Building integration skills in supply chain and operations management study programs

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Abstract

The modern business world requires, in addition to substance knowledge, an extensive set of more practical and generic skills from engineering graduates. Supply Chain and Operations Management (SCM/OM) experts often work as business process developers. This requires skills related to for example cross-functional coordination and the ability to comprehend the big picture and dynamics of supply chains and operation environments. Sharing experiences of generic skill descriptions and teaching methods would facilitate the translation of generic skills into different engineering education disciplines. The aim of the paper is to present a way of describing and categorizing the focal SCM/OM generic skills and to analyze how the skills can be adopted and implemented in SCM/OM study programs. The paper is based on an empirical case analysis of a SCM/OM study program. The main generic skills related to the SCM/OM discipline are described and categorized into two skill areas: the ability to design feasible improvement solutions and the ability to carry out improvement work in organizational networks. These described skill-sets are named integration skills. Teaching integration skills in SCM/OM study programs should be fully integrated with the teaching of substance knowledge, and integration skills should be developed progressively in stages throughout the studies using activating teaching methods. In teaching integration skills, the recognized and analyzed pedagogical methods are the use of increasingly challenging real-life assignments and empowering working processes for students. A combination of the methods in teaching sets gradually increasing requirements for students in learning both integration skills and substance knowledge.

Keywords: Supply Chain Management; Operations Management; Industrial Engineering and Management; Generic competences; Academic education; Study program; Teaching methods

1. Introduction

As an academic Industrial Engineering and Management (IEM) education discipline, supply chain and operations management (SCM/OM) has core substance knowledge that is composed of key concepts, theories and techniques of various fields. These include for example production planning and control, distribution-planning, demand forecasting, inventory management and control, supply chain design and management, and service operations management. In addition, deep understanding of the integration, interdependencies and dynamics of these areas in different types of business environments is a fundamental knowledge requirement for the education (e.g. Chikan, 2001; Holweg and Bicheno, 2002; Pal and Busing, 2008; Rahman and Qing, 2014).

The modern business world increasingly requires from engineering graduates, in addition to the substance knowledge, an extensive set of more practical and generic skills (e.g. Chan et al., 2017; Kordova and Frank, 2014). Modern engineers need to be able to work in teams, communicate effectively, think creatively and critically, act responsibly and use a wide range of other personal and professional skills and competences (e.g. Crawley et al, 2014; Knight et al., 2014; Kordova and Frank, 2014). Varied sets of skills, knowledge and attitudes are essential to strengthen productivity and excellence in increasingly complex work environments (Crawley et al., 2014). Graduates in the field of Industrial Engineering and Management especially need to develop balanced skills both in classic engineering tools and in "softer" management areas as they work in the interface between engineering and management (e.g. Knight et al., 2014; Kordova and Frank, 2014). However, there has been long existing tension between the different types of knowledge and skills in engineering education (Crawley et al., 2014). Studies have shown that generic skills in engineering curricula still have a relatively low status and education schemes do not sufficiently connect practice to theory (Basnet, 2000; Chikan, 2001; Male, 2010).

SCM/OM experts often work as business process developers, which requires for example negotiation skills, cross-functional coordination skills and the ability to comprehend the big picture and dynamics of supply chains and operation environments (Holweg and Bicheno, 2002; Pal and Busing, 2008; Rahman and Qing, 2014). In addition, this integrating role between different organizational functions and network partners requires the ability to comprehend complicated cause-effect relationships, ability to analyze improvement opportunities and challenges, ability to create improvement solutions and recommendations for decision-making, as well as the ability to apply analytic methods and implement changes with organizational improvement teams and projects (e.g. Rahman and Qing, 2014; Sohal, 2013).

It is widely acknowledged that academia needs to take better into account the wider requirements and skills in engineering study programs, and this calls for the systematical reform of engineering education systems (e.g. Chan et al, 2017; Kordova and Frank, 2014, Male, 2010). The wide skills and competences are essential requirements in carrying out expert and managerial work tasks in the supply chain and operations management. Hence, they should be an integral part of SCM/OM study programs and curricula.

Even though curricula need to be adapted to the specific program's goals and other national and disciplinary contexts, there are similar issues and broadly applicable approaches to guide and accelerate engineering education improvement efforts worldwide. The essence of the approaches designed to renew engineering education curricula is the recognized need for dual-impact learning - promoting both the learning of technical fundamentals and the generic skills (e.g. Crawley et al. 2014; Male, 2010).

Currently, the generic skills needed in higher education are discussed in the literature on a rather general level. Therefore, more evidence and discussion on how to translate the higher-level generic skills into more narrow engineering disciplines (like SCM/OM) is needed (e.g. Crawley et al., 2014; Kordova and Frank, 2014). Furthermore, for the renewal of curricula to be consistent and effective, more empirical evidence and research is needed concerning the skills required in different engineering fields, as well as concerning the most effective curriculum designs and teaching methods to achieve the skills needed (e.g. Basnet, 2000; Chan et al., 2017; Crawley et al., 2014). Additionally, to facilitate the curriculum improvement efforts, research studies should analyze the functionality of entire engineering education programs and the operability of different teaching practices to provide potential solutions (Donnelly, 2010).

The overall objective of the paper is to analyze how the required key generic skills can be adopted and implemented in SCM/OM study programs. The research questions of the paper are:

1. How can the main generic skills needed in SCM/OM study programs be described and categorized?
2. How can these skills be incorporated into SCM/OM study programs and what pedagogical methods are suitable?

The study is carried out as an empirical case analysis of a SCM/OM study program. For several years, the authors have been involved in planning the content of the program and carrying out the teaching. The analysis is conducted by combining and comparing the literature concerning generic skills and the development of them in engineering, IEM and SCM/OM education to the current state of the studied program. The analyzed program is a part of the Industrial Engineering and Management (IEM) education in Lappeenranta University of Technology (LUT).

Chapter 2 describes the general content and structure of the analyzed SCM/OM study program as part of the IEM education at LUT. Chapter 3 presents a literature review concerning generic skills in engineering education, as well as the education practices and methods in developing generic skills in engineering education. Chapter 4 presents the research process of the study. Chapter 5 presents the findings of the study. Chapter 6 presents concluding discussion concerning the key findings of the study.

2. Supply Chain and Operations Management Study Program

Lappeenranta University of Technology (LUT) is a science university located in southeastern Finland. The university has academic education and research activities both in technology and business. The Supply Chain and Operations Management (SCM/OM) study program in Lappeenranta University of Technology (LUT) is a degree program under the university's Industrial Engineering and Management education. In general, the Industrial Engineering and Management (IEM) education aims to combine the fields of technology and business management and teach students to become equipped for organizational development by merging technology and management skills. The IEM education includes a Bachelor's degree program (180 ECT, 3 years) and five consecutive Master's degree programs (120 ECT, 2 years).

The SCM/OM study program is one of the five specialization programs under the IEM Master's level education. The number of graduates is approximately 40/year. As a part of their Bachelor's studies, all students take compulsory study modules related to Supply Chain and Operations Management. This structure enables a continuum of SCM/OM studies throughout the whole education process. The key SCM/OM study modules included in the Bachelor's and Master's degree programs are presented in Figure 1.

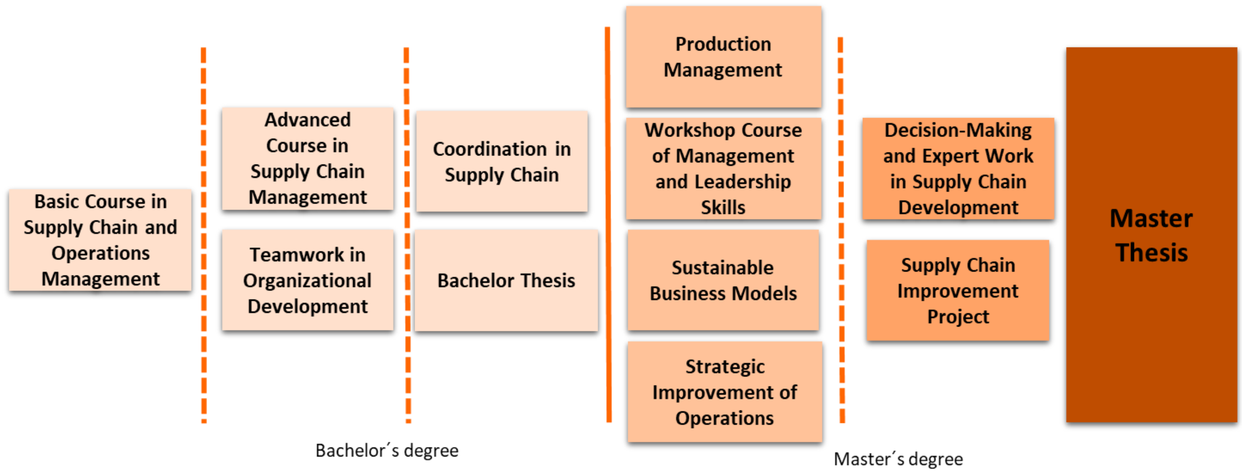

Figure 1. SCM/OM study modules

The general aim is that, during their Bachelor's degree studies, the students acquire basic knowledge of key concepts, theories and techniques. Whereas in Master's degree studies, the students will specialize and deepen their knowledge and ability to apply SCM/OM methods appropriately, create management solutions and carry out improvement work independently.

3. Literature review

The labor market of graduates is constantly under both technological and environmental changes (Bunney et al., 2015; Chan et al., 2017; Torenbeek et al., 2011; Kember et al., 2007). This kind of changing modern business world requires, in addition to substance knowledge, an extensive set of more practical and generic skills from graduates to match heterogeneous graduates to heterogeneous jobs (Heijke et al., 2003).

There is a well-established international need for university students to acquire a higher level of generic competences (also referred as a variety of other terms such as graduate attributes, core skills, key skills, and generic attributes) throughout their studies to match the needs of the labor market (Bunney et al., 2015; Freudenberg et al., 2011; Torenbeek et al., 2011; Kember et al., 2007). Because of the changes in the modern business world, working situations have become more diverse and non-routine-like (Vaatstra and Vries, 2007). The varying working situations require the graduates to be flexible and able to adapt to dynamic environments (Bunney et al., 2015).

Even though there is a lot of research revolving around generic competences, there is still no clear definition for them. The definition of generic competences can differ between disciplines and individual academics (Badcock et al., 2010; Chan et al., 2017; Bunney et al., 2015, Barrie, 2007), and it has been suggested that each faculty or institution could possibly develop its own definition of generic competencies (Barrie, 2007). However, common to the different definitions is that generic competences can be described as work-related competences, values and attitudes, which are not discipline bound and can be used in different professional contexts (Chan et al., 2017; Vaatstra and Vries 2007).

3.1 Generic competences and skills in engineering education

Based on the recognized need for a more comprehensive skill set, Crawley et. al. (2014) identified an underlying need to educate engineers who are able to *Conceive-Design- Implement-Operate* complex value-added products, processes and systems in a modern, team-based environment. This designed engineering education framework is called the CDIO-approach. Within this framework, a taxonomy of specific learning outcomes and skill sets for engineering education have been identified: disciplinary knowledge, personal and professional skills and attributes, interpersonal skills and the ability to understand enterprise, society and environmental contexts.

It is important to acknowledge that the need for generic skills does not diminish the importance of technical fundamentals in engineering education. The education should emphasize the importance of deep working knowledge of technical fundamentals and conceptual understanding, where the students gain the ability to apply knowledge across a variety of circumstances (Crawley et al, 2014). Specialization in IEM-field and in SCM/OM subject area should enable graduates to be managers and experts in the subject area and have deep knowledge of different supply chain and production related fundamentals (Basnet, 2000; Kordova and Frank, 2014; Rahman and Qing, 2014). In addition to subject knowledge, the skills related to cross-functional coordination, the ability to see the “big picture” of business management, as well as team orientation and communication have been seen as especially important skill areas for SCM/OM experts and professionals (Pal and Busing, 2008; Rahman and Qing, 2014; Sohal, 2013).

Additionally, the different personal and interpersonal skills needed include for example analytical reasoning and adaptable problem-solving, experimentation, communication skills, system thinking, critical and creative thinking, responsibility and the willingness to make decisions in the face of uncertainty (e.g. Chan et al, 2017; Eskanderi et al., 2007; Kordova and Frank, 2014; Male, 2010). Kordova and Frank (2014) pointed out in their study that the acquired skills need to be diverse especially in IEM curricula where graduates work in a business world where decisions are not always based on pure facts but also on managerial aspects, multidisciplinary knowledge and a broad systemic viewpoint (for example recognizing opportunities and analyzing organization-wide processes). Similarly, Jordan and Bak (2016) bring forth the diverse skills needed for SCM/OM graduates, including strategic skills, process management skills, people management skills, as well as decision-making and behavioral skills.

Various definitions, classifications and taxonomies related to generic skills in higher education can be identified in the literature (e.g. Chan et al, 2017; Crawley et al., 2014; Eskanderi et al., 2007; Kordova and Frank, 2014; Male, 2010). Sharing experiences of generic skill definitions and classifications across education disciplines would facilitate and guide the efforts of determining the key generic skills required in different educational contexts. In SCM/OM education, more examples and empirical analysis would be needed on generic skill descriptions and classifications incorporating the specific features and needs of the discipline (e.g. Kordova and Frank, 2014). Research attention should be paid especially to the ways of concretizing and focusing the higher-level generic skills into more narrow disciplines. Concrete and focused generic skill descriptions and classifications would enable effective curriculum and course design and the utilization of the most appropriate teaching methods (e.g. Crawley, 2014; Donnelly, 2010; Kordova and Frank, 2014).

3.2. Teaching practices and methods in developing generic skills in engineering education

There has been tension between theoretical and practical needs in engineering education (Crawley et al., 2014), and engineering education curricula and teaching methods have been criticized for emphasizing specialist skills and not giving enough attention to generic skills (Male, 2010). Traditional teaching often uses a transmittal approach, where students are assumed to gain knowledge mainly though passive listening (Crawley et al., 2014). This traditional approach is also called a surface approach to learning in contrast to deeper approaches. (Crawley et al, 2014). Currently it is well acknowledged that engineering education needs to incorporate a variety of skills and apply deeper approaches to learning (e.g. Chan et al, 2017; Crawley et al., 2014). Deeper learning approaches are suitable for effectively incorporating and integrating both generic skills and technical substance into teaching, without the need to make trade-offs between them (Crawley et al, 2014). This means that the structure of curricula, learning contexts and environments, as well as teaching and assessment methods need to be addressed to include the dual goals and outcomes of learning and make them more explicit in teaching (e.g. Crawley et al., 2014; Hoddinott and Young, 2001, Kordova and Frank, 2014).

A learning context means a set of surroundings and environments that contribute to understanding and in which knowledge and skills are learned (Crawley et al., 2014). Within the learning context, modern pedagogical approaches and innovative teaching methods are called for, in order to identify learning needs and provide concrete learning experiences for students (Crawley et al., 2014). The students need to have opportunities for the active application of theories to facilitate both deep understanding and to promote generic skills (Crawley et al, 2014).

The literature suggests that the learning of generic skills and competences should be combined and taught simultaneously with technical knowledge to build well-balanced and structured integrated curricula and to develop "generic engineering competences" (e.g. Chan et al, 2017; Kordova and Frank, 2014, Male, 2010). Generic competences tend to develop progressively and cumulatively as a result of continued learning, contextual practices and feedback (Bunney et al., 2015; Jordan and Bak, 2016). As skills are developed structurally in the context of some specific subject, they can be transferred for use in related subjects and contexts (Hoddinott and Young, 2001). In IEM curricula, the skill areas and discipline subjects often need to be integrated to avoid extensions to curricula (Kordova and Frank, 2014). The integrated approach also decreases the tension between knowledge of technical facts and acquisition of generic skills (Crawley et al., 2014). The curricula should also integrate SCM/OM studies with other business disciplines in order for students to understand the interdependencies of various business functions and to avoid the silo approach in SCM/OM education (Pal and Busing, 2008).

Integrated curricula should contain a sequence of well-planned learning stages, which help interconnect concepts and build knowledge (Crawley et al, 2014). The staged approach to teaching and learning help students gradually become more and more self-directed (Grow, 1991). The curricula should include different types of learning experiences already in the early stages to provide opportunities for the students to utilize and improve the acquired skills effectively throughout their studies and beyond (Hoddinott and Young, 2001). However, this requires that the students' development and ability level have been considered (Chan et al, 2017; Torenbeek et al. 2011). The stages in the curricula can include for example introductory engineering studies (framework for subsequent learning), conventional disciplinary studies (demonstration of the need for interdisciplinary efforts) and final project studies (substantial experience) (Crawley et al, 2014). In IEM studies, the integrated smaller and larger project assignments are especially important because they enable early business experiences and breadth of training for students (Kordova and Frank, 2014). The final year degree projects have also been shown to improve the autonomous learning and self-directive skills of students (Olmedo-Torre et al., 2018).

Studies have shown that more activating learning environments provide students with more generic competences (e.g. Prince and Felder, 2006; Vaatstra and Vries, 2007). In addition, activating learning environments also increase and deepen technical and subject-specific knowledge and understanding (Vaastra and Vries, 2007). Thus, the ideal learning environment for the development of generic competences is interactive and collaborative involving reflective learning and feedback, versatile evaluation methods and integration with working life (Freudenberg et al., 2011; Kember et al., 2007; Torenbeek et al. 2011). Based on these recognitions, it is important that the curricula consist of mutually supporting courses, which utilize the interactive learning approach and activating and experiential teaching methods. Examples are the problem-based learning (PBL), case-based learning and project-based learning approaches. (Donnelly, 2010; Prince and Felder, 2006; Vaastra and Vries 2007) In order to train students to be able to work in increasingly complex networked environments, studies must include complex and "real-world" problems which are structured in a way that there is not one specific correct answer or predetermined outcome and which require integrating tools and techniques (Donnelly, 2010; Gravier and Farris, 2008). Different simulation tools and education games can be used to facilitate experiential learning, demonstrate different phenomena and educate holistic improvement efforts rather than partial and silo solutions. Consequently, there is an established tradition of teaching operations management with different types of production games, where players make decisions in a practical, simulated situation. However, broader conceptual reflection on experiential learning in the SCM/OM educational content would be needed. (Holweg and Bicheno, 2002; Lewis and Maylor, 2007)

A clear trend also for SCM/OM education is the enthusiasm for e-learning, virtual learning, digitalization of teaching and introducing different blended learning education approaches (Arenas-Marquez et al., 2012; Donnelly, 2010; Greasley et al., 2004, Kakehi et al., 2009). Blended courses integrate e-learning with traditional face-to-face class activities in an intentional pedagogically valuable manner. Especially the combination of case-based methods and e-learning has proved to have potential in engineering education. (Arbaugh et al, 2010; Kakehi et al, 2009) The promises of blended learning in the literature are extensive. However, it is acknowledged that more examinations and studies would be needed concerning the interplay between new teaching technologies and pedagogical needs in academic higher education (Arbaugh et al., 2010; Donnelly, 2010). Especially the possibilities of new technologies to make learning more (not less) interactive and experimental should be explored (Arenas-Marquez et al., 2012).

Transition to pedagogical approaches and methods which better include generic skills in engineering education is difficult and requires changes in curriculum design, teaching practices and mindset (e.g. Crawley et al. 2014). Important design principles in this transition can be identified in the literature: application of integrated learning approaches (e.g. Crawley et al., 2014; Jordan and Bak, 2016; Kordova and Frank, 2014), application of staged approaches in building knowledge and skills (Grow, 1991; Hoddinott and Young, 2001; Jordan and Bak, 2016; Kordova and Frank, 2014) and application of activating and experiential learning methods (Chan et al., 2017; Donnelly, 2010; Holweg and Bicheno, 2002; Vaastra and de Vries 2007). However, to further facilitate the improvement of engineering education programs, more empirical research and experimentation are needed concerning the concrete pedagogical methods in applying the approaches in different engineering disciplines and curricula to achieve the dual-outcomes of learning (see e.g. Crawley et al., 2014). Especially analyzed experiences would be needed on the possibilities to plan systematic and coherent application of pedagogical methods throughout the studies to enable graduate learning of both integration skills and substance knowledge.

4. Research process

This study depicts a snapshot of the present situation of the analyzed SCM/OM study program, the currently needed generic skills of SCM/OM graduates and the ways these skills are advanced. The case program enabled thorough analysis on the subject because the program has been renewed considerably during the last decade based on the recognized need for a more comprehensive skill set for SCM/OM students.

The analysis of the program was carried out by reflecting the program curriculum against two sets of literature:

1. The literature on generic skill requirements in the engineering, IEM and SCM/OM fields

2. The literature on teaching practices and methods in developing generic skills

All the authors have long SCM/OM teaching and curriculum planning experience varying from several years to several decades. Firstly, each author individually collected and reviewed data related to the courses, supervision and student feedback. This data included:

- Course objectives and course descriptions (12 courses)
- Course feedback from students (5-year feedback history from all 12 courses)
- Project plans and reports of industry assignment Master's Theses (145 Master's Theses carried out in the past 5 years)

The results of the data review were summarized, discussed and analyzed in group sessions among the authors. Altogether six group analysis sessions were arranged. In the group sessions, supplementary data were also utilized. This data included:

- Materials related to the renewing process of the learning objectives of the curriculum
- Program accreditation process documents and self-assessment report (Accredited in 2017)
- Memos from two annual alumni group meetings

The group-based approach also enabled the use of complementary observation and experience-based data in the analysis. The approach improved the verification of the individual observations and analyses, increased the reliability of the conclusions and enabled different perspectives to be included in the interpretations of the data collected.

The Master's Theses analysis gave insights into the skills and knowledge needed in entry-level job positions. In addition to that, the aimed SCM/OM skills are reflected on in terms of the program graduates' first job positions and job requirements collected from a LinkedIn group and the annual national survey for graduated academic engineers and architects. LUT SCM/OM graduates have been encouraged to join the LinkedIn group called "LUT SCM Professionals Forum" since the year 2010. Currently the group has about 150 members. 48 of those have graduated from the current structured program. A summary of the main results from the LinkedIn group analysis of 48 careers is presented in Appendix 1.

The findings and practical implications are connected to the congruence between the program's perceived generic skills and applied pedagogical methods and literature findings. The research process of the study is presented in Figure 2.

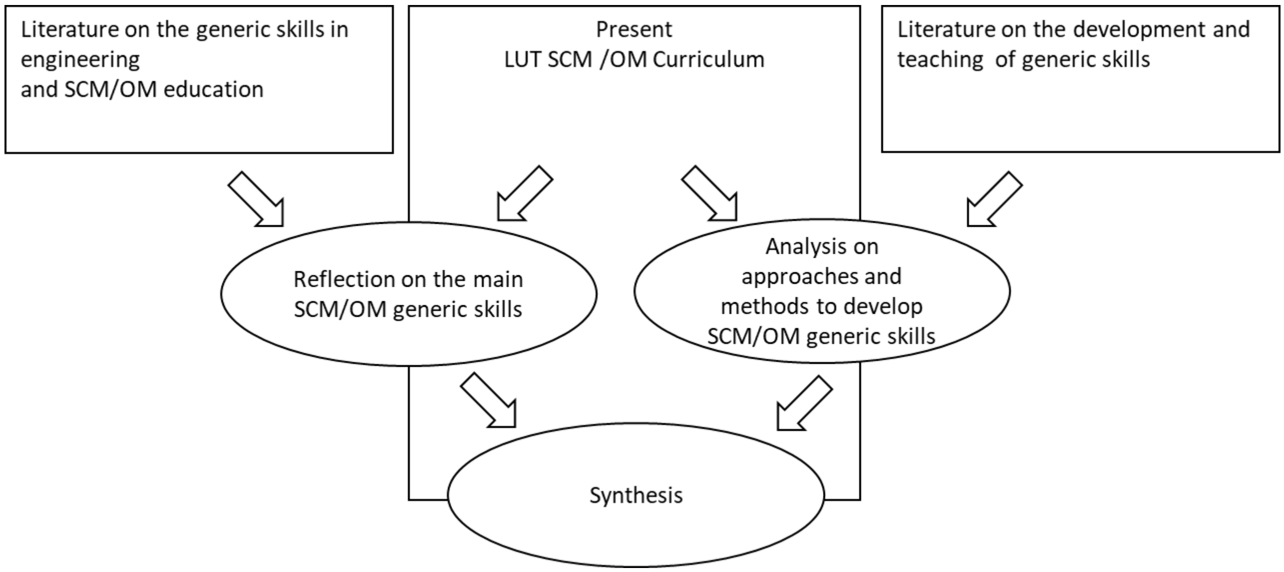

Figure 2. Research process of the study

5. Findings

This chapter presents the findings related to the description of the main generic skills needed in SCM/OM study programs and the pedagogical approaches and methods applicable in incorporating them to the programs. Finally, the main implications of the pedagogical methods to the SCM/OM education program are introduced.

5.1. Generic skills for SCM/OM experts: Integration skills

An integrating role between different organizational functions and networks requires a wide set of skills. To be able to work as an SCM/OM expert, students will need to learn how to apply both substance knowledge and different generic competences in developing and managing organizations' processes, operations and personnel in various business environments and situations.

Based on the analysis, the main generic skills related to SCM/OM can be described and categorized into two broader skill-areas: the ability to design feasible improvement solutions and the ability to carry out improvement work in organizational networks. These skills are called integration skills.

Table 1 presents in more detail the elements and specific skill requirements related to both integration skill areas. The table also includes the analysis of the integration skills in relation to the broad themes described and discussed in the literature.

Table 1. Integration skills for SCM/OM experts

Integration skills for SCM/OM expert		**Generic engineering skills in literature**
Ability to design feasible improvement solutions	Ability to understand organization's capabilities and improvement needs and options in designing managerial solutions and recommendations	Comprehending interconnections and the big picture of operations environment; recognizing opportunities; Multidisciplinary knowledge and systemic viewpoint / system thinking (e.g. Basnet, 2000; Crawley et al., 2014; Eskanderi et al., 2007; Kordova and Frank, 2014, Male, 2010 Rahman and Qing, 2014)
	Ability to integrate multiple types of information from different sources in creating management solutions and recommendations	Analytical reasoning and adaptable problem-solving; critical and creative thinking; cross-functional coordination; designing complex products, processes and systems (e.g. Crawley et al., 2014; Eskanderi et al., 2007; Kordova and Frank, 2014, Male, 2010)
	Ability to apply appropriate supply chain management methods and models to different situations	Decision-making; implementing complex products, processes and systems; understanding enterprise, society and environmental contexts (e.g. Crawley et al, 2014; Jordan and Bak, 2016)

Ability to carry out improvement work in organizational networks	Ability to take and share responsibility	Responsibility and behavioral skills (e.g. Eskanderi, et al., 2007; Jordan and Bak, 2016; Kordova and Frank, 2014)
	Ability to incorporate and utilize necessary human resources and knowhow in improvement work	People management skills; team orientation and communication skills; cross-functional coordination (Jordan and Bak, 2016; Pal and Busing, 2008; Rahman and Qing, 2014; Sohal, 2013)
	Ability to argue for improvement solutions for various stakeholder groups	Communication and interpersonal skills; creative thinking (e.g. Crawley et al., 2014; Pal and Busing, 2008; Rahman and Qing, 2014; Sohal, 2013)
	Ability to coordinate and manage improvement work and projects even without formal authority	Process management skills; cross-functional coordination; operating complex products, processes and systems (e.g. Crawley et al., 2014; Pal and Busing, 2008; Rahman and Qing, 2014)

5.2 Pedagogical approaches and methods

The essential feature in the approach of the studied program is that the teaching of integration skills is fully integrated with the teaching of substance knowledge. There is not a single course focused only (or mainly) on integration skills without a strong connection with SCM/OM analyses and decisions.

Another important approach is that the integration skills are developed progressively in stages throughout the studies. This is done by increasing the requirements for the students systematically throughout the different demand levels towards the Master's Thesis level, where students can independently carry out comprehensive improvement projects in organizations. The case program can be distinguished on three demand levels - namely Master's level 1, Master's level 2 and Master's Thesis level.

The main two methods in teaching integration skills and in designing the SCM/OM study program are the use of increasingly challenging real-life assignments and the empowering working processes. Figure 3 summarizes the main pedagogical methods in teaching integration skills in the SCM/OM case program. It can be concluded that the use of large and complex case assignments mainly improves the skills related to the ability to design feasible improvement solutions, and the empowering working processes advance the skills related to the ability to carry out improvement work in organizational networks. However, both practices have an impact on both skill-sets, and they are utilized concurrently and tightly cohesively.

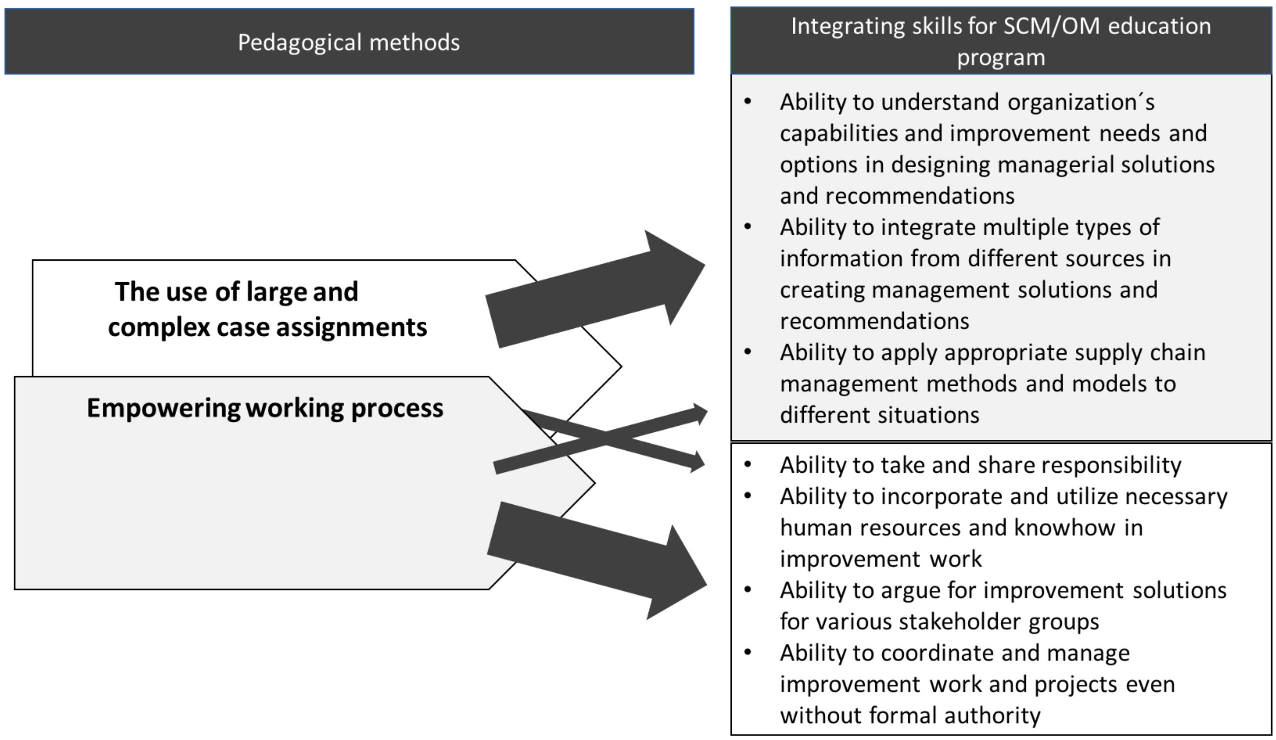

Figure 3. Pedagogical methods in teaching integration skills

5.2.1 The use of large and complex case assignments in progression

Case-assignments imitate real business problems on the first demand level in Master's studies and progress towards actual, in-house, company assignments on later levels. The assignments focus on problem-based learning and business-like reporting and presenting. The idea is that the assignments get more complex and comprehensive as the students proceed from one level to another.

In most of the courses, it is typical that the problem-solving process includes multiple stages extending the length of the whole course. The assignments utilize one wide set of material for the whole course to simulate real-life problem-solving situations. The assignments require the students to use both qualitative and quantitative data and apply multiple theories and models to design solutions in an iterative working approach.

The features of the progressive utilization of large and complex case assignments on the different demand levels of Master's studies are introduced in Figure 4.

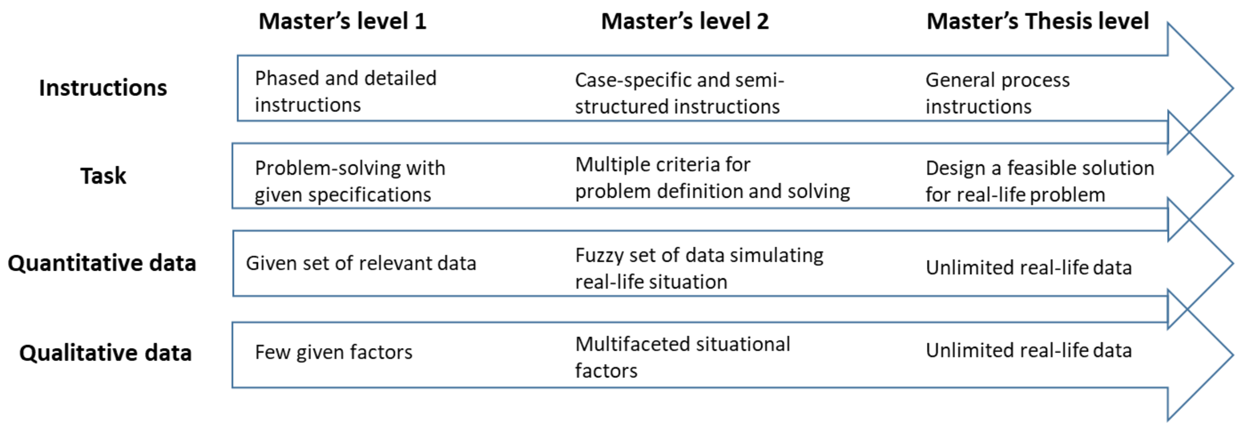

Figure 4. Features of using large and complex case assignments at different levels of Master's studies

5.2.2 Empowering working process in progression

Participatory teaching methods, the activation of students and experimental learning are essential elements in teaching integration skills. Here the focus is on applying interactive team-working techniques and on the instant application of theories. The idea is that throughout the iterative working and problem-solving process there is a balanced combination of student's independence and responsibility and teacher control and support. The students need to learn to be responsible for the outcomes and results of the given assignments. This requires an increase in the freedom and obligation of students to make independent decisions during the working process as they proceed from one level to another.

The features of the progressive utilization of empowering working processes on the different levels of Master's studies are introduced in Figure 5.

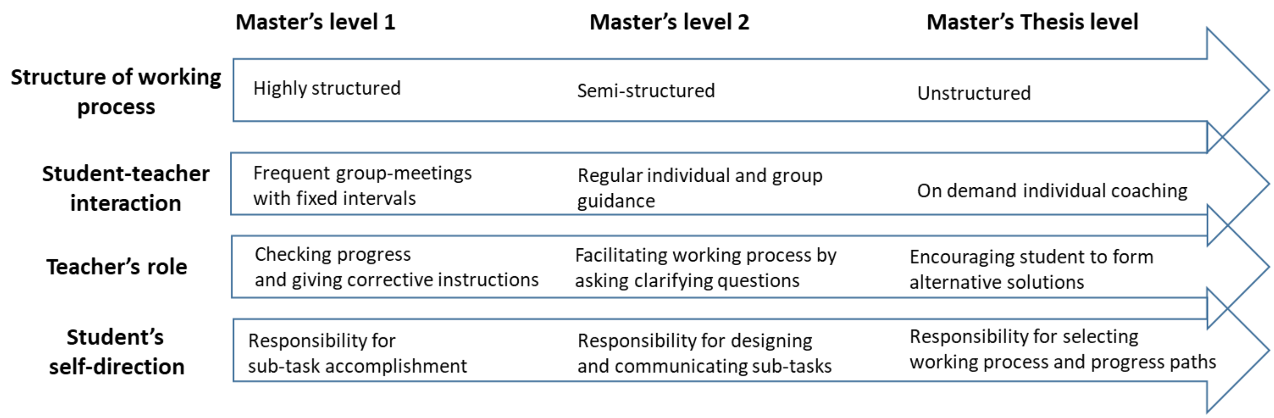

Figure 5. Features of using empowering working processes at different levels of Master's studies

The general design principle in the program is that by systematically repeating the use of increasingly complex assignments and empowering working processes throughout the different demand levels, the student will be able to step-by-step move forward:

- From explicit assignments to fuzzy assignments
- From absolute solutions to feasible solutions
- From leading themselves, independent working skills and taking personal responsibility to leading teams, team working skills and taking responsibility in teams
- From literal presentation skills to oral and visual presentation skills
- From solution producing skills to solution selling skills

5.2.3. Implications of the pedagogical methods to the SCM/OM education program

The applied pedagogical methods have different implications for the program designers, teachers and students, which need to be considered in curriculum and course design. In utilizing the large and complex case assignments, the balancing of group work assignments and individual work assignments is one essential feature. Working in groups is a necessity in acquiring the needed generic competences related to taking responsibility in teams and team leading skills. However, there is a risk of unequal work distribution among team members and even freeriding. This requires the teacher's continuing interaction with students, activating and participatory teaching techniques and the use of multiple assessment methods. Agreeing on division of work and setting shared goals and priorities at the beginning of group assignments, is also good team working practice for students.

The empowering working process enables both regular meetings with the teacher and the possibility to freely schedule and plan working procedures in between guidance meetings. The benefits connected to the students' possibility to plan coursework schedules freely are obvious. However, some students may not have the ability to independently plan large working processes, set targets and intermediate steps for working. This requires the teachers to recognize students with challenges in accountability and sustainability and assist in planning working procedures. Students need to get used to the teaching methods and to taking increasing responsibility for their own studies and working processes.

Teaching integration skills demands a lot from the teacher. Producing real-life assignments and keeping assignments up-to-date demand resources and initial investment of time. The empowering working process also requires that the teacher is actively and regularly involved in the work of all student groups. On the other hand, these types of teaching methods enable more possibilities for interaction and variability in teaching situations. The successful implementation of empowering working processes requires a lot of co-operation and communication between teachers and program designers for the program to have a sequence of well-planned learning stages. This also requires the existence of a common vision and mindset of needed skills and teaching methods among teachers and program designers. The role of individual courses in building the overall empowerment of students needs to be carefully planned, where the focus needs to be on gradually making students more self-directed.

Challenging task is also balancing the use of classroom teaching and the utilization of different types of distance learning and digitalization tools. A prerequisite for learning integration skills is interaction with other students and regular meetings and discussions with the teacher. However, it is feasible to utilize web-based content and instructions for suitable areas of teaching, where students can have control over where, when and how they work.

6. Concluding discussion

Firstly, this study aimed at analyzing how the main generic skills in the SCM/OM study program can be described and categorized. In the literature, the fundamental skill requirements in an academic engineering program are generally divided into knowledge of technical fundamentals and into generic skills (e.g. Basnet, 2000; Crawley et al. 2014; Male, 2010; Rahman and Qing, 2014). The literature presents various and wide classifications and taxonomies on the generic skills for higher education, ranging from leadership issues to interpersonal skills and attributes (e.g. Chan et. al., 2017). Furthermore, the need for more focused discipline-specific generic competences for the engineering discipline (e.g. Crawley et al. 2014; Hoddinott and Young, 2001; Male, 2010), Industrial Engineering and Management and even for the SCM/OM subject area (e.g. Kordova and Frank, 2014; Pal and Busing, 2008; Rahman and Qing, 2014) have been identified. The challenge in defining the important skills for SCM/OM graduates lies in the multitude of industries and job profiles of graduates.

This study highlights the importance of concretizing the most important discipline-focused generic skills. In the studied case program, the focal generic skills for SCM/OM experts (the integration skills) are described and categorized as the ability to design feasible improvement solutions and the ability to carry out improvement work in organizational networks. This way of describing and categorizing generic skills complements the earlier studies on the key competences of supply chain professionals (Jordan and Bak, 2016; Sohal, 2013; Rahman and Qing, 2014). Discipline-focused descriptions and categorizations of generic skills facilitate the designing of coherent and effective curricula by enabling shared understanding and vision concerning key educational priorities among teachers and program designers.

Even though different engineering education programs need to define the key generic skills relevant to the specific discipline, there is a need to acquire knowledge of descriptions and classifications to support the work in education programs. In the case program, the description and categorization of integration skills has proven to be useful in defining the program learning objectives and cascading them down to course level learning objectives. Often, the generic skills presented in the literature are far too general for practical curriculum and course content planning purposes. Presumably, this applies to all engineering programs. In this study, the SCM/OM discipline-specific general skills are described on a more detailed, concrete and practical level to facilitate the utilization of diverse skills in curriculum and course design.

The second aim of the study was to analyze how generic skills can be incorporated into SCM/OM study programs and what pedagogical methods are suitable. In teaching integration skills, the recognized pedagogical methods are the use of increasingly challenging real-life assignments and the empowering working processes. Both methods are concrete and suitable for applying the approaches and principles identified in earlier studies: integrated, staged and activating learning approaches (e.g. Crawley et al. 2014; Kordova and Frank, 2014; Hoddinott and Young, 2001; Chan et al., 2017; Jordan and Bak, 2016).

It can be concluded that teaching integration skills in an SCM/OM study program should be fully integrated with the teaching of substance knowledge, and integration skills should be developed progressively in stages throughout the studies using activating teaching methods. By systematically repeating the use of the methods throughout the study program, the students will gradually become more able to independently carry out challenging assignments. The methods should be used in coherence and in stages to gradually increase the requirements for the students in learning both integration skills and substance knowledge.

The use of large and complex case assignments is a suitable method especially in integrating substance knowledge and generic skills in teaching (see e.g. Crawley et al., 2014). Analyses related to the use of large and complex case assignments support the views of for example Donnelly (2010), Vaastra and Vries (2007) and Chan et al. (2017) that problem-based learning and project-oriented learning together with activating learning environments are preferable to the more conventional learning environments in acquiring generic competences. The use of large and complex case assignments in SCM/OM education not only facilitates the understanding of complex phenomena and technical fundamentals (e.g. Crawley et. al., 2014; Holweg and Bicheno, 2002) but also provides experience in real-life problem-solving situations involving the utilization of versatile data and the designing of feasible improvement solutions. This study supports the view of Crawley et al. (2014) that, even though the use of large and complex case assignments may be time consuming for teachers, it is a compulsory method in effectively integrating the teaching of technical fundamentals and generic skills in engineering education. Case-based teaching also enables the flexible adoption of new substance areas to the assignments and enables keeping the assignments up-to-date.

Earlier studies have recognized the need for specific curricular stages in engineering education where the characteristics of the tasks and deliverables of projects need to become more advanced throughout the program (e.g. Crawley et al. 2014; Hoddinott and Young, 2001). The utilization of the progressively designed empowering working process is a suitable method to ensure that students can gradually become self-directed and able to build their knowledge and interconnect concepts. Based on the findings, in SCM/OM education the need to gradually build the competences of students covers the ability to independently structure working processes and take responsibility for the results. Eventually on a later level of Master's studies, students need to be able to design their own working processes and be responsible for the accomplishment of complex assignments and projects. This requires the role of the teacher in interaction to change as the student progresses in their studies. The ability and willingness of students to adopt different kinds of life-long learning and continuous self-improvement practices independently is an emerging generic skill. The utilization of empowering working processes is a suitable method to teach students to learn and build knowledge also in the long term.

In conclusion, this study presented an empirical case study analysis on describing and teaching generic skills in the SCM/OM education discipline in an academic Industrial Engineering and Management curriculum. This study has contributed to the literature by analyzing how the needed generic skills in a specific engineering education program can be described on a more detailed level than discussed previously in the literature. Previous studies on the subject have also highlighted the need of getting more empirical results and studies on the possible practices and methods to better combine substance knowledge and generic skills in higher education curricula (e.g. Crawley et al., 2014; Hoddinott and Young, 2001; Kordova and Frank, 2014; Male, 2010). This study contributes to this by analyzing the suitable pedagogical methods to address the principles of incorporating generic skills to modern engineering education programs. The analyzed methods complemented the engineering education design principles discussed in previous studies (e.g. Crawley et al. 2014; Kordova and Frank, 2014; Hoddinott and Young, 2001; Chan et al., 2017; Jordan and Bak, 2016). This study was carried out as a single case study aiming to bring out findings and suggestions to be discussed and studied further in different contexts and education environments. The need to recognize the most important discipline-focused skills and analyze the possibilities of incorporating them into teaching is common for all educational programs. The underlying principles and approaches in engineering education programs are also quite similar in different disciplinary contexts, making the results of the case study generalizable to other educational institutions and programs as well.

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Appendix 1:

Analysis of SCM/OM experts' job title and careers

Job title classification of SCM/OM program graduates:

Operations planner	Job titles like Production-, Logistics-, Supply- or Replenishment Planner: expected to carry out daily routines.
Operations manager	Job titles like Supply chain-, Production-, Logistics Manager: expected to have subordinates carrying out the daily routines.
Analyst / specialist	Job titles like Analyst, Specialist, Consultant, Engineer, Project worker: expected to carry out development tasks individually or as member of a development organization.
Development manager	Job titles like Development Manager, Senior Consultant: expected to lead a development team.

The analysis of SCM/OM expert's careers: