demands from industry

B: Learning activities

4. Problem Based Learning
5. Authentic Case Methodology
6. Protoyping and authentic feedback

C: Examination

7. The final product
8. Examination portfolio

D: Program management

9. Quality assurance
10. Faculty alignment

The outline of this article is based on the four system parts and their respective system components. We do not include a theory section in the introduction. All relevant theory is presented under each system component. But before we go any further we would like to give a short overview of the master program in Industrial management.

2. THE IM-PROGRAM: A BRIEF OUTLINE

The Industrial Management Master Program consists of eleven compulsory courses, and a master thesis, in the area of Industrial management. Nine courses are exclusive for the program students and are interconnected, designed for progression and matched with the learning objectives of the program.

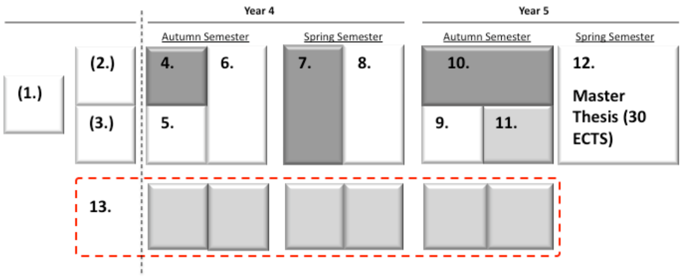

Figure 1. Overview of the Industrial management master program

1) Industrial management basic course (prerequisite course)

2) Team leadership and HRM (prerequisite course)

3) Project management: Leadership and Control (prerequisite course)

4) Perspectives on industrial management (PIM)

5) Finance and control in industrial organizations

6) Operations and supply chain strategy

7) Industrial transformation and technical change (ITTC)

8) Strategy and industrial marketing

9) Managing research and innovation

10) Change project in industrial management (CPIM, over one semester)

11) Research method in industrial engineering and management

12) Master thesis

13) Elective and technical courses related to different 5-year programs

Hence, subject vise the program could be described as covering most of the primary and supporting activities of Porter's well-known value chain model [2], including leadership, the strategic and the industrial dynamic perspectives. However, equally important is that our students should be able to manage change based on a "systems perspective" (see System component 3). The primary goal of the IM-program is to "mould" engineering bachelor students into industrial change managers able to handle complex industrial change processes.

As highlighted in Figure 1 courses nr. 4, 7, and 10 have specific roles in the program. The content and the learning activities are particularly focused on program progression. For our students to be able to handle real world change management they have to be prepared. Courses nr. 4 and 7 are specifically aimed at the program learning objectives, covering the whole area of Industrial management, with a strong focus on case work. The very first course in the program Perspectives on Industrial Management (PIM), we like to call a "crash course in mind-shifting" and we focus on the transition from problem *solving* to problem *formulation*. In the second course Industrial Transformation and Technical Change (ITTEC) we focus on the academic paper, theoretical concepts used as *practical tools* and oral presentation techniques. In both we encourage the students to act as industrial *consultants* formulating an authentic real world problem for their costumer, collect data by a study visit, interviews and literature and present a solution in the form of a report, an oral presentation or an executive summary – based, of course on the academic report (we introduce a template that the students will use through the program). In the PIM-course we use two Harvard cases and one authentic industry case. There are seven feedback loops (prototyping) and an introduction of the examination portfolio based on learning objectives. We have a strong focus on Problem Based Learning (PBL), communication skills and capabilities.

In the final course of the program (course 10, CPIM), before the master thesis degree project, students are introduced to a real company change assignment. In this project-based course the students are approaching the full-blown complexity of authentic challenges within the area of IM. The CPIM-project is run in association with industrial companies and focus on current, or future, challenges that the companies have identified within their operations. During the 20 weeks of the course students will work independently in teams ("consultant teams") starting with an introduction to the identified problem/challenge/efficiency improvement presented by the company. Thereafter the teams frame the scope of the mission and approach the challenge based on primary and secondary sources of data, literature studies, and benchmarking studies. Finally the teams present a comprehensive analysis and a work plan describing how they suggest that the change project will be implemented in the organization.

Our three courses on a program level is closely monitored by Program management. Thereby we secure alignment, progression and learning outcomes trough out the IM-program. The courses form a three-stage rocket preparing our students gradually to authentic change management.

3. THE CHAIN AND ITS LINKS

In the following we present our four system parts and their respective system components. We start by a graphic representation of our "system" (Figure 2). The figure is supposed to show the interconnections between all parts and system components. We have put "Program management" in the middle to illustrate its importance as a central hub or passage point. We want to highligt the constant movement of ideas and critique between the system parts. There are feedback loops in all directions. When something happens in one part of the system it will trigger change in the other parts and components. But this is not an automatic process. Program management must work hard to monitor the system to avoid stagnation and malfunction. We really believe that a chain is only as strong as its weakest link – but the links as well as the chain need maintenance.

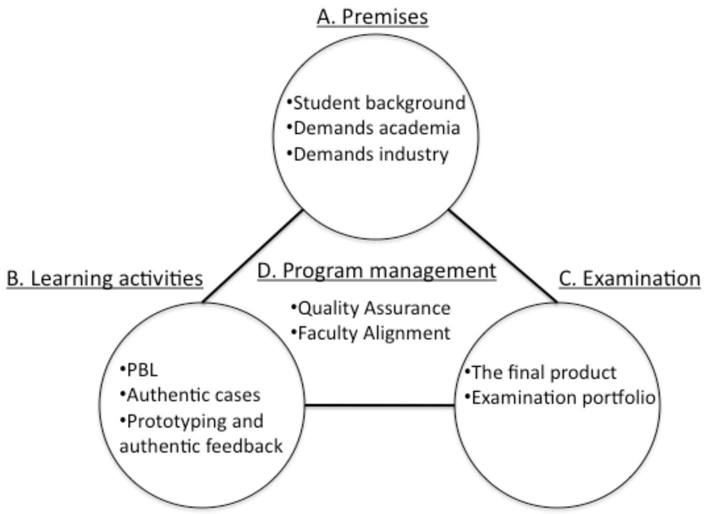

Figure 2. Alignment of system parts and components in the Industrial management master program

4. SYSTEM PART A: PREMISES

In designing the IM-program we have had three important premises or starting points as "in-data" in the process: Firstly, and naturally, the educational background of our students. We want to enable our BSc engineering students´ transition from "problem solving" to "problem formulation", secondly we have to adhere to the explicit demands from academia on a master program, and thirdly, we must meet the demands from industry when preparing students for future managerial positions in technology intensive industrial organizations (e.g. production development, project management, R&D management, marketing, etc.). We like to interpret these starting points as "customer demands" and by that we have three "customers" to satisfy: *Students*, *Academia* and *Industry*.

In this section we will discuss how we have handled these premises defining them as our three first system components – one could say that we start by discussing the input into our "system".

4.1 **System Component 1: Student background**

Traditionally, engineers are professional problem *solvers*. Problem solving is a core capability of every engineer, from any university. Technical problems are typically approached by applying mathematical models. Engineering students are often highly skilled in recognizing technological problems and approaching them by numerical models or simulations. As a consequence of this – especially in an educational environment – they tend to value accurate and detailed quantitative results. They do not love ambiguity!

However, engineering students in the area of Industrial Engineering and Management are typically faced by an extended frame of challenges when the scope of problems are to include issues related to management of R&D, production, and marketing as well as decisions related to strategy and leadership. Students facing such extended scope of challenges need to be well founded in technical problem solving. In addition, they need a new palette of knowledge and skills in order to approach the complexity introduced by the qualitative context of management and strategic decisions making – a context that seldom offers Newtonian approaches or distinctive, undisputable, numerical answers to a given problem.

Our students can handle large workloads, are analytically skilled and trained in problem *solving*. At the same time industrial managers do not primarily solve problems, they *formulate* problems. Our goal is to enhance the students' transition from problem solving to problem formulation.

4.2 System Component 2: Demands from Academia

The second system component in our design process is the demands put on a master program from academia. We have divided this component into four different sub categories: *Learning objectives*; *Constructive alignment*; *CDIO* and *Scientific results*. As mentioned earlier, constructive alignment has been our key source of inspiration in designing on program and course level.

Learning objectives

During recent years state authorities and university boards has increasingly focused their attention on formulating explicit *learning objectives* (outcomes) for degrees and educational programs. From the perspective of the Industrial management master program, this means that the national demands on the master's degree have to be covered in the specific learning objective for the program. These demands are formulated in three categories: knowledge & understanding, competence & skills, and judgment & approach. The specific national demands under each of these categories are then adapted to the specifics of the master program. Finally, each course and its content are mapped against the program's learning objectives in order to create an effective educational program where the learning activities are executed and assessed progressively.

In our program we have worked actively using the learning objectives as a tool for systematic program and course design as well as quality assurance. Firstly we have translated the general learning objectives to fit our program and secondly we have developed course related learning objectives for each course. All learning objectives are not reached in every single course. But when completing all the courses in the program, the students have reached the master level in Industrial management relating to "knowledge & understanding", "competence & skills" and "judgment & approach".

Constructive alignment

Actively using learning objectives requires a systematic framework for creating prerequisites at the program level for activities and examinations being in line with the learning outcomes of the program. We found this framework in *constructive alignment* [1, 3], maybe the most established pedagogical concept to support such an integrated educational structure. In designing the Industrial management master program the concept of constructive alignment has been the central tool for development and coordination. Having learning objectives covering knowledge, skills, and the ability to evaluate require a thorough mapping of course activities and examination forms in order to be effective.

But constructive alignment has not only been our framework for program and course development per se. As stated in the introduction we have also worked hard to align faculty competence, in both subject areas and teaching methods, to the learning objectives of the program – *all* parts of the teaching toolbox and curriculum must be reconsidered.

CDIO

Traditionally, engineering education has been directed towards the ability to design and build a physical product. Being in a managerial environment where the material result of the engineering work is hard to identify, we have focused on *tangible communication*. In our world the written (academic and/or consultancy-) report is the *product* and we encourage students to "show and talk" by enhancing communication skills (written and oral).

The discussion on practicality and applicability in engineering education is not new. Since a decade the Vehicle Engineering program at KTH has used pedagogical frameworks such as CDIO (Conceive-Design-Implement-Operate) [4, 5]. But it has been difficult to transfer CDIO-concepts to other institutions lacking a clear focus on building technical artifacts:

"The concept *design-implement experience* has often been too narrowly understood only as courses in which students build gadgets, mechanical artefacts (sic.). Transferring the idea to other disciplines is challenging, if faculty try to simply translate the *thing* that students build, to other contexts ("What should they design and build - a molecule?")." [6]

We argue, using the words of Edström et. al.:

"…that the *aims of the learning experience* should be transferred to the context of the particular engineering program. Then the task is to create learning experiences which are similar to professional engineering practice, giving students an opportunity to experience a complete project cycle, with a hands-on approach. The aims are that students should integrate, apply and express disciplinary knowledge, and develop *complex* skills and judgment situated in the relevant engineering context. Such learning experiences can be designed for any engineering program, and for all stages of the education." [6]

CDIO has been a great inspiration for us. We have not worked systematically to implement CDIO-concepts in the IM-program. But in hindsight it is easy to see the influence from CDIO. Our ten system components, defined in this article, bears a strong resemblance to the "12 CDIO Standards" recommended when designing a course or a program:

"The 12 CDIO Standards address program philosophy (Standard 1), curriculum development (Standards 2, 3 and 4), design-build experiences and workspaces (Standards 5 and 6), new methods of teaching and learning (Standards 7 and 8), faculty development (Standards 9 and 10), and assessment and evaluation (Standards 11 and 12)." [7]

Scientific results

It goes without saying that university education should teach *scientific theory and methodology*. But from our previous experience, especially in master thesis teaching, we have encountered a conflict between industry and academia when presenting results. Students often report that their company is not at all interested in academic theory and methodology. Industry is supposedly concerned with strait forward and applicable results that can be immediately implemented. These contradicting goals often make students perceive a huge difference between the "consultancy report" and the "academic paper".

In the IM-program we have worked hard to overcome this conflict. From day one, in the first course, our students are encouraged to embrace scientific theory and methodology. We argue that the academic paper is the "mother of all papers". If you are supposed to deliver a power point presentation, an executive summary, a consultancy advice – in what form it may be, written or oral – the structure and the logic of the academic report is of fundamental importance. Academic demands on structure, methodology and theory are vital to ensure quality, reliability and validity in any situation. We argue that the conflict between the academic paper and the consultancy report is an illusion. Our IM-students must understand that knowledge of academic methodology and writing is actually bringing important value to the customer.

4.3 System component 3: Demands from Industry

Concerning the demands from industry we have, trough literature and in discussions with our industry partners, identified three components being extra important: *Managing change*; *Systems perspective*; *Results for business implementation*.

Managing change

One of the most emphasized prerequisites for competitiveness in contemporary management literature is organizations' and individuals' ability to handle change [8]. Input from the program's industrial network also supports this – today's industrial companies are not suited to be studied by static approaches. Instead, dynamic environments imply (e.g. caused by speed of new technology development and globalization of markets) that one must considerer *constant change* as a condition for the understanding and analysis of industrial and technology intensive organizations.

Systems perspective

The next demand identified from the perspective of the industry is based on the need to approach challenges from a *systems perspective*. Arguments from both theory as well as practitioners are unanimous in that integrated business models, combinations of product and service offerings, decentralized, and flat organizational structures in today's business environment require a system perspective when dealing with change. Throughout the program the students are faced with change processes on three system levels

1) Individual (e.g. leadership)

2) Functional (e.g. supply chain)

3) Industrial (e.g. industrial dynamics).

Therefore, we promote our subject area – Industrial management – from a systems perspective, arguing that the individual, functional, and industrial levels and their systemic interrelations must be considered when approaching industrial and technology intensive organizations. This is simply because static linear processes, decupled from each other, are rare exceptions in the future working-life.

Results for business implementation

We start the master program by acknowledging the obvious fact that clients from industry really needs *results that are easy to understand, possible to implement and useful for business*. Then we point out the equally obvious fact that these results must be based on a sound investigation, a clear methodology and that the argumentation must be logical, unbiased, theoretically justified, etc. We conclude by claiming that the academic report is the foundation for all other result presentations. As touched on above, our students are often confused by the perceived difference between the academic paper and the way industry wants the results presented. Throughout the IM-program we try to mediate in this conflict by arguing that the conflict is an illusion. Thus we stress the need for our students to come up with useful and valuable results for our industrial clients. And, that the best way to do this is by a thorough investigation based on scientifically sound methods.

5. SYSTEM PART B: LEARNING ACTIVITIES

We call our second system category "Learning activities". It consists of three components: *Problem Based Learning*; *Authentic Case Methodology*; *Prototyping and Authentic Feedback*. In this section we present our pedagogical tools and what we actually been doing in the learning process. We discuss our usage of these pedagogical tools on a general program level and on course level with examples from the three courses mentioned above.

5.1 System Component 4: Problem Based Learning

Problem Based Learning (PBL) was first developed as a teaching method for medical students at McMaster University, Canada [9, 10, 11]. The focus is strongly put on exposing the students to real context problems. Learning comes from the students struggle to absorb, understand, reformulate and solve a complex real world problem setting. It is very important to understand that

“Problem Based Learning” is not the same as “Problem Solving Learning:

“*Problem-based learning* is sometimes confused with *problem-solving learning* (Savin-Baden, 2000). Problem-solving learning is the type of learning that has been traditionally used for years. In problem-solving learning, students are given a lecture and then a set of questions based on the information given. Students are expected to find solutions to these questions and bring them to the class for discussion. The focus is largely on finding the answers expected by the lecturer and these answers are rooted in the information supplied to students. PBL is different as the focus here is on organizing curricula around problem scenarios and students are not required to acquire a predetermined series of right answers. Instead they are expected to engage in the complex situation presented to them and decide what information they need to learn and what skills they need to gain in order to solve the problem.” [9, 10]

When using PBL-inspired methods, as we have done in the Industrial Master Program, we notice clearly that our role as a teacher changes. We have certainly kept our traditional function as lecturers delivering subject matter knowledge in our respective fields. But we have added the roles of facilitators of knowledge and senior advisors, clients and peers (we return to this topic under system component 10: Faculty Alignment).

The bottom line in our version of PBL is aligned with our goal of turning *problem solvers* into *problem formulators*. We insist on presenting the students with vaguely structured problems and open ended questions – Why? Because ill structured problems prepares you for a managerial position. Outside school, no one will give you a structured and precise problem to solve. There is seldom only one correct answer to real world problems. This training should start in the education context, not after the transition to work life.

Our most explicit use of PBL is to assign our students with the role as consultants. As touched upon above, in the three courses PIM, ITTEC and CPIM we instruct them to act as if they were hired by an industrial company to formulate a problem and solve it. In the first two courses the level of authenticity is not that high, even if we deal with real world companies. But in the last course, CPIM, we actually go live.

Considering the objectives of the program, one can ask if it is a relevant setup to let the students work as management consultants for an industrial company. The answer is yes. Statistically up to 50% of our students start their career as a consultant (management, IT/management, technology/ management). In addition, if they don’t they will probably be buyer’s of consultancy services and, most important, the course demands a temporary project, so the line manager role is not valid in this setting – and the industrial challenge is the same.

5.2 System Component 5: Authentic Case Learning

Learning activities within the Industrial management master program must encompass elements that bring *ambiguity* to the problems that our students are challenged with. This is an important aspect in all types of management education. However, in a situation where students come from a learning environment where numeric precision has been highly rewarded we believe that prompt introduction of ambiguity with in the learning activities is particularly important.

The use of cases and case-based learning is one of the most practiced methods to enhance student’s ability to reason, make decisions, and introduce ambiguity in order to prepare for the uncertainty of professional work-life [12]. Christensen and Hansen have expressed the importance of cases in business education with precision:

“A case is a partial, historical, clinical study of a situation which has confronted a practicing administrator or managerial group. Presented in narrative form to encourage student involvement, it provides data – substantive and process – essential to an analysis of a specific situation, for the framing of alternative action programs, and for their implementation *recognizing the complexity and ambiguity of the practical world*.” [13, p. 27, our italics].

Case-based learning is nothing new in management education. A pioneer and a forerunner in case-based learning and teaching is Harvard Business School that adopts their entire MBA curriculum to the HBS Case method and puts case method teaching as the number one success factor of its MBA education [14].

However, the classic case learning approach (e.g. represented by the implementation at HBS) has more recent been up for debate and the limitations that have been brought up are particularly valid for management education. Two aspects, where the second builds on the first, could be condensed from these discussions. First, the typical cases-based learning approach, using a detailed teaching approach around pre-developed cases, tends to be subject-narrow if used as the dominating teaching activity. By such an approach there is a risk that analysis, solutions, and discussions will be more centered around theoretical concepts then what effects the business context have on the decision process. Hence, the outcome could be described as a deepening of students’ declarative knowledge; missing out much of the functional knowledge, which is often a core objective in management education [1]. Secondly, the issue most intensively discussed is whether business schools have failed to incorporate enough of business ethics and a deep understanding related to real-world responsibilities that comes with the positions that their students aiming for – a discussion leveraged by the focus put on the financial sector during the latest financial crisis. In *Rethinking the MBA* [15] it´s argued that the case-based approach at HBS has evolved to “problem sets, narrowly designed to teach technical skills” instead of develop skills to apply in a “broader company and industry context”. There are also a number of pedagogical founded development trends associated with the limitations of pre-developed cases described above. One is the pedagogical approach where students develops and write the case [16]. By this approach the students encounter a more vivid reality and the whole process of writing the case adds several learning opportunities compared to the pre-written case approach.

In short, case-based learning has been a central pedagogical tool in management education for numerous of decades. However, recently there have been voices raised against too narrow teaching methods associated with business-oriented cases.

In the master program in Industrial management we use cases in the whole range from pre-written cases to the introduction of a real-world case. We see a need for a progression beyond pre-developed cases. In particular, an expansion of the context richness in the cases used – a context that the students can "see – feel – change" [17]. Traditional case methodology is not enough to reach the learning objectives of a master program in Industrial management. We argue that authentic *live cases* are a necessity when trying to turn problem solvers into problem formulators.

The authentic case methodology is establiched in the two program level courses mentioned (PIM and ITTEC) and executed fully in CPIM. In line with our design and the size of the master program, 3-4 industrial companies are required as partners in the CPIM-course. Most companies could be considered as "industrial companies". Students from the Industrial management master program should, therefore, also be prepared for a broad range of companies that need their competence in their organization. Hence, our interpretation of "industrial" is not equivalent with "large manufacturing" companies – let's say, "engineering" profiled companies like Ford or Volvo. The Swedish company IKEA is an excellent example of a company illustrating today's broadness of what could be labeled an "industrial company"; that is, a company with complex operation and a large demand for engineering and industrial management competence. This broad picture of "industrial companies" has guided us when approaching suitable partners for "change projects". In 2011 the partner companies had the following character:

Company A: Supply chain and logistics (Manufacturing)

Company B. Strategic purchasing (Food retailer)

Company C: Functional sales (IT-company)

All companies represent large industrial companies (Net sales >25 000 MSEK), two are global and one is pan-Nordic, and all have a strong demand of Industrial management competence.

The project should focus on current, or future, challenges that the companies' have identified within their operations. An additional requirement is that the possible implementation of a project should not be a too far into the future; we argue that more near term implementation date (e.g. 6 month to two years) enhance the likely hood of more detailed input to the change project. The focus of the projects can vary from more strategic to functional. However, it must fit with in the scope of the 20-week duration of the project and relate to one, or several, subject areas covered in the program. That is, development of new financial products for a bank will not qualify; while a financial strategy for an industrial investment will qualify.

All together, each team presents the whole scope of the project for the company representatives three times (problem formulation; mid-project reporting; final product). Two, or more, representatives in managerial positions attend these presentations. One of these is also the contact person towards course management. During the project students visit the company several times. Planning, setting up meetings, interviews and other types of data collection have been important parts of the skills training. Students know that the access and quality of the processes will affect their empirical foundation in the final report. On top of this we also use secrecy agreements between the students and the companies. This is important for all parts, not the least for the sense of authenticity among the students.

From a course design perspective this setup is also associated with several risks. Things could change in the companies during the time of the course and contact persons can get new positions. In addition, interacting with a company could also be (too) demanding for the students. Two measures have been taken to reduce these risks. One is that each project is required to conduct a benchmarking study related to the project. If resources are stressed at the company, the benchmarking part could be allowed to take a larger part in the students´ project (without limiting that ability of students to reach the learning objectives). The other is the role of the company coaches. Each group has a coach from the faculty with a close contact to the company representatives. This is a vital resource that helps both students and the company in any matter or emerging problem. The coaches also evaluate the progression and results of the work from an industrial/company perspective.

Building the learning activities around authentic challenges within the partnering companies is, needless to say, the strongest aspect of authenticity and change management in the whole program. We argue that few alternatives can offer similar opportunities for our students to experience the characteristics of related to change management.

5.3 **System Component 6: Prototyping and Authentic Feedback**

The last component in the category "Learning activities" comes from our focus on tangible communication – you are supposed to actually build something in an Industrial masters program. But instead of workshops and laboratories we used seminars and we based them on the notion of "prototyping": that you gradually build your project work trough repeated mock up versions – prototypes. Again the notion of prototyping has been gradually implemented in the program starting in PIM, being more developed in ITTEC and finally in a sharp situation in CPIM.

Inspired by Larry Leifer at the PIEp Workshop: *Changing Mindset, Improving Creativity and Innovation in Engineering Education*, Stanford University, 2010, we have launched the concepts of “prototyping” and ”protostorming”. At prototype seminars the students present their work and get feedback from teachers, industrial clients and peers.

We us Larry Leifers metaphor: ”Hunting party in unchartered terrain” to explain the iterative nature of the type of work we expected the students to perform: “Search one area – Return to camp and report – Go out again based on the discussion in camp: Non linear problem formulation; Jump between ”theory” and ”empirical findings”.[18] In fact Larry Leifers methodology is very close to our interpretation of Problem Based Learning.

We aimed at creating a context where collective effort and cooperation was the most effective way to complete the assignment given. We stressed that on this particular “hunting trip” you should never go alone, work hard to preserve ambiguity and that all design is re-design (Larry´s three rules).

The prototyping seminars were aimed at strengthening the incentive for peer-peer learning by focusing on tangible communication (show and talk) – although the product was a written paper/report and an oral presentation. By prototyping and ”protostorming”, and with a focus on unfinished presentations of ideas and prototypes, we wanted to create a creative atmosphere.

In the CPIM-course we had four mandatory prototype seminars (cross section) and reoccurring coach seminars (scheduled and on demand).

The practical setup was quite complex managing 80 students. As mentioned we had three companies (company A, B and C) included in CPIM. Each company was assigned three student/consultancy teams (7-8 students each). Thus we had a total number of nine groups (A1-3, etc.) investigating three industrial areas. To avoid free riding and at the same time maximizing learning we organized the prototype seminars in two categories:

<u>Coach seminars:</u> The three consultancy teams from each respective company were assigned a company coach from faculty to discuss common problems, factual details and practical matters close to the company and the industry.

<u>Cross-section seminars:</u> In this type of seminars we cut the groups in another way and arranged seminars for a cross-section constellation of groups: ABC-1; ABC-2; ABC-3

Each team got the same general assignment from course management: “You are to act as a consultancy team. Based on the assignment you get from your company: Define a problem that is not trivial. Suggest a plausible solution to this problem in a report.”

Before the first prototype seminar the three companies had given a lecture on their respective businesses and presented a general problem formulation. Each team got the task to formulate their preliminary *problem formulation,* a preliminary *general research question* and a preliminary *objective*. This was called “Prototype 1” and presented orally and as a Power point at the first prototype seminar.

Before the second prototype seminar the three teams from each company (A1-3, etc.) visited the company and presented their respective prototype 1 to get feedback and comments. After this meeting each team were asked to restate a new version of their *problem formulation*, *general research question* and *objective* (“Prototype 2”). Prototype 2 also included a discussion on delimitations, a discussion on primary and secondary sources, a discussion on possible bench mark studies that could be of interest and a description of the project plan and project organization for each team. Prototype 2 was presented orally and as a Power point at the second prototype seminar.

Prototype seminar three, our midterm seminar, included all stakeholders in the course, i.e. course management, the company coaches and the company representatives. The task was to present and discuss the project work and results half way in the process by a full “mock up” report.

Prototype seminar four was the last prototype before the finalization of the report and the oral presentation. This fourth prototype was to be a preliminary version of the report based on the standard academic form <u>and</u> a preliminary version of the final oral presentation. On this fourth seminar the students were supposed to discuss the parts that were missing in the final report. Prototype 4 was presented orally and as a Power point at the fourth prototype seminar.

The last seminar was not really a prototype seminar. By now the students presented their final product in full class. The company representatives were invited and gave comments on the presentations. This was actually the first time the three student teams working for the same company were able to get to know the work of their fellow consultants.

To conclude it is safe to say that we managed to maximize the feeling of authenticity in this project course by using prototyping as a tool. The students had to interact with their clients in a continuous loop from the first feedback meeting with the company and formulating the first prototype problem formulation, over the mid-term seminar and all the way to the presentation of the final product.

We aimed at creating a context where collective effort and cooperation was the most effective way to complete the assignment given. By a focus on unfinished presentations of ideas and prototypes during the course, we managed to create a creative atmosphere. Our students did not fear change, ambiguity or unclear and vague instructions.

The combination of authentic cases and different types of feedback seminars we argue are the most important activities in order to bridge the “demands” from both academia and industry.

6. SYSTEM PART C: EXAMINATION

The third system category that needed change was the format of the examination – if you will the out-put part of our system. Following our learning activities (system part B) we wanted a strong sense of authenticity in this system part as well. Authentic live-Cases, group-based work and advanced skills training, demands non-traditional examination tools. Standardized written examination is hardly possible to implement in order to assess skills and learning from real world complexity – which we value as the most important learning outcomes in the later stages of our programs. The system part "Examination" consists of two components: *The final product* and the *Examination portfolio*

6.1 System Component 7: The final product

We have used traditional exams sparingly in the IM-program. In line with our discussion on the two first system parts (A and B) we have tried to change the traditional teacher-student relationship. We wanted our students to view faculty as a client asking for professional advice in a certain area, not as superiors policing knowledge acquirement. In many of our courses we have examined by some form of academic report, most often in the context of a consultancy project. This is also in alignment with our focus on prototyping and tangible communication – to actually produce a product. As mentioned we started this process already in the first course (PIM) and developed the final product set up in ITTEC.

Returning to our claim that the academic paper is the "mother of all papers" we postulated that in all consultancy deliveries – in what form it may be, written or oral – the structure and the logic of the academic report is of fundamental importance and vital to ensure quality, reliability and validity in any situation. We argue that IM-students must understand that mastering academic methodology and writing add value to the client. In the CPIM-course, the *final product* was defined as:

- A written consultancy report in the form of an academic paper (approx. 50-60 pages).
- A power-point presentation based on the most important results, presented orally in front of each company (20 minutes speech)
- An executive summary based on the academic paper (5-6 pages)

For the academic paper we stressed the importance of investigating the case from our IM-systems perspective (individual, functional, industrial). We used our general template for an academic paper, already utilized in the first course (PIM), we stressed the importance of both primary and secondary sources, and the need for a clear message/thesis. The template used was the standard form: Introduction – Dissertation – Conclusion.

Our demands on the academic report: accuracy, validity and reliability, was very high. We wanted our students to realize the importance of quality when delivering advice to a client. Perhaps the client won't actually read the full report. But the facts, the evidence and the arguments to underpin all solutions are stored in the report. The academic methodology is the best insurance a consultant can get.

For the power point and the oral presentation in front of the class, course management and, not the least, the industrial clients, we used a "rhetoric template" introduced in the earlier course mentioned above (ITTEC). The template is based on a classic formula of argumentative speech: *Introduction:* Create ethos – win the audience. Introduce your thesis; *Argumentation:* Use logos. Support the thesis–*three* arguments; *Conclusion:* Summary of thesis and the three arguments. End with pathos. [19]. We wanted our students to be able to boil down the three most important results of their investigation and present them in front of an audience in a twenty minutes speech.

The third part of the final product was a 5 page *executive summary* of the report and the power point, handed in to the company representatives for circulation among colleagues at the home base.

Authenticity concerning the final product and deliverance of results was very high. The industrial clients participated at the final seminar and discussed pros and cons of the results presented by all three consultancy teams working for their company. The discussions in the seminar on the validity of different, and contradicting, advice from different teams, were heated. Everyone wanted to argue for their own solution to the problem perceived. For the company representatives it became obvious that one given problem area could generate many answers. They agreed on the obvious benefit of getting their problem highlighted from several angels. But the companies agreed not only on the benefits of getting clearly stated results possible to implement in business. They also appreciated (perhaps a bit surprisingly) the thorough academic connection to theory: "This is great! Typically we don't have time to go this deep into a subject in our day- to-day business". The students learned to appreciate the difference between a written report and a speech. But more importantly, they learned "*saw* and *felt*" the ambiguity and complexity of authentic organizational *change*.

We argue that, the assessment of our "final product" represents a strong alignment of both academic and industry demands. We teach our students the importance of the academic paper as "the mother of all documents" and we deliver added value to our (the student´s) industrial clients.

6.2 System Component 8: Examination portfolio

Especially when it comes to group-based projects, central activities for how we train core skills and capabilities, assessment is demanding. A founding pillar in strong educational environments is the individual assessment of core learning outcomes – without this one can never guarantee the quality of an educational institution. Therefore, we must adapt to effective tools for individual assessments of knowledge and skills also, when educational activities are based on large group project work.

The approach used in the CPIM course builds on the early introduction and acceptation *examination portfolio* in the program. We view the examination portfolio as a form of “reversed burden of proof”. We do not assess specific pieces of knowledge like in traditional examinations. Instead students are supposed to show us to what extent they have reached the learning objectives on a master level in Industrial management relating to “knowledge & understanding”, “competence & skills” and “judgment & approach”. To put it simply the students have to argue and give evidence supporting their claim on a certain grade.

This type of examination is introduced in the first course (PIM). In the final course (CPIM) the examination portfolio consists of four parts: 1) Individual argumentation in “learning paper” for each learning objective; 2) Individual literature review (related to case); 3) Individual reflection of group’s work, progression, and achievements; 4) Signed peer-student feedback, rating and confirmation of #1. Together with the group’s final report and presentations, this represents the examination portfolio in the CPIM course.

Not only do we argue that this type of examination allows us to combine students to work with authentic cases and at the same time support individual examination; it is also in it self an authentic type of assessment. That is to say, this examination tool is very similar to professional assessment methods used in industry. For example, in performance management – as used by most companies and extensively described in the HRM literature [20] – performance assessment is partly based on the employee’s own arguments of how they have reached the goals during a certain time period.

7. SYSTEM PART D: PROGRAM MANAGEMENT

Finally, the last system category is program management. Its most important objective is quality assurance. As mentioned in the beginning of the paper, program management must work hard to monitor the system to avoid stagnation and malfunction. We really believe that a chain is only as strong as its weakest link – but the links as well as the chain need maintenance.

We also stress the fact that program management has to be aligned to the changed pedagogical setup. In the literature lack of involvement from management has been pin pointed as one of the most severe obstacles for change in higher education teaching. However, reflecting over how one’s own role in educational change processes is central [1].

7.1 **System component 9: Quality assurance**

The quality assurance in the program is handled in four different ways. First, on the highest level, KTH’s periodical Education Assessment Exercise represents the main activity. This thorough process includes mapping of all courses’ learning objectives against the learning objective of the program and the specific degree (objectives set by the authorities of higher education in Sweden). The process also includes formal program evaluations, student interviews, quantification of specific targets (such as gender balance), and the involvement of external international assessors.

Second, program management closely monitor the program’s learning objectives to secure alignment and progression of content and examination forms, especially in the three courses already mentioned in the overview (see above). On a course level quality assurance is reached trough close cooperation between management and faculty (see below) and trough quantitative course evaluations by the students. Continuous monitoring and feedback is also handled by the establishment of a student board of elected students and a program board with representatives from all compulsory courses.

Thirdly, we have used student evaluations very actively in the IM-program. Although the program is quite young we have had we have achieved high scores from the students. For example in the CPIM-course the overall rating was 4,35 of a 5, and more importantly the qualitative statements of the students indicates a success in our pedagogical approach.The biggest difference from earlier experiences of evaluation methods is our focus on the explicit learning objectives on both program and course level. The evaluation forms always include questions on the perceived usefulness of the particular course in relation to future work life and career. We do not ask the students if they “like” our teaching. We ask them if course content and learning activities has reached the goals stated in the learning objectives and if the specific course is constructively aligned in the whole program. And, we ask them to motivate their reflections and analyze their own learning process. By this we get a much fuller picture of student learning compared to traditional evaluation forms. The focus on learning objectives also creates an atmosphere in which students feel that they actually can contribute in program and course development trough constructive criticism.

Active use of student evaluations has helped us to correct mistakes and to keep and strengthen god parts. We have used the input on three levels (more actively on level 1 and 3, but we hope to develop level 2):

1. Course development
   This is of course the most common way to use evaluations – as input on development of a specific course. But focusing on learning objectives instead of likes and dislikes gives us concrete information that can be implemented at once.
2. Alignment between courses
   We have used student evaluations to check the alignment between courses in the program in respect to learning objectives, content, activities and examination forms. Thus we can correct overlaps, and more importantly monitor progression and variety between courses offered.

3. Program development
   We ask our students questions on constructive alignment of specific courses in relation to program level learning objectives. This is especially important feedback concerning authenticity. Our students must get an education that prepares them for reality.

The fourth and last aspect of quality assurance is the level of our actual results – our products. Being only in our second year we can´t produce any quantitative measurements yet. But our strong impression is that the academic quality of reports and presentations is very high and that our work to overcome the divide between demands from academia and industry has proven fruitful. Later on we will closely measure the quality of the master thesis projects from the program, especially to reveal the difference between the old master program and our new approach. In a longer perspective alumni will be an important source for quality assurance.

7.2 **System Component 10: Faculty alignment**

Already in the initial stages of the program design process we involved all teachers that were to be responsible for courses within the Industrial management program. Discussions concerning learning approaches, theoretical coverage, and types of examination – especially if they promote change – have a tendency to be stormy in the university environment.

In this work we believe strongly that the fact that most teachers had passed an internal pedagogical course, had a strong impact on aligning our view on the pedagogical approach in both courses and on a program level. As in all projects, involvement also implies the possibility to for the individual to influence. Hence to start early with the involvement of all teachers – when there still was room for rethinking – have been an important factor.

As mentioned, the change process related to the design of the industrial master program was also supported by a sense of “urgency” (important aspects in most literature on change management). This was related to KTH’s decision to follow the “Bologna process”. In the Swedish educational system this meant that our traditional 4.5 year engineering programs should be divided in to a 3+2-year structure (representing a BSc and a MSc degree). Put another way, if we wanted to change our way of teaching fundamentally and systemically – this was the time to do it!

Next, in order to achieve alignment, integration, and progression throughout the program all teachers have to have a rather good understanding of content in the other courses. Several workshops were arranged with a focus on mapping learning objectives, learning activities, and examination types of each course with the learning objectives of the program. This was not a direct success; rather it was a learning process where ideas came first after each teacher had started to understand details in other parts of the program as well as the whole picture.

We should also mention that not only our faculty is involved in activities regarding educational change. Related to the Bologna process, KTH as a university have also increased activities that support implementation of new teaching activities and program designs. Particularly important to this master program and our personal engagement for these change process was the workshop at Stanford University “Changing Mindset, Improving Creativity and Innovation in Engineering Education” which fuelled our ambitions and helped us modeling through with the most challenging changes in this work.

Finally, as mentioned our professional field is widened due to the change process in creating the IM-program, we have introduced the following teacher roles in our program:

- Lecture on demand: The faculty or invited guests address subject matters asked for by the students in their own search for relevant knowledge
- Lectures on the “philosophy of the program”: We openly address PBL, CDIO, academic writing, oral communication, etc. Our goal is to convince students of the real world value of these skills in their future industrial work place
- Seminar leaders or moderators in student driven seminars
- Costumer – not teachers: We introduce, quite strongly, a change in mind set. We want the student to look upon the teachers as costumers or clients asking for good advice in the fields of Industrial Management. They are not simply asked to answer questions in exams.

8. CONCLUSION

The objective of this paper was to present and discuss our explicit use of a systems perspective in designing the Industrial masters program. We identified four major parts of “our system” where changes had to be made: *Premises – Learning activities – Examination – Program management*. These four system parts were divided into ten subsections – “systems components”. We have discussed all four system parts in relation to our goals to enhance *authentic skills* in *change management*.

In the paper we have not talked a lot about risks and drawback following our set up. Of course they exist. For example we don´t have a lot of elective courses in the program. This fact reduces the possibility for individual student specialization. But we need a high number of compulsory courses in order to secure quality and constructive alignment both in content and learning activities. Another drawback is that our setup is not easy to combine with longer periods of studies abroad. A generic risk in all projects including this type of systemic change is the dependency of enthusiastic individuals. We have to trust on a few individuals taking an overall view, motivation and aligning the components in order to reinforce the continuing change of the system. As mentioned, a chain is only as strong as its weakest link – but the links as well as the chain need maintenance.

We will not repeat all our arguments and conclusions. But if you really want to change higher education, we believe that this paper gives sound evidence for the necessity of change in all system parts and system components. If you want to "mould" students into industrial managers able to master complex industrial change processes, you also have to "mould" your own pedagogical tools, examination forms, and not the least, faculty. We argue that you must implement a *Systems perspective*, both in regards to program and course design and in regards to the actual skills you want to teach.

In addition, trough our pedagogical program "system" we argue that students are given the toolbox for lifelong knowledge acquirement and the abilities to approach tomorrows´ challenges in Industrial management.

We end by giving two examples, quotes from the evaluation of the CPIM-course in the autumn of 2011:

"[the best thing was] the prototyping concept with feedback, which allow the group to constantly work with the final product. In the case where you only get feedback in the end of the course it's easy to forget about it. Recurring feedback and meetings with the team coach has also been great -reality-based cases, thats really good!"

"One main strength, believe it or not, has been the ambiguity of the case. It really feels as if we did not get much help from anybody - but this is good! I can really picture that is how it is in real working life, people are not always gonna have your back and you have to make the most of the little information you have in a complex environment. It really feels as if this course has made me less afraid of vaguely formulated problems in a serious and "sharp" context, and actually being able to deliver something after all makes me have a confidence boost and feel some pride."

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Lanac je jak koliko i njegova najslabija karika: upravljanje promenom u obrazovnom studijskom programu industrijskog menadžmenta

Pär Blomkvist i Lars Uppvall

Rezime

U ovom radu govorimo o procesu kreiranja novog Master programa za industrijski menadžment na Departmanu za industrijsku ekonomiju i menadžment na Kraljevskom institutu za tehnologiju (KTH) u Štokholmu u Švedskoj. Temelj Master pograma za industrijski menadžment nalazi se u pojmovima autentičnosti i promene. Na početku procesa kreiranja odlučeno je da je naš cilj da podučavamo veštine menadžmenta promene u stvarnom svetu i da „ukalupimo" naše studente u industrijske *menadžere koji mogu da savladaju složene procese industrijske promene. Ali shvatili smo da takođe treba da „ukalupimo“ naše vlastito pedagoško oruđe, forme ispita, i ne manje bitno, fakultet, kako bi postigli naše ciljeve. Ovi uvidi doveli su nas do toga da je poseban akcenat stavljen na sistemsku perspektivu,kako u pogledu programa i kreiranja kurseva, tako i u pogledu stvarnih menadžerskih veština koje smo hteli da predajemo.*

Cilj ovog rada je da se predstavi i argumentuje naša eksplicitna upotreba sistemske perspektive u kreiranju industrijskog Master programa. Identifikovali smo četiri glavna dela „našeg sistema“ gde su promene neophodne: Premise – Aktivnosti učenja – Ispit – Programski menadžment. Ova četiri dela sistema podeljena su u deset jedinica – „sistemskih komponenti“. Rad govori o sva četiri dela sistema vezano za naše ciljeve da poboljšamo autentične veštine u menadžmentu promene.

Ključne reči: *sistemska perspektiva, metodologija autentičnih slučajeva, industrijski menadžment, univerzitetsko obrazovanje, Master program*