Educational Gap Analysis Between Contemporary Industry Demand And Universities State Of The Art In The Construction Logistics

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Educational Gap Analysis Between Contemporary Industry Demand And Universities State Of The Art In The Construction Logistics

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Pavle Sakhanberidze
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Abstract

The social challenges that are directly related to human health care and wellbeing became an obstacle for modern urban development and new city constructions, such as traffic congestion, noise, air pollution, and safety. The solution to overcome those barriers appeared to be in the proper organization of construction activities, particularly, in the construction logistics management.

Hypothesis of this research suggest that modern construction logistics management cannot correspond social challenges as industry does not possess highly qualified staff, which questions current educational quality provided by institutions. Universities, therefore, search an answer what education needs to be provided to students to make specialists relevant to the contemporary construction industry, which requires coordination of activities and business processes within and between various organizations and sectors.

The aim of this research is to find out if there is a need for development of the novel learning contents for the future workforce for effectively manage construction logistics, to analyze where is the gap between construction industry demands and state of the arts of universities in the construction logistics, and answers the following questions:

What is the gap between educational state of the art in the construction logistics of leading universities and construction logistics practice? What is the educational state of the art in the construction logistics practice? And, what an education is demanded by the industry in the construction logistics practice?

The hypothesis was checked based on cases selected from the three Western European countries. The case selection conducted according to replication logic of Robert Yin (2003), which considered selection and research of multiple cases that allows generalizing findings in Western European region. Following leading universities were selected: Royal Institute of Technology (SW), Northumbria University (UK), University of Twente, and Amsterdam University of Applied Sciences (NL). These universities were identified because of the existence of consistent courses and topics in the field of logistics and supply chain management, both, at Bachelor's and Master's level. The research was hold according to methods used in the scientific paper of Sacks and Pikas (2013) where they studded educational gap analysis for Building Information Modeling (BIM). The methodology consist of six main steps, such as: (1) Preliminary literature review; (2) semi-structured interviews among the representatives of academia and industry; (3) development of comprehensive topics list for construction logistics; (4) online survey among the practitioners and evaluation of topics according to Bloom's cognitive dimensions; (5) in-depth interviews among the educators and evaluation of construction logistics related topics and courses according to Bloom's cognitive dimensions from 1 to 6; and final step (6) educational gap analysis. During this study researcher faced with limitations related to data collection from the university representatives. The lack of information was compensated by finding out alternative source of information, such as universities official web pages.

The findings validated the hypothesis partially. The knowledge gap between the state of the art of universities and industry requirements in the construction logistics appeared to be through number of topics related to reverse logistical processes and construction activities that was completely excluded or only partially included in the selected study courses. In addition, it showed that some courses are not well balanced as either they do not reach out industry requirements or exceed the demand in provided quality. Finally, research shows that state of the art in construction logistics are number of courses focusing on general logistics and supply chain management, after which a student needs an additional time to specialize in the construction logistics. Research provides recommendations for the reduction of educational gap and development of novel learning content for the education of construction logistics managers, and for better utilization of educational capacities within the industry.

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1. Introduction

New constructions in the city, while pushes the progress forward, also creates demand for a new holistic managerial approach. Which consider societal and environmental challenges, leading to the reduction of environmental footprint of construction materials distribution. This requires new highly educated specialists in the construction logistics domain.

1.1. Research problem

The hypothesis is either dynamic, fast-changing environment makes current educational programs out of date, or traditional and stagnated market does not allow employees to come up with innovative solutions. Universities, therefore, search an answer what type of education they have to equip specialists to make them relevant to the contemporary construction industry, as it requires coordination of activities and business processes within and between various organizations and sectors. It addresses various concepts of business integration and requires specialists to be educated not only in logistics management but, more importantly in the realization of that education in the sustainable urban development process.

1.2. Research questions

The research questions that have been studded are:

1. What is the gap between educational state of the art in the construction logistics of leading universities and construction logistics practice?

Sub questions,

2. What is the educational state of the art in the construction logistics practice?
3. What an education is demanded by the industry in the construction logistics practice?

1.3. Research goals

The main goal of this research is to define if there is a need for the development of novel learning contents for the future workforce for effectively managing construction logistics. To analyze where is the gap between construction industry demands and the existing learning framework that is provided by universities Bachelor's and Master's courses. Also, to define how novel learning content can be effectively provided by the universities.

1.4. Research contributions

Current research has theoretical and practical implications for educational institutions, such as:

- Scientific contribution - Identification of new topics and new methods of education will develop existing education processes and give stimulus for the creation of smart citizens out of ordinary engineers.
- Educational contribution - Bridging the educational gap in the study programs will be valuable input for universities in order to prepare specialists for effective participation in the interdependent business world.
- Practitioner's contribution - Translation of tacit knowledge into educational programs will enable young specialists to be ready to handle challenges of industry without extra training and time investment after graduation.
- Social contribution - The improvement of construction logistics practice will dramatically reduce the resources used and transport utilization, bringing by this way environmental costs down and rising urban living standards.

2. Background

This paragraph gives background information about existing education that is provided by the universities and demanded by the construction industry by highlighting important processes.

2.1. Education provided by the universities

Economic interdependency and rapid development of Information and Communication Technology (ICT) radically change the way in which people live, work and learn. Nowadays, the primary purpose of university education is to provide graduates with flexible problem-solving skills and abilities to adjust themselves in the fast-changing environment (Cho et al., 2015). The Dele et al., (2011) as cited in Voogt, (2012) characterize modern knowledge as:

- Transversal - Which is not directly linked to a specific field but are relevant across many fields.
- Multidimensional - Which includes knowledge, skills and attitude.
- Ability to cope with complex and unpredictable situations - Students will not focus on the repetitive action, but access and analyze the information in a business world context.

Despite application of modern knowledge, the university still may have a gap in providing sufficient knowledge in preparation of experienced specialists in the construction logistics. Integrated coordination of social, economic and environmental responsibilities become the primary task for construction logistics practitioners, and requires proactive and reactive measures from specialists in adapting their knowledge, capacities and competence in the business world context (Yang et al., 2015). Responsibilities related to sustainable urban development challenged educational institutions as they realized that future demand might be the preparation of specialists for jobs that do not exist yet.

2.2. Education demanded by the industry

In light of modern urban development, sustainable consumption becomes a crucial part of the construction economy because it is directly related to social health and wellbeing. For instance, negative impact of freight vehicle movement in the cities, poor materials flow management at construction sites has affected number of social dimensions. Those social dimension are:

- Air quality - Freight traffic emission includes toxic pollutants, which has impact on human health (Givoni, 2013);
- Noise - Citizens are exposed to high levels of noise from freight transport, which affects their quality of life and can be responsible for long-term health effects (Givoni, 2013);
- Safety - Construction industry is characterized by high level of mobility therefore, safety culture is crucially important (Fang et al., 2006).
- Traffic congestion - Construction activities often block roads and prevent accessibility.

Consideration of social dimensions in urban development process also becomes the responsibility of construction logistic managers. Some stand-alone job descriptions and openings are focusing specifically on construction logistics management (See appendix 2). Overview of the industry requirements showed that self-directed, problem-solving skills and knowledge of various disciplines combined in one person, are essential for construction logistics managers to be able to manage complex processes holistically. One of the examples of managerial knowledge requirements for industry entry-level are described as *'Intellectual capacity to deal with complex logistics issues, and to implement logistics and supply chain vision (CIOB, 2013).'* Holistic approach in construction logistics are emerging field and includes application of both forward and reverse logistical processes. The knowledge and implementation of both processes can reduce cost, harmful environmental effects, improve social dimensions and boost sustainable urban development.

3. Methodology

The research methodology described in this paragraph refers to the methods used in the scientific paper of Sacks and Pikas (2013) where they studded educational gap analysis for Building Information Modeling (BIM). The graphical description of data collection and analysis processes are presented in six steps, in figure 1. The detailed explanation of those steps follows in the next paragraphs.

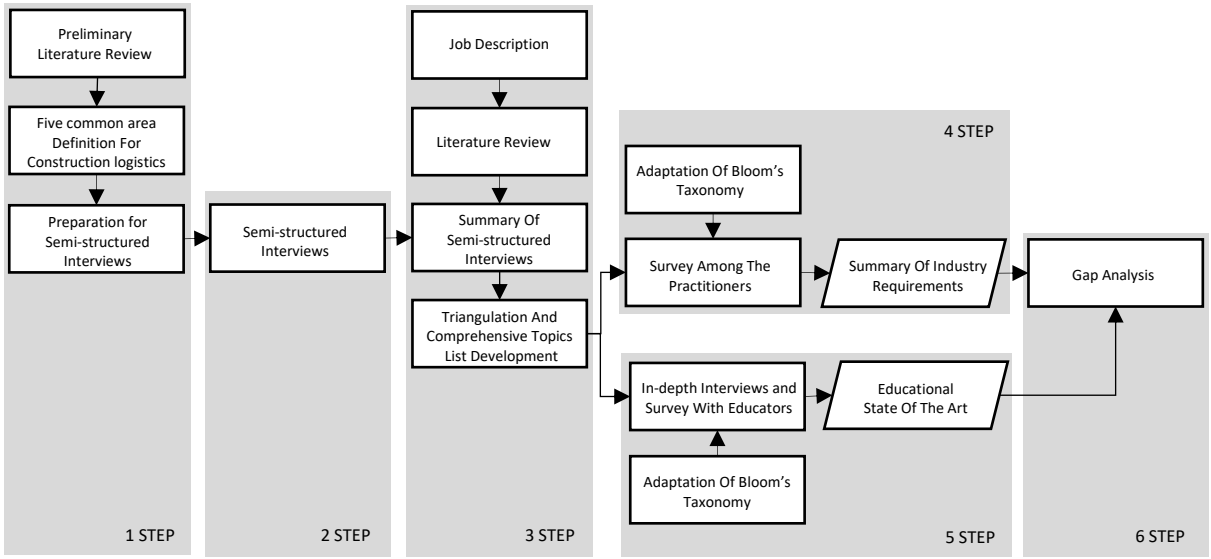

Figure 1: Six steps of data collection and analysis.

3.1. Cognitive Bloom's taxonomy

The effectiveness of existing education was evaluated by results of the practical application of education. For that reason, Bloom's Taxonomy matrix has been applied in this research as a tool to analyze education quality provided by the universities and demanded by the industry. Bloom's Taxonomy was created in 1956 under the leadership of educational psychologist Dr. Benjamin Bloom to promote higher forms of thinking in education, such as analyzing and evaluating concepts and processes, rather than just remembering facts. It was useful for dividing knowledge into smaller distinct parts within which levels of achievement can be measured. Original Bloom's taxonomy tool is presented in table 1. The table includes list of knowledge levels rated from 1 to 6 and gives explanation of each level and dimensions.

Table 1: Bloom's old taxonomy. Source (Marzano, 2006).

Levels	Cognitive processes dimensions	Description
1	Knowledge	*Knowledge* includes those behaviors and test situations which emphasize the recognition or recall, of ideas, materials or phenomena.
2	Comprehension	*Comprehension* represents the largest class of intellectual skills and Abilities. It is taking in new Information via some form of communication.
3	Application	*Application* is described in relationship to a specific type of knowledge – abstractions. Abstraction understood at the level of comprehension can be used only when the conditions for its use are specified.
4	Analysis	*Analysis* emphasizes the detection of relationships of the parts and of the Way they are organized.
5	Synthesis	*Synthesis* is defined here as putting together elements and parts as to Form a whole. This is a process of working with elements and parts.
6	Evaluation	*Evaluation* involves making judgments about the value of knowledge.

Given taxonomy model was criticized by Kreitzer and Madaus, (1994). As cited in Marzano, (2006) one of the most common criticisms was that the taxonomy oversimplified the nature of thought and its relationship to learning. Therefore, taxonomy model was revised by Anderson et al., (2001). The revised version updated the framework regarding the advances in cognitive psychology since its imprint and to use more a common language. Revised Bloom's taxonomy has been adapted for current research, and it is defined in table 2.

Table 2: Adapted Bloom's taxonomy. Source (Anderson et al., 2001).

levels	Cognitive processes dimensions	Description
1	Remembering	Employees or students can recognize knowledge from memory.
2	Understanding	Employees or students can construct meaning by interpretation or explanation.
3	Applying	Employees or students can carry out or use a procedure through execution or implementation.
4	Analyzing	Employees or students can break materials or concepts into parts, determine how the parts relate to an overall structure or purpose.
5	Evaluating	Employees or students can make judgments based on criteria and standards through checking and critiquing.
6	Creating	Employees or students can put elements together to form a new product or process.

3.2. Data collection

Research based on the collection of primary and secondary data. The primary data were collected by semi-structured interviews, in-depth interviews, universities web pages and by an online survey that was conducted among the relevant candidates. By semi-structured interviews researcher got in touch with academia and industry representatives and find out an important issues related to construction logistics, which later was translated into comprehensive topics list. An in-depth interviews, helped to get insight about expected educational levels for each particular topics and evaluate them according to Bloom's taxonomy. Online survey was main tool to find out industries educational requirements for employees with Bachelor's or Master's degree, and for employees with more than 10 years of practical experience. University web pages were source of official qualitative data, it helped to define expected educational levels for selected courses as well as for single topics. For the secondary data, desk review has been applied for both construction journals, as well as non-construction journals. Papers were selected from the library of University of Twente and internet. Following six journals were selected as secondary data reference: Journal of Construction Engineering and Management (JCEM), Automation in Construction (AC), Journal of Civil Engineering and Management (JCEM), Journal of Management in Engineering (JME), Construction Innovation (CI) and Construction Management and Economics (CME). These journals were chosen because they have a reputation for publishing influential papers on managerial issues in the construction industry. As non-construction journals, were selected the following journals, they are Journal of Business & Industrial Marketing (JBIM), Journal of Purchasing and Supply Management (JPSM), International Journal of Physical Distribution & Logistics Management (IJPDLM), International Journal of Operations & Production Management (IJOPM), International Journal of Logistics (IJL), Journal of Business Logistics (JBL), Journal of Transportation Engineering (JTE), International Journal of Production Economics (IJPE) and International Journal of Economics and Management Sciences (IJEMS).

3.2.1. 1 step: Preparation for semi-structured interviews

The five common areas related to construction logistics and supply chain management has been derived from scientific papers for future discussion with the representatives of academia and industry, they are:

- Collaborative behavior.
- Business management tools.
- Information and Communication Technologies (ITC).
- Reverse logistics.
- Delivery management.

For each of those areas were defined two open question, one central and another additional question. The relevance of those areas supported by arguments is presented in appendix 1. Also, some recruiter companies were contacted for interview participation, to identify exact market requirements for construction logistics managers. However they refused, because of non-competency in this particular field. Therefore, research relied on a job description list for construction logistics managers derived from the online recruiter company (CIOB, 2013), which is presented in appendix 2. After the definition of relevant areas, semi-structured interviews have been conducted. The results of interviews are discussed in the next paragraph.

3.2.2. 2 step: Semi-structured interview

The candidates for Semi-structured interviews have been selected from the personal data base of supervisor Dr. Hans Voordijk and by researcher's personal communication during the logistics symposium that held in Amsterdam in April 2017. Representatives of academia and industry have been interviewed according to areas defined in step 1, to obtain relevant topics for construction logistics activities and create comprehensive framework specifically for the construction logistics context. From the 46 selected candidates, only 16 (35 %) replied and participated in the interviews (See table 3). The transcripts of records of semi-structured interviews are presented in appendix 3. Collected data and information was sent back to the respondents and cross-checked against wrong interpretation. After positive feedback, the next step of data development has been undertaken that is explained in the next paragraph.

Table 3: Definition of candidates.

#	Candidate No:	Position
1	6	
2	9	
3	12	
4	17.1	
5	19	
6	22	
7	24	
8	25	
9	26	
10	29	
11	31	
12	32	
13	33	
14	37	
15	38	
16	45	

3.2.3. 3 step: Comprehensive framework development

The data obtained from the interviews and job description list (See appendix 1 and 2), together with evidence derived from scientific papers and books has been triangulated. The relevant topics for construction logistics context have been developed. Example of triangulation is presented in the table 4, in the following order: number and name of a topic, description of the topic, origin of data, and exemplary evidence. The final topics list was created by intensive iterative process together with supervisors. The first draft of the final comprehensive framework also was crosschecked with respondents and after positive feedback (See appendix 5) it was approved and accepted by the researcher and supervisors. The rest results of triangulation are specified in similar ways in the appendix 4.

Table 4: Example of triangulation.

Number and name	1.1 systems perspective / overview
Description	The construction logistics is a system, it is a network of related activities with the purpose of managing the forward and reverse flows of materials and information. It states that all functions or activities need to be understood in terms of how they affect and are affected by other elements and activities with which they interact (Ellram et al, 2006).
Data	Respondents No: 6, 12, 17.1, 19, 24, 25, 31; Job description list chapters: from 1 to 17; Papers: (Gunasekaran, 2004) (Irizarry et al., 2013)
Exemplary evidence	As stated by the respondent No: 12, The student should learn about systems approach/integration in the context of construction logistics because *'generally within construction logistics, all those factors are missing, such as network, the relationship in the network and competence'*. In addition, candidates No: 19 and 31 argued about comprehensive education: *'I think one of the crucial aspects is that they need to be able to see whole pictures, they need comprehensive understanding of all the different aspects that may influence the logistics […] that would affect logistics, and logistical managers should be able to grasp that communicate that to different stakeholders.'* They also stated that logistics managers should be aware of impact of construction logistics, on the operational level. Majority of interweaves mentioned the lack of systems approach and integrated actions. *'If you combine the logistical system with planning then you have stepped forward because then all actors can see the schedule (No: 24)'.* There are *'lack of planning and sort of patterns of collaboration. In many cases when something happens during production they start collaborating (No: 17, 1).'*The respondent No: 25 argued that *'collaboration in construction can be achieved by implementation of complete transparency and standardized systems […] the reverse thinking still needs to be developed.'* In addition, respondent No: 6 stated that *'Innovation is needed at all the levels of logistics, how all the parties can share the information, goods and resources.'* Furthermore, all the responsibilities mentioned in the job description list (ch: 1-17) defines necessity of systems approach/ integration to manage logistical processes. In addition, scientific paper Gunasekaran, (2004) state that *'supply chain integration is the key business process from end user through original suppliers that provides products, services, and information and hence add value for customers and other stakeholders.'* In his paper Irizarry et al., (2013) argued that *'construction industry shows a considerable amount of waste produced by poor management of the materials supply chain (delivery, service, inventory, communications) in this regards use of information technologies (IT) is suggested to achieve better logistics processes and avoiding delays […] various IT application have been used in the literature as a way to improve integration process of supply chain management.'* Based on the interviews we clarified that, system approach /integration is recognized as a relevant topic for students' educational program.

The construction logistics comprehensive framework presented in table 5, was divided according to three main categories characterized by logistics processes such as (1) Planning, (2) Implementation, and (3) Control. This was obtained from the scientific definition of logistics management:

'Part of supply chain management that plans, implements, and controls the efficient, effective forward and reverse flow and storage of goods, services and related information between the point of origin and the point of consumption to meet customers' requirements (Ellram et al., 2006).'

The framework is the content of ideal construction logistics course that was used for comparison of state of the art university courses and construction industry requirements. Following paragraphs explains how Bloom's taxonomy tool and comprehensive framework has been used for collection of expected educational level from the construction industry and academia representatives.

Table 5: Comprehensive framework for construction logistics context.

(1) Planning	(2) Implementation	(3) Control
1.1 Systems perspective/overview 1.2 Enterprise Resource Planning 1.3 BIM-based planning *(e.g. 4D/5D modeling)* 1.4 Demand forecasting 1.5 Return planning 1.6 Procurement 1.7 Construction site layout planning 1.8 Inner city deliveries *(e.g. hubs, control tower systems)* 1.9 Delivery strategies *(e.g. JIT)* 1.10 Routing and scheduling techniques 1.11 Circular business models 1.12 Site waste management	2.1 Total quality management 2.2 Supplier relationship management 2.3 Risk management in supply chains 2.4 Sensoring technologies 2.5 Transport regulations 2.6 Transport modes and intermodality 2.7 Robotization and automation *(e.g. autonomous vehicles, 3D printers, drones)* 2.8 Construction sequences 2.9 Deconstruction sequences 2.10 Site-specific safety management *(e.g. fire, health, crime)*	3.1 Physical distribution cost 3.2 Materials flow control methods *(e.g. early involvement, 3TP)* 3.3 Progress monitoring *(e.g. dashboard systems, scorecard systems, supplier performance reporting, KPIs)* 3.4 Tracking technologies *(e.g. GIS, tagging)* 3.5 Site storage space management 3.6 End-of-life-cycle scenarios *(e.g. refurbishing, reusing, recycling, disposing)* 3.7 Asset information models *(e.g. material passports)*

3.2.4. 4 step: Construction industry requirements

An online survey was used to reach out construction industry representatives from the different countries and collect information about knowledge level that is expected from the potential employees with different education level. Online survey form was created with a combination of Bloom's taxonomy tool and comprehensive framework. Vertically it contained topics list taken from the framework. Horizontally, it contained empty fields for evaluation of cognitive thinking according to Bloom's taxonomy levels from 1 to 6 (An example is specified in appendix 6). The data collected by the online survey is specified in appendix 7. Potential respondents were selected from the personal data base of supervisor Dr. Hans Voordijk, internet and throughout of the LinkedIn search. The primary focus was on managerial level employees that had minimum 5 years of working experience for construction companies in the Western European countries, because this logic allowed to make a proper sample and generalize findings among the given region. The candidates were asked to indicate, the knowledge level that is expected from potential employees with Bachelor's/Master's degree, and from employees with more than 10 years of professional experience. Also, they were asked to suggest new topics for development of a comprehensive framework. Each level was evaluated separately. The respondents were filtered out by the researcher to raise the reliability of the data. Filtration process was based on personal details indicated in an online survey form, such as:

- Organization name - Allowed to crosscheck whether it was a construction company.
- Position - Allowed to know whether respondent was managerial level employee.
- Years of experience - Allowed to identify that respondent has more than 5 years of experience, which was pre-defined as a threshold for this research.
- Geographical location - Allowed to identify that company has operational experience in the Western European region, for the generalization of findings.

In general, 550 candidates were selected, but contributed only 55 (10%). However, due to data filtration the reliable respondents turned out to be only 41 (74.5%) see in table 13, in the appendix 8. Results of filtration process is graphically represented in figures 2 and 3.

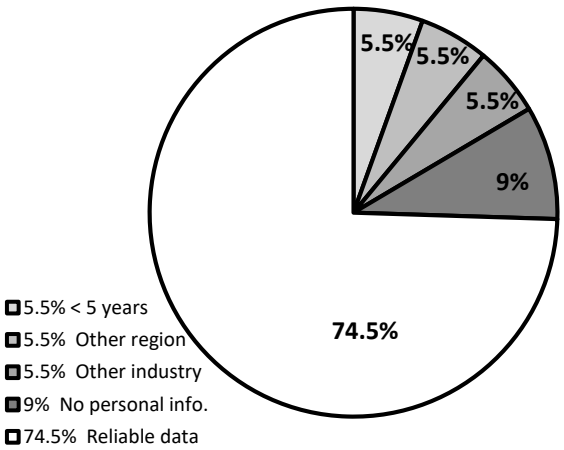

Figure 2: Respondents filtration.

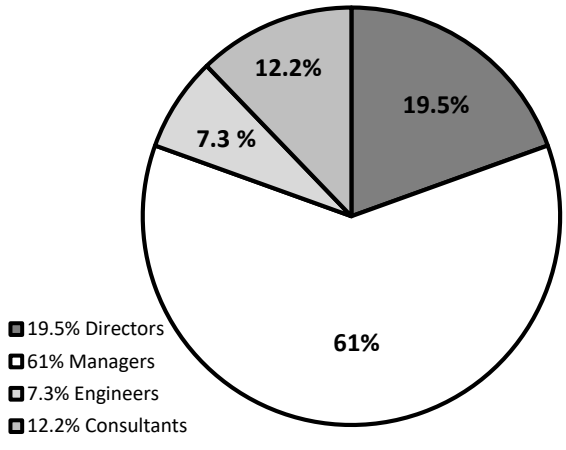

Figure 3: Respondents positions within firm.

The figure 2, shows different percentage values for candidate filtration. 74.5% is total amount of reliable data; 5.5% are candidates that were rejected because of less than 5 years of professional experience; 5.5% of respondents were rejected because of their irrelevant geographical location (they worked outside of Western European region); another 5.5% of respondents were rejected because they worked for other industries and 9% of candidates were rejected because they did not provide personal information. Figure 3, shows percentage values of positions held by reliable respondents within organizations. After filtration, the relevant data was summed up and average values of expected

educational levels derived. Calculation held separately for the employees with Bachelor's degree, Master's degree and with more than 10 years of professional experience. Below table 6, shows educational levels that was demanded from the construction industry among the Western European countries.

Table 6: Industry requirements.

Comprehensive framework			Average		
			BA	MSc	EXP
(1) Planning	1.1	Systems perspective/overview	3	4	5
	1.2	Enterprise Resource Planning	3	4	5
	1.3	BIM-based planning	3	4	4
	1.4	Demand forecasting	3	4	5
	1.5	Return planning	3	4	5
	1.6	Procurement	3	4	4
	1.7	Construction site layout planning	3	4	5
	1.8	Inner city deliveries	3	4	4
	1.9	Delivery strategies	3	4	5
	1.1	Routing and scheduling techniques	3	4	4
	1.11	Circular business models	3	4	4
	1.12	Site waste management	3	4	4
(2) Implementation	2.1	Total quality management	3	4	5
	2.2	Supplier relationship management	3	4	5
	2.3	Risk management in supply chains	3	4	5
	2.4	Sensoring technologies	3	4	4
	2.5	Transport regulations	2	3	4
	2.6	Transport modes and intermodality	3	3	4
	2.7	Robotization and automation	3	3	4
	2.8	Construction sequences	3	4	5
	2.9	Deconstruction sequences	3	4	5
	2.1	Site-specific safety management	3	4	5
(3) Control	3.1	Physical distribution cost	3	4	5
	3.2	Materials flow control methods	3	4	5
	3.3	Progress monitoring	3	5	5
	3.4	Tracking technologies	3	4	4
	3.5	Site storage space management	3	4	5
	3.6	End-of-life-cycle scenarios	3	4	4
	3.7	Asset information models	3	4	4
Total average			3	4	5

3.2.5. 5 step: Educational state of the art

Evaluation of educational state of the art started with a selection of Bachelor's and Master's courses among the world's leading universities by geographical location. Cases were selected from the Western European countries with the intention that findings would be applicable for the entire region. The universities were selected from Sweden (SW), England (UK), and the Netherlands (NL) as they were among the most technologically advanced countries in the world that have a good experience in the development of holistic approach in the logistics and supply chain management, and could contribute to finding answers to research questions. Those universities and courses are presented in table 7.

Table 7: Selected universities and courses at Master's and Bachelor's levels.

Course identification	Course name and number	University	program
A	MO0487: Strategic Procurement and Logistics	Northumbria university (UK)	MSc
B	AI2805: Building Informatics and Logistics	Royal Institute of Technology (SW)	MSc
C	195810200: Supply Chain Management & ICT	University of Twente (NL)	MSc
D	MO9409: Operations and Integrated Supply Chain and Marketing Management	Northumbria university (UK)	BA
E	AF1723: Building Logistics and Risk Management	Royal Institute of Technology (SW)	BA
F	34390: Logistics Engineering	Amsterdam University of applied sciences (NL)	BA

The general approach to logistics and supply chain management education among the selected A, B, C, D, E, and F courses was derived from universities webpages and syllabus (Introduction, 2017; Module information, 2017a, and b; Syllabus MSc, 2017; Syllabus BA, 2017; Vordijk, 2015 a, b, c, and d; Year I, 2017; Year II, 2017; UT blackboard, 2017 a, and b). Obtained information are presented in the table 8, in the following order. Horizontally it contains names of selected Western European universities' and vertically it is divided by number of category, such as:

- Motivation - Defines what the main focus of study courses is.
- Content - Stands for exact name and number Bachelor's and Master's courses, and what course can offer to students.
- Concept - Emphasize nowadays important processes related to logistics and supply chain management.
- Approach **-** Defines the ways how students are handling the education process.
- Teaching methods - Explains how information is provided to the students.
- Learning goals - Shows what should be achieved after graduation of this course.
- Exams - Shows how qualification of students are assessed.

Table 8: Education at the selected A, B, C, D, E, and F courses.

Category	Northumbria University (A)	Royal Institute of Technology (B)	University of Twente (C)	Northumbria University (D)	Royal Institute of Technology (E)	Amsterdam University of Applied Sciences (F)
Motivation	Value adding through the production and delivery of services in the supply chain.	Strategic business perspective of construction logistics.	Predictability and control of building processes.	Organization of supply chain within the business context.	Knowledge of the building supply chain, capacity, planning and scheduling.	Customers' satisfaction.
Content	Course: MO0487 - Strategic Procurement and Logistics, offers modern approaches to strategic procurement and logistics management.	Course: AI2805 - Building Informatics and Logistics, offers organizational and project management, and IT systems in construction sector.	Course: 195810200 - Supply Chain Management & ICT, offers application of supply chain and, purchasing management contents of other industries in the construction sector.	Course: MO9409 - Operations and Integrated Supply Chain and Marketing Management, offers strategies for supply chain management.	Course: AF1723 - Building Logistics and Risk Management, offers how different delivery service solutions support efficient production.	Course: 34390 - Logistics Engineering, offers plant and monitor logistics flows and optimizes inventory management, production and transportation.
Concept	Course improves individual or organizational decision making on strategic procurement and logistics management.	Courses emphasize importance of IT in the construction logistics process and teaches how communicate production plan in its entirety.	Supply chain management is a methodology that Improves materials transportation and distribution between manufacturers and construction sites.	The courses provides modern approaches of logistics and supply chain management by considering cross-functionality and integration of business processes.	Course emphasize different logistics tools that can be used in planning, work environment and purchasing.	Course concept is based on responsiveness to market demand and customers' needs.
Approach	Students will learn by reflective-practitioner approach that includes workshops and seminar sessions.	It is based on data analysis and handling of design and construction processes within supply chain.	It is based on analysis of similarities and differences of supply chains in the construction industry and supply chains in other industries.	Students are encouraged to develop independent learning, direct learning and critical reflection on knowledge, experience and practice.	It is based on evaluation and comparison of several different action options with respect to the risk of changing a specific logistics system.	Students will come across with project research, bilingual communication, data analysis, report writing and presentations of improved logistics process within supply chain.
Teaching methods	Module is supported by a teaching and learning plan, which outlines the formal sessions, together with the tutor-directed study and independent reading.	Teaching is based on practical assignments. Group work and report writing.	Theoretical course with group assignment and individual papers. Including guest lecture and board game that simulates supply chain within construction industry.	Teaching is based on interactive learning, team-based discussion and guided seminar activities. Students are involved in both individual and team work.	Teaching is based on theoretical course and practical assignments.	Teaching process includes practical assignments in projects and company visits. Study trip abroad and minor program that includes participation in logistics research.
Learning goals	Analyze the approaches to managing procurement and logistics management in a global business environment.	Knowledge of the building supply chain, capacity, planning and schedules. Also, knowledge of IT from an organizational and strategic business perspective.	Analysis of supply chain management and purchasing concepts. Knowledge about Building Informational Model and its role in the construction.	Knowledge of managerial and operational issues in business context.	Application of basic construction concepts, models, tools and working methods. Description of logistics system at a general level.	Improve, plan and (re) design logistics processes in companies and organizations.
Exams	Individual exam (25%) and individual assignment (75%).	Seminars, project assignments and examination.	Individual theory test written or verbal (50%). Group assignment research project (50%).	Individual exam (25%) and individual assignment (75%).	Assignments and examination.	Practical assignments, examination and thesis at graduation company.

The expected educational level for selected courses has been evaluated separately as per-topics also per-courses. Evaluation process held by using Bloom's taxonomy cognitive dimensions and topics list from the comprehensive framework. The 19 candidates were selected from the given courses and invited for in-depth interviews. They were mostly former students, program leaders and leading lecturers. Reply rate from the lecturers were 42% (8 people) Three former Master's students from the (C) course; Three lecturers from (F) course; One principal lecturer from (B) course, and one program leader from (E) course. Nobody replied from the courses (D) and (A). Originally research intended interview with minimum two people from each course, to triangulate the data and avoid personal bias from the respondents. However, the involvement of academia representatives in an in-depth interviews became difficult. Some respondents were hesitating to share personal critical thoughts about their universities educational programs and courses. The confidentiality became an obstacle for data collection. The situation was improved by personal involvement in an in-depth interviews one of the supervisor Dr. Hans Voordijk, and even those not all the respondents replied. In a given circumstances researcher decided to take an alternative approach and compensate lack of data by collecting the information from the universities public web pages and syllabus. Data was collected by identification of similar topics provided in the comprehensive framework and by definition of expected educational level per topics according to Bloom's taxonomy. The per course evaluation held by the calculation of the total amount of included topics into percentage values and definition of expected educational level according to Bloom's taxonomy. The quantitative data obtained from interviewees and web pages were triangulated (See appendix 10). The final finding of expected educational levels for each course topics are presented in the table 10. The example in the table 9 explain how the written definition of intended learning outcomes derived from universities web pages was translated into quantitative data by using Bloom's taxonomy.

Table 9: Example of translation qualitative data into quantitative.

Intended learning outcomes for (B) course AI2805
After the course (B), the students should: Be able to describe and ***analyze*** the information handling in the design and construction process. According to cognitive process dimensions stated in table 2, the word ***analyze*** corresponds to the level 4. Which means students can break information into parts, and after determining how these parts relate to an overall structure or purpose. In the same logic, all the topics were translated from the text into quantitative data. The cognitive levels derived from different sources were triangulated logically for the same topic and final cognitive level defined. Such an approach reduced risk of personal bias from the respondents. The details of triangulation of all the topics are specified in appendix 10. The results of triangulation are shown in table 10.

Table 10: Educational state of the art for A, B, C, D, E and F courses.

Category	#	Comprehensive framework (Topics list)	Bachelor's degree Expected educational level for courses			Master's degree Expected educational level for courses		
			D	E	F	A	B	C
(1) Planning	1.1	Systems perspective/overview	-	3	4	-	3	4
	1.2	Enterprise Resource Planning	-	-	4	5	2	4
	1.3	BIM-based planning	-	-	-	-	4	4
	1.4	Demand forecasting	2	4	4	-	2	4
	1.5	Return planning	-	-	4	-	-	-
	1.6	Procurement	2	-	4	5	3	4
	1.7	Construction site layout planning	-	-	-	-	2	-
	1.8	Inner city deliveries	-	-	5	-	2	4
	1.9	Delivery strategies	-	-	4	-	2	3
	1.10	Routing and scheduling techniques	-	-	4	-	2	-
	1.11	Circular business models	-	-	6	-	2	-
	1.12	Site waste management	-	-	-	-	1	-
(2) Implementation	2.1	Total quality management	2	-	3	-	1	5
	2.2	Supplier relationship management	2	-	5	5	1	6
	2.3	Risk management in supply chains	2	4	3	5	2	-
	2.4	Sensoring technologies	-	-	2	-	2	-
	2.5	Transport regulations	-	-	2	-	-	-
	2.6	Transport modes and intermodality	-	-	3	-	-	-
	2.7	Robotization and automation	-	-	3	-	2	-
	2.8	Construction sequences	-	-	-	-	3	1
	2.9	Deconstruction sequences	-	-	-	-	4	-
	2.10	Site-specific safety management	-	-	-	-	3	-
(3) Control	3.1	Physical distribution cost	-	3	4	-	1	4
	3.2	Materials flow control methods	-	3	5	5	-	4
	3.3	Progress monitoring	2	-	5	-	3	-
	3.4	Tracking technologies	-	-	5	-	2	-
	3.5	Site storage space management	-	-	4	5	-	-
	3.6	End-of-life-cycle scenarios	-	-	3	-	2	-
	3.7	Asset information models	-	-	3	-	3	-
Total percentage amount of included topics:			21%	17.5%	80.5%	21%	84%	42%

3.2.6. 6 step: Gap analysis

Table 11, defines educational gap analysis between state of the art universities and construction industry requirements in the construction logistics. Per topics analysis include results of triangulation defined for A, B, C, D, E, and F courses based on the table 10, and average values derived from the industry requirements based on the table 6. All values are represented in accordance to Bloom's cognitive dimensions.

Table 11: Education best practice vs industry requirements (gap analysis per- topics).

Category	#	Comprehensive framework (Topics list)	Bachelor's degree				Master's degree			
			Current level of achievement for course topics			Industry requirement	Current level of achievement for course topics			Industry requirement
			D	E	F		A	B	C	
(1) Planning	1.1	Systems perspective/overview	-	3	4	3	-	3	4	4
	1.2	Enterprise Resource Planning	-	-	4	3	5	2	4	4
	1.3	BIM-based planning	-	-	-	3	-	4	4	4
	1.4	Demand forecasting	2	4	4	3	-	2	4	4
	1.5	Return planning	-	-	4	3	-	-	-	4
	1.6	Procurement	2	-	4	3	5	3	4	4
	1.7	Construction site layout planning	-	-	-	3	-	2	-	4
	1.8	Inner city deliveries	-	-	5	3	-	2	4	4
	1.9	Delivery strategies	-	-	4	3	-	2	3	4
	1.10	Routing and scheduling techniques	-	-	4	3	-	2	-	4
	1.11	Circular business models	-	-	6	3	-	2	-	4
	1.12	Site waste management	-	-	-	3	-	1	-	4
(2) Implementation	2.1	Total quality management	2	-	3	3	-	1	5	4
	2.2	Supplier relationship management	2	-	5	3	5	1	6	4
	2.3	Risk management in supply chains	2	4	3	3	5	2	-	4
	2.4	Sensoring technologies	-	-	2	3	-	2	-	4
	2.5	Transport regulations	-	-	2	2	-	-	-	3
	2.6	Transport modes and intermodality	-	-	3	3	-	-	-	3
	2.7	Robotization and automation	-	-	3	3	-	2	-	3
	2.8	Construction sequences	-	-	-	3	-	3	1	4
	2.9	Deconstruction sequences	-	-	-	3	-	4	-	4
	2.10	Site-specific safety management	-	-	-	3	-	3	-	4
(3) Control	3.1	Physical distribution cost	-	3	4	3	-	1	4	4
	3.2	Materials flow control methods	-	3	5	3	5	-	4	4
	3.3	Progress monitoring	2	-	5	3	-	3	-	5
	3.4	Tracking technologies	-	-	5	3	-	2	-	4
	3.5	Site storage space management	-	-	4	3	5	-	-	4
	3.6	End-of-life-cycle scenarios	-	-	3	3	-	2	-	4
	3.7	Asset information models	-	-	3	3	-	3	-	4
Total percentage amount of included topics:			21 %	17.5 %	80.5 %		21 %	84 %	42 %	

The data presented in table 11, was translated into figures. The figures demonstrate the relationship between comprehensive frameworks per topics, horizontally and Bloom's taxonomy cognitive levels, vertically. Red line shows per topics industry requirements, which is separated for Bachelor's and Master's courses. For Bachelor's courses, the general requirement is level 3, with only exception topic *2.5 - Transport regulation*, which is requested at level 2. As for Master's courses industry requirements are fluctuating between levels 3, 4, and 5. Colored boxes represent topics that are matching with the framework.

Figure 4, shows per topics detailed gap analysis for Bachelor's course (D) provided by the Northumbria University (UK) with number *MO9409 - Operations and Integrated Supply Chain and Marketing Management.*

In figure 4, most of the topics match in the following order at first place comes category *(2) implementation*, with three topics that are, *2.1 - Total quality management; 2.2- Supplier relationship management; 2.3 - Risk management in supply chain*. After that comes category *(1) planning*, with two topics that are, *1.4 - Demand forecasting; 1.6 – Procurement,* and last is category *(3) control,* with one topic only that is, *3.3 - Progress monitoring*. Majority of the topics are concentrated in category *(2) implementation*. Course (D) covers only forward processes and do not provides topics about reverse processes, such as *1.5 – return planning, 1.11 – circular business model,* and *1.12 – site waste management.* Also, it does not provide construction-related topics, such as *1.3 – BIM-based planning, 2.8 – construction sequences,* and *2.9 – deconstruction sequences.* An expected educational level for all included topics is 2 that means after graduation students can understand given functions from different types of activities by interpretation. While industry requires level 3, which considers the application of knowledge in practice. It seems there is an educational gap because, from 29 (100%) topics of framework only 6 (21%) topics are covered by course (D), the rest 79% of the topics are not included. The amount of topics and provided educational level in course (D) is not balanced, because neither supplied educational level corresponds to industry requirements, nor majority of topics are covered by the course (D).

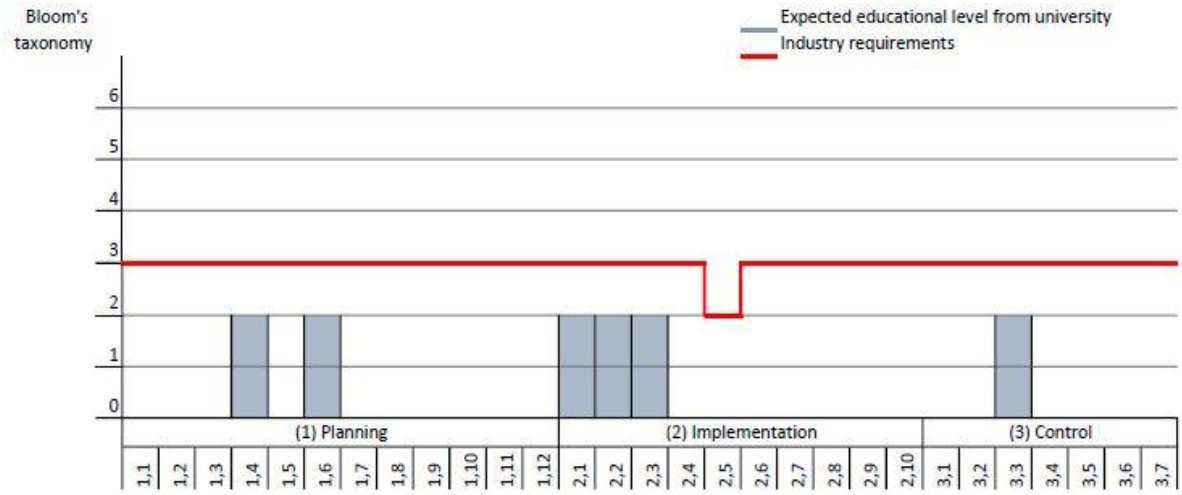

Figure 4: Educational gap analysis per topics for the Bachelor's (D) course.

Figure 5, defines per topics detailed gap analysis for Master's course (A) provided by the Northumbria University (UK) with number *MO0487 - Strategic Procurement and Logistics.*

Figure 5, shows that for each category there are two matching topics in the following order, in the category *(1) planning* there are two matches, *1.2 - Enterprise Resource Planning* and *1.6 – Procurement.* For the category *(2) implementation* there are also two matches, *2.2 -Supplier relationship*

management, and *2.3 - Risk management in supply chains,* and in final category *(3) control* there are again two matches, *3.2 - Materials flow control methods,* and *3.5 - Site storage space management.* Course (A) mostly covers forward processes and do not provides topics about reverse processes, such as *1.5 – return planning, 1.11 – circular business model,* and *1.12 – site waste management.* Also, it does not provide construction-related topics, such as *1.3 – BIM-based planning, 2.8 – construction sequences,* and *2.9 – deconstruction sequences.* An expected educational level for all included topics is 5 that means after graduation students can evaluate logistics function and make judgments based on criteria and standards through checking and critiquing. Provided education level for given topics exceeds industry requirements with 1 level. Despite right expected educational level among the included topics, still it seems that there is an educational gap, because from 29 (100%) topics of framework only 6 (21%) topics are covered by Master's course (A), the rest 79% of topics are not included. The course (A) is not balanced, probably it exceeds required educational level by the industry, however it still does not cover majority of the topics.

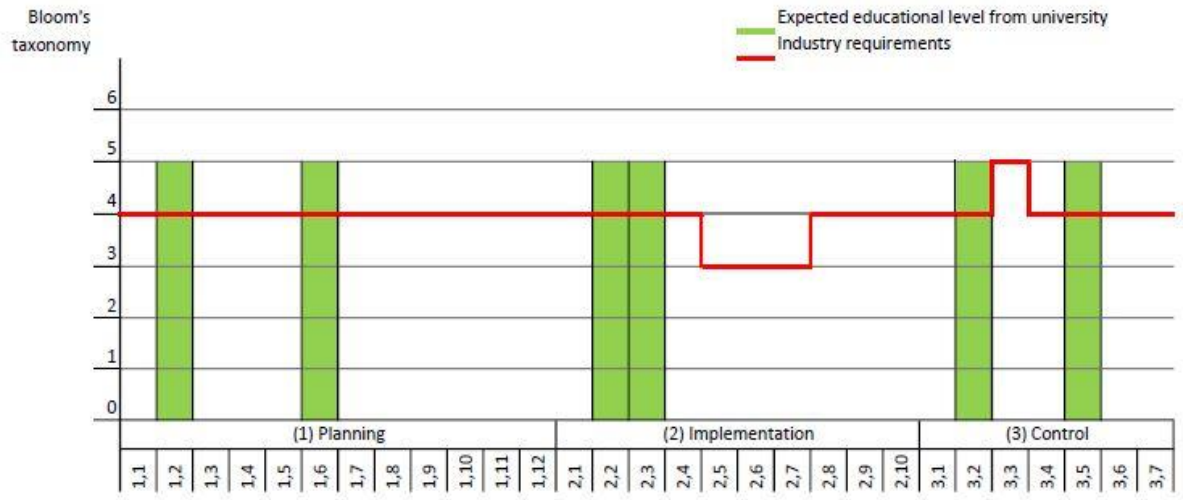

Figure 5: Educational gap analysis per topics for the Master's (A) course.

Figure 6, shows detailed gap analysis for both Bachelor's (D) and Master's (A) courses provided by the Northumbria University (UK), in case students are to combine them. Figure 5, shows that average educational level at Master's course is significantly higher than a Bachelor's course. Also, they have three topics in common; they are *1.6 -Procurement; 2.2 - Supplier relationship management,* and *2.3 - Risk management in supply chains.* The total amount of matching topics are 9 (31.5 %). The combination of both courses balance expected educational level for number of topics however, they still do not cover majority of the topics.

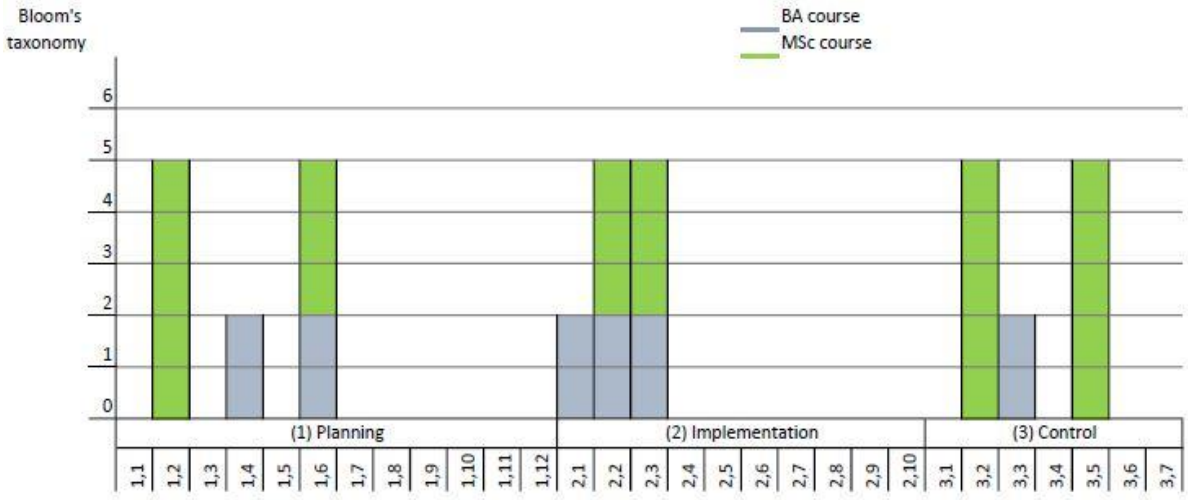

Figure 6: Educational gap analysis per topics for the Bachelor's (D) and Master's (A) courses.

Figure 7, shows detailed per topics gap analysis for Bachelor's course (E) provided by the Royal Institute of Technology (SW) with number *AF1723: Building Logistics and Risk Management.*

Figure 7, defines that most of the topics are concentrated in the category *(1) planning* they are, *1.1 - Systems perspective/overview,* and *1.4 - Demand forecasting.* Also in category *(3) control,* with two topics: *3.1 - Physical distribution cost,* and *3.2 - Materials flow control methods.* Last, category *(2) implementation* includes only one topic: *2.3 – Risk management in supply chains.* Course (E) covers only forward processes and do not provides topics about reverse processes, such as *1.5 – return planning, 1.11 – circular business model,* and *1.12 – site waste management.* Also, it does not provide construction-related topics, such as *1.3 – BIM-based planning, 2.8 – construction sequences,* and *2.9 – deconstruction sequences.* An expected educational level for those topics is different, such as: for topics 1.1, 3.1 and 3.2 are level 3, which means after graduation students can apply knowledge during the implementation and task execution. Topics 1.4 and 2.3 are exceeding industry requirements by reaching out level 4, which means after graduation students will be able to analyze logistical concepts into parts and determine how this parts are related to an overall purpose. Provided education level is in compliance with industry requirements. However, it seems that there is an educational gap because from 29 (100%) topics of framework only 5 (17.5%) topics are covered by course (E), the rest 82.5 % of topics are not included. The course (E) is not balanced, probably it provides required educational level by the industry, however it still does not cover majority of the topics.

Figure 7: Educational gap analysis per topics for the Bachelor's (E) course.

Figure 8, defines per topics detailed gap analysis for Master's course (B) provided by the Royal Institute of Technology (SW) with number *AI2805: Building Informatics and Logistics.*

Figure 8, shows that for each category there are some excluded topics as the rest is entirely covered by the course (B). In the category *(1) planning,* only one topic is excluded, such as *1.5 – return planning*. For category *(2) implementation* there are two excluded topics, such as *2.5 – transport regulations,* and *2.6 – transport modes and intermodality*. In the final category *(3) control*, there are again two excluded topics, *3.2 – materials flow control methods,* and *3.5 – site storage space management*. However, despite course (B) covers the majority of topics still it barely considers reverse logistics processes as topic *1.5 – return planning* is excluded from the *(1) planning* category, and topics *1.11 – circular business model,* and *1.12 – site waste management* are provided at a shallow level. Also, expected educational level for the topics 1.12, 2.1, 2.2, and 3.1 are at level 1, which means students can only remember about the topics after graduation. For topics 1.2, 1.4, 1.7, 1.8, 1.9, 1.10, 1.11, 2.3, 2.4, 2.7, 3.4, and 3.6 are at level 2, which means after graduation students are able only to understand the meaning of the different type of logistical functions. For topics 1.1, 1.6, 2.8, 2.10, 3.3, and 3.7 are at level 3, which means after graduation students will be able to apply knowledge by implementation and task execution. Topics 1.3 and 2.9 are provided at level 4, which means after graduation students can analyze concepts for given topics into parts and determine how these parts are related to an overall purpose. However, provided educational level is not in compliance with industry requirements, only topic 1.3 and 2.9 reaches industry demand. Given those, there is educational gap, because from 24 (84%) of included topics 22 (77%) is below the demand. The course (B) is not balanced, of course it covers majority of the topics, however provided educational level for most of them are low.

Figure 8: Educational gap analysis per topics for the Master's (B) course.

Figure 9, shows detailed gap analysis for both Bachelor's (E) and Master's (B) courses provided by the Royal Institute of Technology (SW), in case student will decide to combine them.

The figure 9, shows that expected educational level at Master's course (B) is not significantly higher than a Bachelor's course (E), for instance matching topics: *1.4 – demand forecasting, 2.3 – risk management in supply chains*, and *3.1 – physical distribution cost* are 2 levels higher than same topics provided by Master's course (B). Also, in the category of *(1) planning* topic 1.1 has the same expected educational level 3, for both courses. The total amount of matching topics are 26 (91 %). Should be admitted that in combination they are looking more balanced as half of the covered topics are provided at high level 3 and 4.

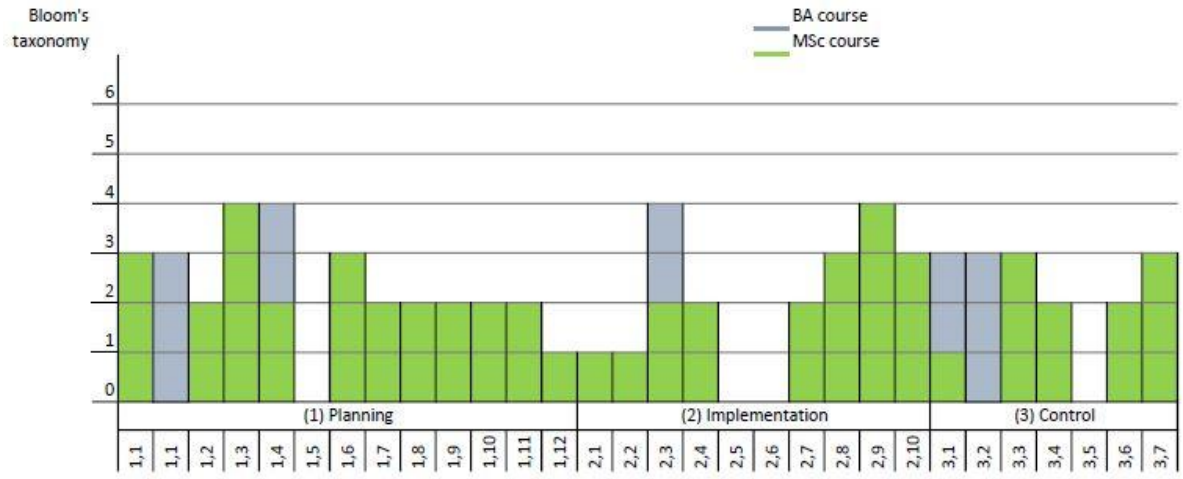

Figure 9: Educational gap analysis per topics for the Bachelor's (E) and Master's (B) courses.

Figure 10, shows per topics detailed gap analysis for Bachelor's course (F) provided by the Amsterdam University of Applied Sciences (NL) with number *34390: Logistics Engineering*.

In figure 10, most of the included topics are concentrated in the category *(1) planning*, they are: *1.1 – systems perspective, 1.2 – enterprise resource planning, 1.4 - Demand forecasting, 1.5 – return planning, 1.6 - Procurement, 1.8 –Inner city deliveries, 1.9 – delivery strategies, 1.10 – routing and scheduling technic,* and *1.11 - circular business model*. The following category *(2) implementation* includes *2.1 - Total quality management, 2.2 - Supplier relationship management, 2.3 - Risk management in supply chains, 2.4 - Sensoring technologies, 2.5 - Transport regulations, 2.6 - Transport modes and intermodality,* and *2.7 - Robotization and automation.* Final category *(3) control* includes all topics such as *3.1 - Physical distribution cost, 3.2 - Materials flow control methods, 3.3 - Progress monitoring, 3.4 - Tracking technologies, 3.5 - Site storage space management, 3.6 - End-of-life-cycle scenarios, 3.7 - Asset information models*. Course (F) partly covers topics for both forward and reverse logistics processes. However, it does not provide construction-related topics, such as *1.3 – BIM-based planning, 2.8 – construction sequences,* and *2.9 – deconstruction sequences.* An expected educational level in most of the cases reaches out industry requirement level 3 and even exceeds it with some levels. The only exception is topic 2.4, it has lowest expected educational level 2, which means after graduation students are able only to understand the meaning of the different type of functions. The topic 1.11 has highest expected educational level 6, which means after graduation student will be able to combine different components and create new processes. However, it seems there is an educational gap because from 29 (100%) topics of framework only 23 (80.5%) topics are covered by course (F), the rest 19.5% of the topics are not included. Course (F) is well balanced it covers majority of the topics and expected educational level corresponds or exceeds industry requirements.

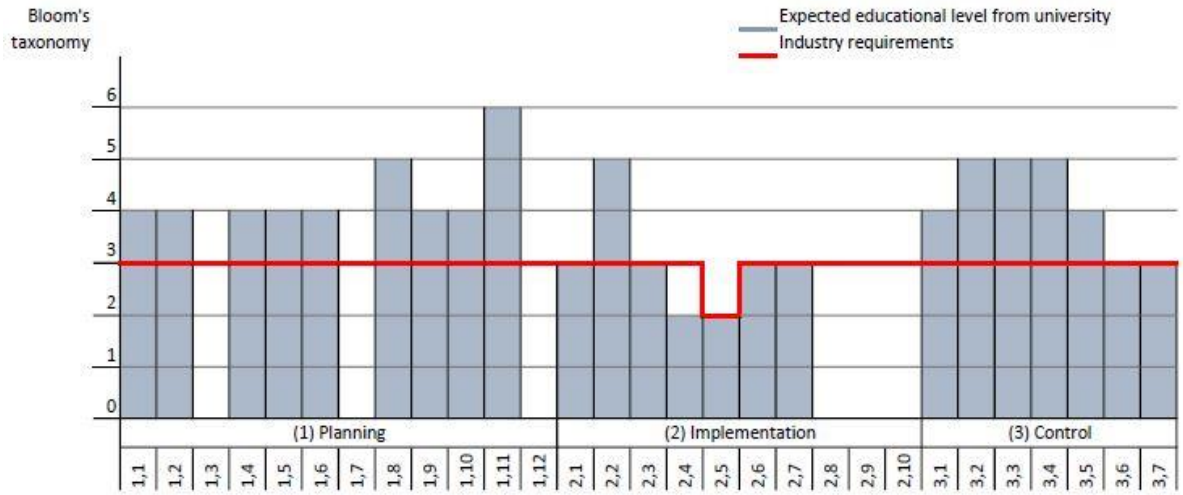

Figure 10: Educational gap analysis per topics for the Bachelor's (F) course.

Figure 11, defines per topics detailed gap analysis for Master's course (C) provided by the University of Twente (NL) with number *195810200 Supply Chain Management & ICT.*

Figure 11, shows that most of the topics matching are concentrated in the category *(1) planning*, there are seven matching topics such as *1.1 - Systems perspective/overview, 1.2 - Enterprise Resource Planning, 1.3 - BIM-based planning, 1.4 - Demand forecasting, 1.6 - Procurement, 1.8 - Inner city deliveries, and 1.9 - Delivery strategies*. After comes category *(2) implementation*, with three matching topics, such as: *2.1 - Total quality management, 2.2 - Supplier relationship management*, and *2.8 - Construction sequences*, and final is category *(3) control*, with two matching topics, such as: *3.1 - Physical distribution cost* and *3.2 - Materials flow control methods*. Course (C) covers only forward processes and do not provides topics about reverse processes, such as *1.5 – return planning, 1.11 – circular business model,* and *1.12 – site waste management*. Also, it poorly provides construction-related topics, such as *2.8 – construction sequences*, and *2.9 – deconstruction sequences*. An expected educational level for included topics is different, such as: for 1.1, 1.2, 1.3, 1.4, 1.6, 1.8, 3.1 and 3.2 are at level 4, which means after graduation students can analyze concepts for given topics into parts and determine how these parts are related to an overall purpose. Topic 1.9 is at level 3, which means after graduation students will be able to apply knowledge in practice. Topic 2.1 is at level 5, which means after graduation students will be able to evaluate and make judgment based on criteria and standards through checking and critiquing. Topic 2.2 is at level 6, which means students can combine all the aspects of given topic and create new processes or situations. Topic 2.8 is at level 1, which means students can remember or recognize knowledge from memories. Provided education levels for given topics comply with industry requirements, only topics 1.9 and 2.8 are below of industry requirement. Topics 2.1 and 2.2 are exceeding industry requirements. Despite the course (C) covers substantial part of category (1) planning still there is an educational gap, because from 29 (100%) topics of framework only 12 (42%) topics are covered by Master's course (C), the rest 58 % of topics are not included. The course (C) is not balanced, because majority of covered topics are concentrated in category *(1) planning* and do not cover entire framework, however majority of provided topics expected educational levels corresponds or exceeds industry requirements.

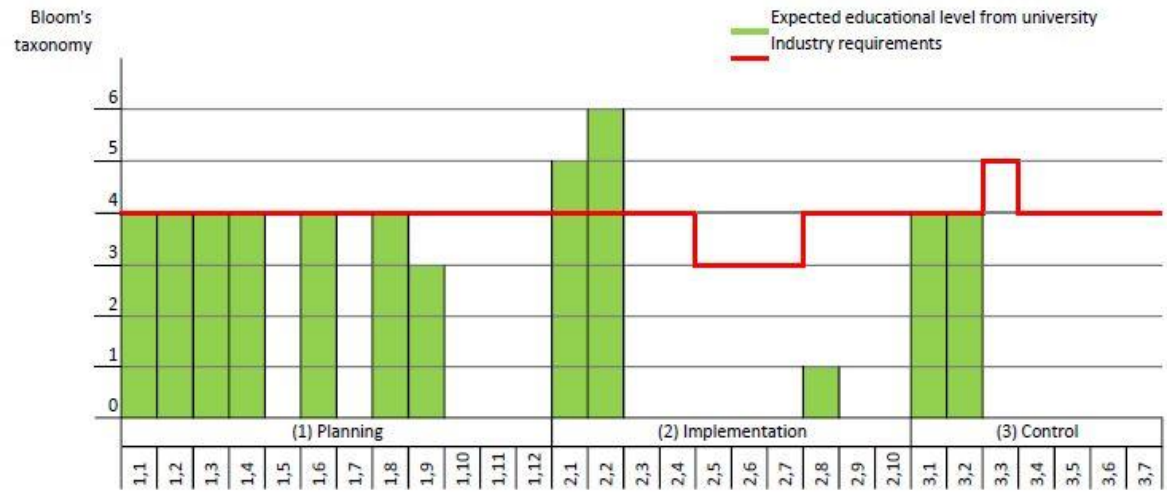

Figure 11: Educational gap analysis per topics for the Master's (C) courses.

Figure 12, shows detailed gap analysis for both Bachelor's (F) and Master's (C) courses provided by the University of Amsterdam of Applied Sciences and University of Twente (NL), in case student will decide to combine them.

The figure 12, shows that expected educational level at Bachelor's course (F) is higher and intensive than at Master's course (C), for instance matching topics: *1.8 – inner city deliveries, 1.9 – delivery strategies,* and *3.2 – materials flow control* are 1 level higher than the same topics provided by Master's course (C). In addition, in the category of *(1) planning* and *(3) control* the topics 1.1, 1.2, 1.4, 1.6, and 3.1 has the same expected educational level 4, for both courses. Total amount of included topics are 25 (87.5 %). Should be admitted that combination of both courses are well balanced as they cover majority of topics with high expected educational levels.

Figure 12: Educational gap analysis per topics for the Bachelor's (F) and Master's (C) courses.

Per topics evaluation are summarized in table 12, which demonstrates frequency of topics repetitiveness, among the selected Bachelor's and Master's courses. Should be admitted that none of the topics from the comprehensive framework appeared excluded, however they showed different frequency of includes. The highest frequency was demonstrated by 1.4, 1.6, 2.2, and 2.3 topics, they were covered by all 5 courses (83%), with equal ratio of Bachelor's and Master's courses; Topics 1.1, 1.2, 2.1, 3.1 and 3.2 were included in all 4 courses (66.4%), with dominancy of MSc courses; Topics 1.8, 1.9, and 3.3 were involved in all 3 courses (49.8%), with dominancy of Master's courses. The low frequency showed following topics, 1.3, 1.10, 1.11, 2.4, 2.7, 2.8, 3.4, 3.5, 3.6, and 3.7 they were included only in the 2 courses (33.2%), with dominancy of Master's courses; and the lowest includes

showed topics 1.5, 1.7, 1.12, 2.5, 2.6, 2.9, and 2.10 they were covered only by 1 course (16.6%), with dominancy of Master's courses.

Table 12: Frequently of same topics included in the different courses.

#	Category number	Topics	Frequency						
			None courses	1 course	2 courses	3 courses	4 courses	5 courses	All 6 courses
			0.0 %	16.6 %	33.2 %	49.8 %	66.4 %	83.0 %	100.0 %
1	1.4	Demand forecasting				3 BA / 2 MSc			
2	1.6	Procurement				2 BA / 3 MSc			
3	2.2	Supplier relationship management				2 BA / 3 MSc			
4	2.3	Risk management in supply chains				3 BA / 2 MSc			
5	1.1	Systems perspective/overview				2 BA / 2 MSc			
6	1.2	Enterprise Resource Planning				1 BA / 3 MSc			
7	2.1	Total quality management				2 BA / 2 MSc			
8	3.1	Physical distribution cost				2 BA / 2 MSc			
9	3.2	Materials flow control methods				2 BA / 2 MSc			
10	1.8	Inner city deliveries				1 BA / 2 MSc			
11	1.9	Delivery strategies				1 BA / 2 MSc			
12	3.3	Progress monitoring				2 BA / 1 MSc			
13	1.3	BIM-based planning				2 MSc			
14	1.10	Routing and scheduling techniques				1 BA / 1 MSc			
15	1.11	Circular business models				1 BA / 1 MSc			
16	2.4	Sensoring technologies				1 BA / 1 MSc			
17	2.7	Robotization and automation				1 BA / 1 MSc			
18	2.8	Construction sequences				2 MSc			
19	3.4	Tracking technologies				1 BA / 1 MSc			
20	3.5	Site storage space management				1 BA / 1 MSc			
21	3.6	End-of-life-cycle scenarios				1 BA / 1 MSc			
22	3.7	Asset information models				1 BA / 1 MSc			
23	1.5	Return planning			BA				
24	1.7	Construction site layout planning			MSc				
25	1.12	Site waste management			MSc				
26	2.5	Transport regulations			BA				
27	2.6	Transport modes and intermodality			BA				
28	2.9	Deconstruction sequences			MSc				
29	2.10	Site-specific safety management			MSc				

Following tables 13, 14, 15, 16, 17 and 18 defines per course gap analysis. The amount of covered topics for each course was defined from the table 11, and translated into percentage values. Percentage amounts are calculated for each category of comprehensive framework and compared with percentage values of industry requirements. General expected educational levels for each course according to Bloom' taxonomy is presented in table 19. The qualitative data for entire courses was derived from universities web pages (See appendix 9) and translated into quantitative data in the same logic as it was explained in table 9.

Table 13: Per course gap analysis, for course (D).

Course (D)	(1) Planning		(2) Implementation		(3) Control	
	Current expected education	Industry requirements	Current expected education	Industry requirements	Current expected education	Industry requirements
Included topics 21%	7 %	41%	10.5%	35%	3.5 %	24%

Bachelor's course (D), *MO9409: Operations and Integrated Supply Chain and Marketing Management* includes in total 21% content of comprehensive framework. Whereas, 7% covers content of category (1) against 41% of industry requirements; with 10.5% covers content of category (2) versus 35% of industry demand; and with 3.5% corresponds to the category (3) where industry requires 24%. Overall, Course (D) cannot cover even 50 % of comprehensive framework that indicates on educational gap. As an expected educational level for entire course (D) was recognized level 2 (understanding), which means after graduation students will be able only to understand the meaning of the different type of functions by interpretation.

Table 14: Per course gap analysis, for course (E).

Course (E)	(1) Planning		(2) Implementation		(3) Control	
	Current expected education	Industry requirements	Current expected education	Industry requirements	Current expected education	Industry requirements
Included topics 17.5%	7 %	41%	3.5%	35%	7 %	24%

Bachelor's course (E), *AF1723: Building Logistics and Risk Management* includes in total 17.5% content of comprehensive framework. Whereas, 7% covers content of category (1) against 41% of industry requirements; with 3.5% covers content of category (2) versus 35% of industry demand; and with 7% corresponds to the category (3) where industry requires 24%. Overall, Course (E) cannot cover even 50 % of comprehensive framework that indicates on educational gap. As an expected educational level for entire course (E) was recognized level 3 (appling), which means after graduation students will be able to implement different type of functions in practice.

Table 15: Per course gap analysis, for course (F).

Course (F)	(1) Planning		(2) Implementation		(3) Control	
	Current expected education	Industry requirements	Current expected education	Industry requirements	Current expected education	Industry requirements
Included topics 80.5%	31.5 %	41%	24.5%	35%	24 %	24%

Bachelor's course (F), *34390: Logistics Engineering* includes in total 80.5% content of comprehensive framework. Whereas, 31.5% covers content of category (1) against 41% of industry requirements; with 24.5% covers content of category (2) versus 35% of industry demand; and in last category (3) it fully covers presented content. Overall, Course (F) can cover major part of comprehensive framework, however still there is an educational gap. As an expected educational level for entire course (F) was recognized level 4 (analyzing), which means after graduation students will be able to see different parts of processes and determine how those parts are related to overall purpose.

Table 16: Per course gap analysis, for course (A).

Course (A)	(1) Planning		(2) Implementation		(3) Control	
	Current expected education	Industry requirements	Current expected education	Industry requirements	Current expected education	Industry requirements
Included topics 21%	7 %	41%	7%	35%	7 %	24%

Master's course (A), *MO0487: Strategic Procurement and Logistics* includes in total 21% content of comprehensive framework. Whereas, 7% covers content of category (1) against 41% of industry requirements; with 7% covers content of category (2) versus 35% of industry demand; and with 7% corresponds to the category (3) where industry requires 24%. Overall, Course (A) cannot cover even 50 % of comprehensive framework that indicates on educational gap. As an expected educational level for entire course (A) was recognized level 3 (appling), which means after graduation students will be able to implement different type of functions in practice.

Table 17: Per course gap analysis, for course (B).

Course (B)	(1) Planning		(2) Implementation		(3) Control	
	Current expected education	Industry requirements	Current expected education	Industry requirements	Current expected education	Industry requirements
Included topics 84%	38.5 %	41%	28%	35%	17.5 %	24%

Master's course (B), *AI2805: Building Informatics and Logistics* includes in total 84% content of comprehensive framework. Whereas, 38.5% covers content of category (1) against 41% of industry requirements; with 28% covers content of category (2) versus 35% of industry demand; and with 17.5% corresponds to the category (3) where industry requires 24%. Overall, Course (B) can cover major part of comprehensive framework, however still there is an educational gap. As an expected educational level for entire course (B) was recognized level 4 (analyzing), which means after graduation students will be able to see different parts of processes and determine how those parts are related to overall purpose.

Table 18: Per course gap analysis, for course (C).

Course (C)	(1) Planning		(2) Implementation		(3) Control	
	Current expected education	Industry requirements	Current expected education	Industry requirements	Current expected education	Industry requirements
Included topics 42%	24.5 %	41%	10.5%	35%	7 %	24%

Master's course (C), *195810200: Supply Chain Management & ICT* includes in total 42% content of comprehensive framework. Whereas, 24.5% covers content of category (1) against 41% of industry requirements; with 10.5% covers content of category (2) versus 35% of industry demand; and with 7% corresponds to the category (3) where industry requires 24%. Overall, Course (C) cannot cover even 50% of comprehensive framework that indicates on educational gap. As an expected educational level for entire course (C) was recognized level 3 (appling), which means after graduation students will be able to apply knowledge in practice.

Table 19 shows per-course analysis where expected educational level for A, B, C, D, E, and F courses are presented according to Blooms taxonomy. The qualitative data are collected from the universities web pages (See appendix 9) and translated in to quantitative data in the same logic as presented in table 9. While industry requirements as a total average values are taken from table 6.

Table 19: Education best practice vs industry requirements (gap analysis per- courses).

Bachelor's degree				Master's degree				Industry Requirements after 10 years of practical experience
Current level of achievement for courses			Industry requirements	Current level of achievement for courses			Industry requirements	
D	E	F		A	B	C		
2	3	4	3	3	4	3	4	5

The data provided in table 19 are translated into figure 13. Which graphically shows per course analysis. The figure 13, horizontally it shows Bachelor's and Master's courses and theirs geographical location. Vertically, it shows Blooms taxonomy levels. It also shows industry requirements for employees with different education. Figure13, demonstrate that (F) and (C) courses in Netherlands are not balanced as (F) course exceeds industry requirements, while (C) course do not corresponds industry demands. The study courses (D) and (A) from Unite Kingdom looks more balances however, neither (D) nor (A) course corresponds construction industry requirements. Regarding (E) and (B) study courses from Sweden they seems well balanced and they correspond industry demands.

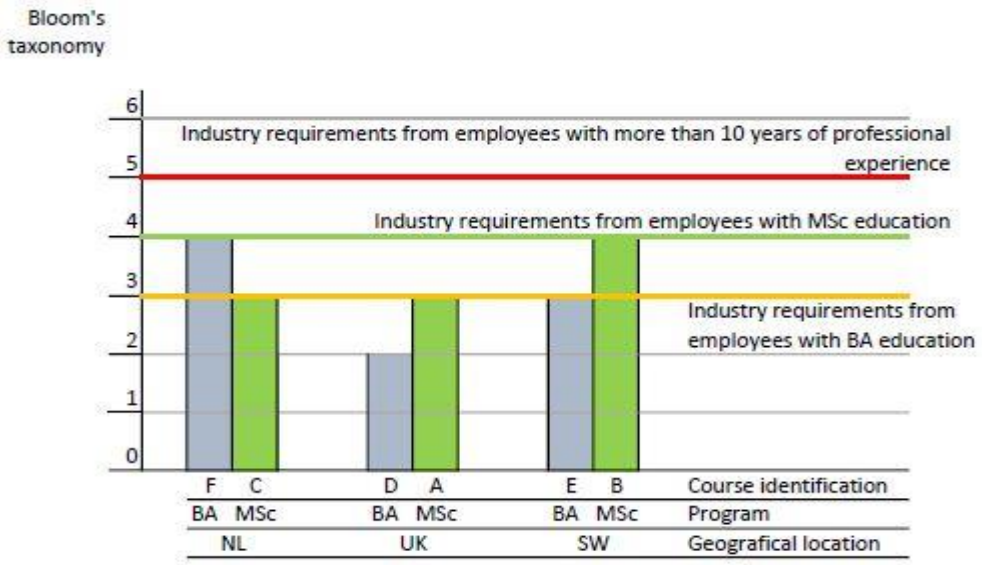

Figure 13: Educational gap analysis per courses.

4. Discussion

The results of this research show that study courses provided by the universities mainly covers topics related to forward logistics processes and poorly includes topics related to reverse logistics. Also, selected courses partly include construction related activities that is essential knowledge for construction logistics managers. In addition, it turned out that combined Bachelors and Master's courses appeared to be more balanced as they can cover majority of topics from the comprehensive framework and can supply higher educational level than separate courses alone. Also, interesting details were discovered during the gap analysis for example, only 9 topics were included by the majority of the courses, they are: *1.4 - Demand forecasting; 1.6 - Procurement; 2.2 - Supplier relationship management; 2.3 - Risk management in supply chains; 1.1 - Systems perspective/overview; 1.2 - Enterprise Resource Planning; 2.1 - Total quality management; 3.1 - Physical distribution cost; and 3.2 - Materials flow control methods.* On the other hand, following topics were almost ignored as they were covered only by one course, *such as: 1.5 - Return planning; 1.7 - Construction site layout planning; 1.12 - Site waste management; 2.5 - Transport regulations; 2.6 - Transport modes and intermodality; 2.9 - Deconstruction sequences;* and *2.10 - Site-specific safety management*. The obstacles that appeared during the data collection process are listed below as limitations for this research.

4.1. Limitations

The time and financial constraints prevented the researcher from meeting and conducting an in-depth interviews with some university professors.

The qualitative and quantitative data partly was collected from the universities' public websites and syllabus. Therefore, data analysis might be under the influence of researcher's personal bias.

Universities' web pages and syllabus contains the only summary of the course content, and therefore there is a risk that some topics with low expected education levels were excluded from the document. Especially reliability of data was limited for course (E). Where, web page did not included enough information and to get in touch with leading lecturer was also not possible. Therefore, course (E) shows less topics in the per topics analysis than it claims in the per course analysis.

The data collected via in-depth interviews from the universities' professors might be biased. Unfortunately, it was not possible to cross-check the in-depth interviews with more than one representative including a student, whose opinions as practical users of the knowledge are also important.

The research has geographical constraints; cases were selected only from Western European countries such as Sweden, England, and the Netherlands. Therefore, outcomes of the study are only applicable to the Western European context.

The research considers the Bloom's taxonomy cannot scale that number of new topics derived from the industry representatives. Therefore, those topics are listed in next the paragraph separately for the future exploration. In the next section research defines large potential for improvement of educational practice in the universities.

Filling the educational gap should begin with the rethinking of existing educational practice at the universities, as well as by the creation of enabling conditions in the industry that facilitates innovations in the construction logistics sector. For that reason number of recommendations has been developed (See below).

4.2. Novel learning content development

The development of novel learning content can bridge the educational gap, as it should include all the forward and reverse logistics processes related to construction activities. It should provide an integrated educational approach by linkage of all life cycle from the design till final stage. This kind of knowledge can be demanded in the future for the sustainable urban development. The topics list given in the table 5, can serve as a basic for the development of novel learning content. However, it should permanently be modified to bridge the gap between universities educational supply and industry demand. For that reason current research identified number of new topics suggested by the industry that requires academic assessment. These topics are: *Handling of explicit information (e.g. creation, usage and storage of information); Construction traffic forecasting, creation of dynamic models, and its application and evaluation; Operational change management; Master data management; People management; Knowledge of plant and equipment types and capacity (e.g. materials hoists, tower cranes/hook time analysis).* These new topics are recommended to be assessed by the academia and incorporated in the comprehensive framework, as needed.

4.3. Effectiveness of novel learning content

Effectiveness of novel learning content depends on number of factors discussed as follows. Construction engineering background seems to be a 'must' requirements for the students who would like to specialize in the construction logistics. Since the construction industry is very context dependent and requires proper knowledge of construction related procedures.

The kinesthetic way of learning is needed to raise students' cognitive thinking level. Knowledge given at the universities are mainly theoretical and is not always supported by practical assignments, which includes all the aspects of construction logistics processes. Software games, practical assignments and home written exams are recommendable. Assignments should include different scenarios such as, winter and summer conditions, within developed countries and within countries of transitional economy. Learning process can be extended more than one semester and include more than one university students. Such an approach will help students to learn business communication in practice, to analyze and evaluate other disciplines that are linked with construction logistics processes, and finally to come up with creative and innovative solutions. As learning by doing it seems to be most of

the accepted learning method for engineering faculties. I believe such an interdepended learning process makes multi-disciplinary engineers with vide overview on the logistics activities.

Creative thinking and intuitive approach needs to be developed. At the end of construction logistics course when students acquired a solid foundation in the discipline, the learning process should contain special assignments that provokes students to come up with original ideas. Learning point should be novel ideas. Course should include extra time for students to facilitate open-ended and flexible projects about any topic of study.

Cooperation with government is recommended for universities as educational gap reduction process should be supported by new rules and regulations in the construction logistics. The government should allow the industry to come up with innovations through some incentives, to stimulate alternative solutions. Interestingly study revile that some topics offered by universities exceed industry requirements. This shows that at this point industry is not able to utilize the knowledge offered by the universities. There is a capacity and knowledge available on the market, but is not utilized due to low demand, universities should lob the governments to introduce new incentives and encourage industry to apply more innovative solutions in practice. This would encourage industry to make full use of the academic capacities of newly graduates.

5. Conclusion

This chapter contains summary of research and data analysis that partly proved truth of hypothesis. Current educational system can provide highly qualified specialists for construction logistics domains. However, it still needs improvements in order to correspond industry requirements and social challenges.

5.1. Research question 1

The paragraph answers the primary research question: What is the gap between educational state of the art in the construction logistics of leading universities and construction logistics practice?

The results defined that main educational gap between state of the art universities and industry are absence of holistic approach in the construction logistics management. Selected courses mainly covers forward logistical processes, however they partly or absolutely did not include topics related to reverse logistics, such as: *1.5 – return planning; 1.11 – circular business model;* and *1.12 – site waste management*. In addition, educational gap exist in the providing of specific construction logistics context during the education. Analyzed topics and courses mainly stands for general logistics context considering that they can be applicable for any industry, which requires from graduated specialists further investment of time and other resources to specialized particularly in construction logistics. Courses A, B, C, D, E, and F either partly or absolutely did not include topics related to construction activities, such as: *2.8 – construction sequences; 2.9 – deconstruction sequences;* and *1.3 – BIM based planning*. Moreover, per course analysis show that some of the courses is not balanced. Bachelor's course exceeds industry requirements while Master's course needs further developments. Or both Bachelor's and Master's courses are balanced well but both cannot reach out industry requirements. This is the main educational gap found out during this research.

5.2. Research sub-question 2

This paragraph answers the second sub-question. What is the educational state of the art in the construction logistics practice?

The results of research defined number of courses that can cover 84% of topics included in the comprehensive framework. In case of combined education such as Bachelor's and Master's courses, they can cover even more 91% of topics. However, state of the art in the construction logistics consist of a number of separately provided courses and topics, which mainly focus on general logistics context and does not include important construction related topics provided by comprehensive framework. Therefore, universities are lacking to equip graduate specialists with multi-disciplinary education with future perspective that are highly demanded by the construction industry. Universities are giving general knowledge about logistics and supply chain management after that student should spend extra time in industry to specialize in the construction logistics.

5.3. Research sub-question 3

This paragraph answers the third sub-question. What is an education demanded by the industry in the construction logistics practice?

Results show that industry requires specialists with multi-disciplinary education. Who has holistic approach and are able to consider social dimensions in the materials flow management process. To be more specific, research found out that average demand from the employees with Bachelor's degree is mainly focused on level 3, which means specialists should be able to apply and implement theoretical knowledge in practice. Besides, industry's average demand from the employees with Master's degree is focused on level 4, which means specialists should be able to analyze single processes of construction logistics and determine how those processes are related to overall purpose. Also, the industry expects from the employees after 10 years of professional life to reach out level 5, which means specialists should be able to evaluate construction logistics related processes and make appropriate decisions through checking and critiquing. In summary, construction industry demands highly qualified multi-disciplinary educated specialists, which can apply, analyze and evaluate logistics related processes within a social, environmental and economic context.

Probably after this research educational programs focusing on construction logistics will incrementally include new topics defined in the comprehensive framework (See table 5). And exclude the topics that so far were provided but they are no longer relevant. The main accents should be on the holistic approach that considers well knowledge of forward and reverse logistical processes in the construction that can improve urban environment and bring multiple benefits for society.

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Appendix 1. Five common areas related to construction logistics

Collaborative behavior

The collaboration is important, because according to business consultant Peter Drucker as cited in Fawcett et al., (1994) business world is fast adapting marketing concept rather than the narrower product-led sales-oriented approach, therefore demand for improvement of logistics operational performance raised. An integrated approach has been identified as the key to success in achieving those vital goals. The concept of integrated management includes an element of supply chain management. According to Cooper et al., (1997) as cited in Mentzer et al, (2001) each firm in the supply chain, directly and indirectly, affects the performance of all the other supply chain members. Where the main objective is to view the supply chain as an interdepended entity that integrates and manage the sourcing, flow, and control of materials by using a total systems perspective across multiple functions and multiple levels of suppliers. Successful implementation of integrated concept requires a collaborative effort between supply chain partners. The importance and relevance of this area in the context of construction industry is obvious, because collaboration occurs when two or more autonomous and self-interested business units form a coalition and exchange or share resources with the goal of making decisions or undertaking activities that will generate benefits that they cannot generate individually (Audy et al, 2010). In addition, it includes a strong sense of integration among the suppliers and customers, it controls the timing and synchronizes material flows. The researcher Waller (1997) as cited in Akintoye et al, (2000) stated that quality, cost and delivery times can be based on teamwork, collaboration and elective coordination throughout the organization. Furthermore, by intensive exchange of information between partners timely can be mitigated organizational slack and adversarial relationship (Chen, 2004). The collaborative behavior can generate collective learning, teamwork and influence the development of a total quality management practice within construction logistics activities (Love et al, 2004). I am sharing the idea of Sperkman et al, (1998) as stated in their papers that collaborative behavior initiates new form of competition where accent is on global network at the core of which are managers whose proactively looking for alternative interpretations of events, and think differently about their business in order to respond quickly to business world's changes.

- **Main question** - *What tools, processes or knowledge are needed for collaboration within construction logistics?*
- **Additional question** - *Would you add any new processes, which might become important in the future?*

Business management tools

Business management tools are an important area, according to scholar Amstel, (2017) business management tools are essential for successful logistics, because companies within 20 years at the strategical level learned the cost of failure and they are pretty aware of difficulties. However, at the tactical and operational level logistics companies are still lacking in the implementation of business management tools and qualified staff members. For the same reason Illinois University, in the USA recently recognized supply chain management course as a core business competency within logistics. According to scholars, Bowersox and Closs (2013) as cited in Akalin et al., (2016) supply chain management course includes business management tools relevant to the logistics since it is an interdisciplinary, process-based, and boundary-spanning activity. In addition, the Council of Supply Chain Management Professionals (CSCMP), (2013) as cited in Akalin et al., (2016) stated that: 'supply chain management encompasses the planning and management of all activities involved in sourcing and procurement, conversion, […] coordination and collaboration with channel partners.' The demand

for the logistics professionals who understand and communicate well with other areas of businesses, including marketing, sales, finance, and information technology is raising. The unique challenges of contemporary logistics call for leaders that possess distinctive toolsets that enable them to develop innovative solutions and stay competitive within business turbulence. Logistics as a commercial activity also face with increasing level of business turbulence, which requests from logistics managers to be equipped not only with functional knowledge, such as inventory management, warehousing, transportation management etc. But also with business management tools in order to sense and seize opportunities within a turbulent business environment (Tatham et al, 2017). Researchers Mangan and Christopher (2005) argued that managers should be as 'managers first and logisticians second' which means that they should think as a businessman and manage relationships with multiple customers and suppliers within the internal and external network. In addition, in his paper Srivastava (2014) defines that logistics requires cross-functional awareness, and the ability to make decisions quickly and independently. Scholar Johnson et al. (1999) as cited in Srivastava, (2014) suggested that today's logistics manager must be both a technical expert and a generalist. The competence of people and excellence in the business management will be crucial for logistics managers since turbulence in construction business environment becoming a norm rather than an exception and it necessitates changes in the existing training and education programs.

- **Main question** - *What are the core business management tools within construction logistics?*
- **Additional question** - *Would you add any new tools that might become important in the future?*

Information communication and technology (ICT)

ICT is an important area in the contemporary construction logistics. According to Mentzer, et al, (2008), it is characterized by poor quality, increased time, and increased risks to health and safety, which requires effective logistics systems to ensure delivery of the right products and services to the right players at the right time. The researchers Bassi and Parand, (2002) as cited in Omar (2009) stated that construction companies can achieve efficient logistics outputs by using advanced Information and Communication Technology (ICT) and wireless technologies, they argued that traditional communication methods rely on static business modes of information delivery and do not consider other players changing context and dynamic project conditions, which makes logistics process inefficient. According to report Berger (2017) Association of German Chambers of Commerce and Industry (DIHK), 93% of companies agree that ICT will influence every one of their processes and it replace traditional business model completely, because construction companies concentrate primarily on the usage of ICT tools within planning, construction and logistics processes. Besides, building material traders also add a strong focus on online trading to their logistical considerations. The implementation of ICT tools are important for proper functionality of supply chain and it includes following key elements: Electronic collection of data; Mobile access to the internet; Self-organizing systems; and Synchronization of activities. ICT can raise productivity among the construction logistics activities, such as: Logistics - most of well-defined ICT tool for construction logistics is Building Informational Modeling (BIM). Because, this is an integrated 3D design where all suppliers are able to exchange the project data digitally. BIM supports decision-making process by creating value for stakeholders (Khalfan, 2015). In addition, according to Berger (2017) smart building site logistics needs potential for optimization, because construction workers devote only about 30% of their working time to their principal activity. The remaining 70% is taken up by transporting materials, rearranging the building site and looking for materials and equipment. Many onsite activities can be optimized by using various ICT applications. Procurement - electronic tendering is becoming popular. Because, the ICT application has the added advantage that electronic calls for tender reduce costs while increasing

efficiency. Suppliers have ability to contribute to planning processes via digital channels, for example through CAD library. Finally, Production/Construction - drones and robots are the future of construction project they can save time and money, such as: 3D lasers can quickly identify underground communications and make them immediately available to the project manager or designers. Drones are likewise already in operation in the construction industry, they monitor large building sites. In addition, mobile 3D printers are another digital innovation with a huge potential to change construction logistics processes in the future. Application of ICT in construction practice is very helpful, and therefore it has been considered as one of the key area for future discussion with respondents, which can bring opportunities for construction companies to make them more sensitive towards business strategy.

- **Main question** - *What are core tools and knowledge for application ICT within construction logistics?*
- **Additional question** - *What ICT service can you recommend for the future construction logistics?*

Reverse logistics

Reverse logistics are important area. Because, construction industry is a large consumer of the world's natural resources and generator of huge volume of waste (Rameezdeen et al., 2016). The researchers Schultmann and Sunke, (2007) as cited in Chileshe et al., (2016) believes that implementation of reverse logistics would reduce environmental and societal effects, and boosts construction economy. The main benefit for companies would be reduction of operational costs and increase sales revenue, which are potential opportunity to remain competitive advantage in the market (Vahabzadeh et al, 2015). In addition, main benefit for society and environment would be protection of natural resources and reduction of CO2 emission (Sobotka, 2015). The scholars Carter and Ellram (1998) as cited in Sobotka (2015) described reverse logistics as 'The process whereby companies can become more environmentally efficient through recycling, reusing, and reducing the amount of materials used'. Furthermore, researchers Vrijhoef and Koskela (2000) as cited in Chileshe et al., (2016), stated that implementation of reverse logistics should take into account the characteristics and the specific situation of construction industry, by investigation of influential factors. Shakantu and Emuze, (2012) as cited in Rameezdeen et al, (2016) highlights main influential factors and the reasons behind those factors that needs proper management, such as: Regulatory environment - the government should implement supportive regulations that makes it easy for people who wants to use salvaged materials and prevent disposing them in landfills. Lack of standards, codes and guidelines for salvaged materials prevent building inspectors accepting them as appropriate for new construction. Additional costs – for the countries with high labor costs reverse logistics is expensive service. Therefore, mechanical demolition and disposal is more appropriate method for people. In some cases price for salvage materials are higher than that of virgin ones, because the selection of right materials from salvage yards are time-consuming and labor-intensive activity. Lack of recognition in construction supply chain - the suppliers involved in supply chain do not always recognizing second hand materials useful for new construction. For instance, designers usually copy and paste specifications from earlier designs. Because, priority of designers is to safeguard themselves and they would not take any risks by using salvaged materials. Also, for designers budget are more priority than environmental protection and therefore, they fit their design within the client's budget. Extra effort involvement - often stakeholder concerned about shipment of salvage materials as it is labor-intensive activities. The things becoming worse when practitioners encountered with polluted and hazardous materials, which require specific procedures and licensed contractors to deal with them. Selection of specific size materials is challenging process, as it requires from contractor to visit many salvage yards to find what they want.

However, virgin materials are quite opposite. Given those, reverse logistics has been selected as one of the key areas for future discussion with respondents, which can bring societal and environmental benefits to the urban development.

- **Main question** - *What core knowledge is needed for application of RL in construction logistics?*
- **Additional question** - *Based on your experience would you add any new processes to this category?*

Delivery management

Material delivery management is vital important as it affects progress on site due to market status, delivery times, product availability, and delivery lead time (Hamzeh et al, 2007). According to Scholars Koskela and Howell (2002) as cited in Ala-Risku, (2006), the traditional methods of delivery management is obsolete and there is no new methodology where planning, execution, and control are implemented in an integrated and flexible way. They conclude that no plan can ever be detailed enough to enable execution without feedback from the environment. To overcome challenges of traditional delivery management, Ballard, (2000) as cited in Ala-Risku, (2006) suggested flexible delivery management system, so-called Last Planner System, which from the supply chain perspective is the tool that supports - transparency of material availability and short response times. Furthermore, according to Dovey et al., (2016) the necessity of understanding of new economy, particularly in times of financial uncertainty, led scholars to the creative hub systems. Hubs for delivery of construction materials can be seen as 'logistics centers', according to Tsamboulas, as cited in Meidute, (2005) the 'logistics centers' are part of transport infrastructure, it integrates different transport modes where the distribution of different materials concentrates. The reasons behind creating new delivery management methods and importance of those methods are described as follows: Transparency of material availability - is important, because all project tasks in which materials availability acts as a constraint can be detected, and rescheduled to a later date where the material needs are satisfied. Short response times in the supply chain - is important, because it ensures effective communication and near-term scheduling between construction site and suppliers. Implementation of logistics centers - are important, because it facilitates globalization of business processes and inter-collaboration between parties. According to Mizushima Port International Logistics Center as cited in Meidute, (2005) Purpose of the Logistics center is to stimulate international trade and economic growth in that region or city. Given those, delivery management has been selected as one of the key area for future discussion with respondents, which should bring new business solutions and inter-collaboration possibilities to the construction companies.

- **Main question** - *What are most of common strategies for service and material delivery?*
- **Additional question** - *Based on your experience what would be new delivery methods in the future?*

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Appendix 2. Job description list for construction logistics managers

Summary

The construction logistics manager is responsible for all aspects of the logistics supply chain, stores management, development and optimization of site logistics solutions to meet the needs of the project. The logistics manager will be required to manage the movement of people, goods and equipment at the construction site and control site facilities management.

Key interfaces that the logistics manager must ensure early engagement with are: the project planner; the commercial managers procuring the works and the senior construction manager on the site. The construction logistics manager should ensure that the construction team is fully aware of logistics activities in support of the build program.

The construction logistic manager's role can be described under the following headings:

1 Planning/programming

a) Plan site set-up to move labor, plant, and materials around site efficiently (eg hoarding, gates, site accommodation, cranes, hoists, security, temporary services, material delivery and waste management strategy, catering).
b) Plan internal and external logistics routes through the project phases focusing on separation of vehicles, machinery and people. Lay down areas and offloading points.
c) Pre-plan the usage of key assets such as hoists to ensure planned assets meet the needs of the program.

2 Moblilization

a) Create a secure site
b) Responsible for all traffic management internally and externally, weighbridges and road network cleanliness.
c) Manage installation of site accommodation and manage these facilities
d) Create operational procedures and method statements
e) Organize site inductions, ensure induction records are securely stored.
f) Create a schedule of logistics meetings and ensure logistics is represented at site meetings.

3 Supply chain management

a) Describe the characteristics of the site, including site access /egress, storage capacity and arrangement by programmer, labor, hoists, cranes etc.
b) Use the description to produce daily, weekly and long term movements plans
c) Understand procurement arrangements
d) Control materials in and out of site.
e) Plan and integrate with key contractors to meet the needs of the planned programmer and de-confliction of on-site space and time where appropriate.
f) Assist in the evaluation of potential logistic suppliers and appropriate delivery management booking systems.
g) Be capable of managing sub-contractors to deliver their package of goods or services
h) Variation control and early communication of foreseeable change

i) Commercial/contract basic understanding
j) Utilize business management system procedures.
k) Record keeping and key performance indicator (KPI) production.

4 Programme support

a) Embrace a delivery-focused culture.
b) Organize resources to enable contract deadlines to be achieved.
c) Organize resources to work additional hours as required to meet project deadlines (eg extended site hours if required by client).
d) Responsible for ensuring logistics activities are not a constraining factor on the program, where deemed unavoidable ensuring the issues are communicated in order that de-confliction can occur.

5 Safety

a) Ensuring the organization's safety policies are followed
b) Creating of site-specific safety manual, ensure first aid cover and equipment is present
c) Responsible for ensuring that material movement to and from the workface does not cause damage to the works, the workforce or the public.
d) Complete safety inspections to company and client standards
e) Ensure team has safety training to the company and client's standard programme.
f) Create appropriate logistics awareness training and deliver to site workforce via presentation/TBTs as required.
g) Manage and maintain visitor PPE stocks to an agreed number.
h) Produce method statements, risk assessments ensure lifting plans are produced.
i) Safeguard vulnerable road users from traffic and transport created by the site.

6 Fire

a) Create, maintain and update the Site Emergency Plan (including the Site Fire Plan) reporting to the appointed site fire officer.
b) Maintain fire points and all common lifesaving equipment.

7 Site communications

a) Create a system to communicate information around the site eg noticeboards, email distribution lists, monitor displays, web pages.
b) Update site safety performance and key project indicators to pre-agreed frequency.
c) Ensure local hospital data is regularly updated, communicated and routes are checked.
d) Manage the 'near miss' returns and project suggestion box. Collate and issue to management team.

8 Signage

a) Define and organize all site signage to the agreed corporate standard.
b) Ensure that signage and signage symbols used are internationally recognized.
c) Ensure additional languages are used in signage to ensure messages are understood.

9 Delivery management

a) Select a delivery management technique, process and system.
b) Provide logistics instruction to all project suppliers.
c) Manage all movements to and from site and keeping associated records.
d) Enforce the full use of the organization's delivery management system.
e) Plan to and maximize load capacity on all vehicles arriving at site were possible, ensure suppliers use appropriate vehicles for delivery.
f) Ensure that drivers and vehicles meet the required standards before being accepted to site.

10 Vehicles, plant, equipment and vertical transport

a) Specifying and managing plant and equipment.
b) Maintain an asset register of all equipment.
c) Ensure vehicles and plant are operated safely by trained personnel and in a legally compliant manner
d) Ensure all equipment is inspected, maintained and tested to agreed frequencies
e) Have a knowledge of hoists and cranes, and create and agree booking system to manage their capacity.

11 Security

a) Manage guarding resource including rotes and contingency.
b) Ensure compliance with the Private Security Industry Act (2001).
c) Ensure adequate training has been provided and certification is valid.
d) Actively police compliance with site rules.

12 Workforce

a) Be capable of managing a team of operatives, including taking any necessary disciplinary action.
b) Ensure supervisors provide and record 'Tool Box Talks' to workforce.
c) Understand the roles of standard logistics operatives: laborer, waste operative, carpenter, hoist driver, handyman, traffic marshal, SIA guard.
d) Ensure operatives are assured of their roles and responsibilities.
e) Ensure competencies of own team are demonstrable.
f) Recruitment of operatives.

13 Environmental

a) Complete environmental risk assessment.
b) Create, maintain and regularly update the Site Waste Management Plan to ensure the safe and efficient removal of waste from the project.
c) Update environmental reporting on site communications boards and other media.
d) Ensure duty of care certificates from all contractors are kept as required by project director.
e) Ensure Safety, Health and Environmental monitoring is completed.

14 Corporate social responsibility (CSR)

a) Conduct at least one CSR activity per month (monthly).
b) Produce a project newsletter

15 Desirable skills and competencies

a) A track record of delivery within a construction management or logistics function (over the past 3 years) that has led to performance improvement e.g. cost reduction, process/service enhancements, innovation, winning work etc.
b) Personal commitment to promoting a sustainable approach to logistic procurement and supply chain development.
c) Excellent communication skills that build empathy and support, engage with individuals at all levels, influence, promote.
d) Intellectual capacity to deal with complex logistics issues, and to implement logistics and supply chain vision, strategy and priorities. A driver of performance improvement.
e) IT skills (eg PowerPoint, Visio, Word, Excel)
f) An inspirational manager that can get the best out of individuals and teams. Can build consensus, work in a matrix structure, deliver performance and outcomes, and drive the professional and personal development of team members.
g) Manage suppliers: scaffolding, temporary electrics, plumbing, and welfare and office accommodation.

16 Desirable qualities

a) Professional/lead by example.
b) Passion/can do attitude/constructive challenge.
c) To hold a proven track record of integrity and ethical behaviors.
d) Open to change/new ideas.
e) Share information.
f) Supportive.
g) Customer focused.

17 Beneficial qualifications

a) CSCS
b) SMSTS / SSSTS
c) Current full UK driving licence
d) Recognized safety programme, qualified and up to date
e) First Aid
f) Lifting Supervisor Certification
g) A suitable qualification in traffic management (eg Chapter 8 awareness)
h) Institutional membership

Appendix 3. Transcripts of records of semi-structured interviews

Color code:
… Potential topic.
… Potential argument.
… Potential recommendation.

Candidate No: 6
Name:
Name and affiliation:
Date of interview:
Location of interview:
List of acronyms:
Editing Index:
Date of edit:
Editor's name:

1. Collaborative behavior:

PS: What tools, processes or knowledge are needed for collaboration within construction logistics?
RF: There are soft tools and hard tools. As a soft tools I mean trust to each other. We have to make set of rules, to see at the end how performance went. It is important to have a permission. Also, parties have to make several rules and there should be shared vision, to which parties will collaborate with. Most of an important to start with, there is no trust if you have no vision then is not common to work.
PS: Would you add any new processes? What would be important in the future, do you see any tools or processes for the future that will be important for collaboration?
RF: ICT and digital data sharing between different parties. That is most important thing share of data.

2. Business management tools:

PS: What are the core business management tools within construction logistics?
RF: Can you explain further?
PS: What business management tool is needed for specialist to work in the construction logistics industry?
RF: Leadership is important, open mind and ability to collaborate. You can share is important tools, not to look only on yourself. Collaboration is very important tools.

3. ICT:

PS: What are core tools and knowledge for application ICT within construction logistics?
RF: Important to share the data among the parties, but before you have to know what you want, where are you steering at, what kind of data you want to collect.
PS: Well, is there any software you can recommend?
RF: Now we are working with ILIPS, and the product we are developing is construction tickets system it involves all the parties among the chain and it says who will be available on site on a given date. It also measures the pollution of cargo.

4. Reverse logistics:

PS: What core knowledge is needed for application of reverse logistics (RL) in construction logistics?
RF: The core knowledge is to deliver your product like the buyer wants it, in time. Buyer of your product should be satisfied. You should do it efficiently as less as possible waste.
PS: Based on your experience could you add any new processes to this category?
RF: I would recommend some kind of dashboard system by which you can measure all the time where you stand and make necessary changes through out of processes.
PS: Dashboard system is it kind of software? Is it about materials?
RF: Not just for materials, it is for process arrangements, how efficiently did you do your processes, how many movement you have, what is capacity of trucks 60% -100% ?! I use right things to change the process. You need knowledge prior to process, not at the end of process, because it is too late.

5. Delivery management:

PS: What are most of common strategies for service and material delivery?
RF: You should be on time. Important to be right materials on right time on right place.
PS: Based on your experience what would be new delivery methods in the future?
RF: Important is that all the parties should combine production with each other. The preparation of construction site, material supply, crews, and resources should be processed at the same time.
PS: What is the tools for coordination of logistics processes?
RF: Horizontal logistics, tower crane logistics, I think in the future logistics chain should coordinate everything.
PS: Would you add new categories to those list?
RF: Logistics is also innovation. Innovate all the times. Innovation is needed at all the levels of logistics, how all the parties can share the information, goods and resources.

Summary of potential topics

Collaboration: Soft skills such as trust, shared vision, permission to share the information.
Business management tools: Leadership, ability to collaborate.
ICT: Construction ticket system.
Reverse logistics: No information.
Delivery management: Combined production, Dashboard system.

Candidate No: 9
Name:
Name and affiliation:
Date of interview:
Location of interview:
List of acronyms:
Editing index:
Date of edit:
Editor's name:

1. Collaborative behavior:

MD: I am not expert in construction logistics field. I concern not to disturb you.
PS: No problem. We are taking information form logistics specialists and translating it into construction context, so feel free to share your opinion with me.
MD: Is it construction of large scale projects like railway?

PS: yes.
PS: what a tools processes and knowledge are needed for collaboration?
MD: what is needed for collaboration?
PS: Yes.
MD: Important to have a parties who's willing to cooperate. Willingness to benefit from each other and reach some kind of goals. This is a main aspect and ones you have it then you can collaborate. As we say into Dutch 'everyone at the same goal'. In addition, they should be ready to give up something for the higher goal. The main tools should be for information sharing such as: ERP system that makes you access to information.
PS: Thank you. Do you see any changes in the future within collaboration processes? Do you think that only willingness of two parties is enough for collaboration?
MD: companies are now dyes more focusing on core business and specialism which increase need for collaboration, because all outsourced processes should be managed as we call contract management that should be used for managing the relationship with 3rd party service program.

2. Business management tools:

PS: What are the core business management tools within construction logistics?
MD: Can you give me some kind of example what you call business management tools?
PS: For example risk management, planning, marketing.
MD: I am not really sure how it is in construction logistics, I think SCM are most of important because of the fact that there are more collaboration. I think in construction logistics SCM is most of important tools.

3. ICT:

PS: What are the core tools and knowledge for application of ICT in construction logistics?
MD: As ICT tools I would expect in construction logistics ERP system, warehouse management system and some planning tools for materials and resources. If we are talking about construction logistics point of view I expect that everything is less planed and there is no much changes within location that construction engineers deal day to day.

4. Reverse logistics:

PS: What knowledge is need for application of reverse logistics (RL)?
MD: In general I would expect that inspection of environment should be important. Knowledge about construction product what is used for construction and you are going to recycle after life period is finished. How those products should be made.

5. Delivery management:

PS: what are the most of common delivery strategies for material and service delivery?
MD: Larger construction parts will be delivered on site by just-in-time by supplier, no stock. However, small construction parts can be stocked by construction companies.
PS: What do you think about logistics centers or hubs in the cities? Are they applicable for construction industry?
MD: I do not think that hubs and logistics centers can be applicable for construction industry because, hubs requires multiple demand and many customer for the same product, but I am not sure if this is the case for construction industry. Because every project is different and I do not expect that local hub can give you much benefit.
PS: Can you give me some additional suggestion?

MD: I think will be important supply chain finance for construction logistics, which considers agreement among the companies within supply chain, which considers - how to pay each other.

Summary of potential topics

Collaboration: Contract management, willingness to benefit from each other.
Business management tools: Supply chain management. Supply chain finance.
ICT: ERP system, warehouse management system.
Reverse logistics: Environmental inspection, knowledge about construction product.
Delivery management: JIT.

Candidate No: 12
Name:
Name and affiliation:
Date of interview:
Location of interview:
List of acronyms:
Editing index:
Date of edit:
Editor's name:

1. Collaboration:

PS: What knowledge is needed for collaboration within construction logistics?
PA: Three basic factors are necessary for collaboration 1). Right network of companies, in addition one of the things we miss in construction logistics is having tools that make calculations about savings. Savings is difficult to calculate, because saving is not often in the logistics itself. Logistics is more expected to give productivity, faster building, less hours where supply chain becomes value chain. Collaboration is lacking in tools to calculating the benefits. Right partners, exchange information, data and planning accuracy, planning whole model of operational technical decision, every company is doing planning and control model and those planning and control models should be communicated to another company, they must be able to exchange the information. 2. Relationship within network by providing the fare share and awareness where in supply chain benefits are ranking. Without calculations it becomes difficult to know that. 3. Right people and competence, a lot of opportunistic behavior, not only among the construction companies, but also among the principals, in the tender processes. In the construction logistics often final prices are determining factor. Competence of purchasing people. Third factor is missing within the government for instance in the city Amsterdam. Generally within construction logistics all those factors are missing (network, relationship in the network and competences). Because, construction complexity starts with the principals they should take care of their environment.

2. Business management tools:

PS: What are the core business management tools for construction logistics?
PA: You mean strategic management or tactical management?
PS: Both.
PA: On the levels of strategic management we see that slowly CEO's of construction companies (bigger ones not small ones) already got awareness because of cost of failure. However, awareness is lacking

on the technical management levels, such as: report writing and tendering. The tender procedures is not collaborated with subcontractors, service providers and suppliers. The tender should be approached with different prospective from the construction logistics. CEO's have big awareness in the business management tools. Would be vise if we take actual project leaders from the tactical and operational levels which have zero awareness about logistics, they just want to finish project on time. Social innovation is missing. What is actually missing in supply chain relation is also the tools that support of the best solution.

3. ICT:

PS: Thank you. Let's move to third category. What are the core tools and knowledge for application of ICT within construction logistics?
PA: ICT should be used to communicate specifications among contractor, sub-contractors and suppliers. Companies should create dashboards system that is necessary for single site logistics. ICT we see as technical planning tool (BIM model) and operational planning tool (BIM model) they also use special tool for crane planning control tower system. We have students they all are trained how to use BIM, control tower, during the one year.
PS: do you have only engineers or you also have some architects?
PA: No, also an architects, we have whole process it's integrate all cycle from design till final stage, project management, asset management and maintenance. It takes design built finance maintenance approach.

4. Reverse logistics:

PS: Next category is waste management, do you also consider RL processes,
PA: Yes, it should be directly linked. Circular model for construction of cities it is logical step. Waste in the city is construction related if you make logistics substantive and you do not have money to rework materials then you need to link existing sites to new sites this is necessary needs careful process, then you can use materials from one project for another one, this process should be exactly synchronized. If you have two week delay then your projects get complicated. We did not have BIM 10 years ago and we did not know what materials we have in the buildings for instance in Amsterdam. So, all the new buildings are in BIM this is synchronization of operational level.

5. Delivery management:

PS: What are the common strategy for material and service delivery?
PA: I see emerging of construction hubs for all materials very effective. Also, electrical transportation, new type of trucks is expected (driver seating lower)
PS: For instance in Amsterdam you will have several hubs according to regions, and approximately what is the life period of each hub?
PA: Hubs will be interconnected. In Amsterdam we have big constructions and you see their unique hubs for the next two or four years, after what they will closed.
PS: Would you recommend me some additional category?
PA: Two things. Firstly, coordination which is last thing important for construction. Central or decentral coordination. This is complexity of the planning task and predictability of planning task. Predictability is do, check, and act. Life cycle of construction project is constantly changing and some parts are not complex but very unpredictable. The logistics problem is the way people decide. Decentral central that also I am missing as an element we know all about logistics processes. Second step would be to have planning and control models in production industry, we are missing planning and control model.

Because if determine you informational capabilities and linked with logistics organizational aspects. In addition, proper monitoring of transportation systems is missing.

Summary of potential topics

Collaboration: Network, relationship in the network and competences, model of operational technical decision, planning and control model, Tools for calculation of savings and benefits,
Business management tools: Report writing and tendering, social innovation.
ICT: Dashboard system, BIM (as a technical and operational planning tool),
Reverse logistics: Synchronization of operational level.
Delivery management: Hubs for all materials, electro transportation. Coordination (central decentral), planning and control model in production, monitoring of transportation systems.

Candidate No: 17.1
Name:
Name and affiliation:
Date of interview:
Location of interview:
List of acronyms:
Editing index:
Date of edit:
Editor's name:

1. Collaborative behavior:

PS: What core processes and knowledge are needed for collaboration within construction logistics?
VS: What are you interested how we are teaching those skills and connections in the university or what we experienced in the industry?
PS: Would be nice to hear about both.
VS: One major problem in terms of collaboration regarding logistics in industry is lack of planning and sort of patterns of collaboration. In many cases when something happens in the production then they start collaborating. We are not educating students in terms of this, we are to blame as well.
PS: what is missing in education, why universities do not put effort in collaboration?
VS: We teach those general things, leadership, team work, I think we are lacking in sort of teaching collaborative patterns in relation with construction industry. Most of the courses teach BC and MSc they are about production, what is important at the construction site, courses is not how to link production with other phases in terms of design. Also it becomes 'silo'. Our courses are more about personal level development like leadership, or communication it is not about processes, standardization, routines between the different phases.
PS: Is there any attempts to change this?
VS: We have discussion among the teachers what kind of courses is needed, take more considerations in terms of industry, we are discussing more process oriented view of all things, and not just to stick to 'silo' thinking, stick to each course separately.

2. Business management tools:

PS: What are the core business management tools that is needed within construction logistics?

VS: I would say that good planning tool is key. Planning beforehand, important to see logistics routine as process. Process thinking is essential, you plan something and then you can sort of follow whole process, and if something happens you know what to do as an alternative way out, kind of plan B or C. Also, management tools in a sense of communicating demands.
PS: what do you mean?
VS: In industry is lack of demand regarding logistics, client could demand some condition and logistics should solve it in certain way. Contractor can have high demand to theirs sub-contractors, because when production starts then nothing works. Also would be an advantage to communicate needs of logistics.

3. ICT:

PS: What ICT service can you recommend for the future?
VS: Increase of BIM modeling usage.
PS: what type of BIM modeling 5D planning or...?
VS: I think all type of BIM modeling, for instance if you have 5D model it still is not used for logistics - for ordering materials, or delivery planning, it is more related to production who is doing what in that sense. It would be key thing if BIM could be connected with supply chain and use it in logistics.
PS: Why it happens that industry do not use BIM in logistics?
VS: One reason for that is despite of BIM was run many years, still BIM has slow adaptation into industry.
PS: What university is doing to change status quo?
VS: We are teaching BIM but we are lacking in terms of teaching logistics, we need to use applied learning that is something we are working on.
PS: How you thing people educated in logistics are they able to handle construction context?
VS: I think so, because they can do good job if you have those skills. But they deliberately choosing other industry, construction industry has huge difficulties to find people with logistics skills, because people prefer to go to another industry for instance car production.
They prefer to work with advanced technologies in other industry.
PS: In this case who is in charge of logistics in construction industry?
VS: Nowadays site managers are in charge of logistics, often site managers coming from contractor and they supposed to have overview of the site. Each sub-contractor have responsibility ordering their own materials and in terms to delivery on site each actor on site is responsible on own logistics. This cause lot of problems, planning, waiting hours on site, and a lot of moving around materials.

4. Reverse logistics:

PS: What is the core knowledge for application of reverse logistics (RL) in construction?
VS: Main knowledge is the same as ordinary logistics has, but there are so many new laws and regulations for waste management, we see category of people that are specialized in terms of environmental issues, in terms of life cycle. There is definitely increase in waste management specialists similar way as we have BIM specialists. They have to know logic behind processes.
PS: How do you see BIM for RL?
VS: There are two things: 1). if you have old information about who to build structure and all the components, this is something you can use during the deconstruction, you have an overview of buildings, and then you know what to do with all bits and pieces.2). BIM model you can use for planning of waste management processes, for deconstruction and risk management.

5. Delivery management:

PS: What is the common strategy for service and material delivery?
VS: You means coming into the site?
PS: Yes.
VS: Important is scale of economy full track on site with a lot of materials, but what is happened that not all materials are used on site some of them you have to keep in storage. However, in storage many materials are wasted, because of whether, or they are stolen, damaged and also it takes a lot of space on site. I think for the future huge densification of cities in Sweden, lack of space and other pedestrians, create new trend, which is also forcing construction industry for improvement. Suddenly you cannot store lot of materials on site and connect of this pre-brand small delivers coming all the time on site, what we see industry try to cope with this conditions, and we both have logistics specialists who taking full responsibilities for delivery planning systems but we also have seen consolidation centers, in terms of bringing materials from there, hubs, logistics centers.
PS: do you have hubs in Stockholm?
VS: Yes. We have them in Stockholm already and in Goteborg. But problem is that hubs are established for one project and not for regional usage.
PS: Are those hubs connected with each other?
VS: Not really, mostly they are established for one project site only.
PS: Why they are not establishing hubs for regional purpose?
VS: I think they in the industry care only about one project, this is how industry works.
PS: Do you believe that for construction context united coordination of hubs will not work?
VS: In terms of routines, principals and way of working it is far stretched, sort of progress in that sense. you can see so many money can be saved by addressing logistics, many firms start realizing that, so this also speed up the process.
PS: How would you categorized construction logistics processes?
VS: On site construction logistics and off site supply chain logistics and two key areas that should function well together. But many times companies do focus only what is going on site and off site supply chain activates just needs to adapt to that. What kind of conditions demand logistics, how do you value good logistics for materials? Many cases where logistics are most of expensive one that is a problem of buying behavior that also matter condition within the industry in terms of arm-length conditions or strong focus on competitive tendering. You can see more close collaboration between contractor and client, but they do not apply those principles between contractors and suppliers. That is the issue.

Summary of potential topics

Collaboration: Pattern of collaboration within construction context, connection of production and other phases of construction, process oriented view.
Business management tools: Planning tool, communicating demand. Communicating needs of logistics.
ICT: BIM model that is connected with supply chain, production and delivery. BIM model for waste management.
Reverse logistics: Rules and regulations.
Delivery management: Interconnected consolidation centers.

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1. Collaborative behavior:

PS: What is the core knowledge and processes for collaboration within construction logistics?
KW: First of all you know to know what you going transport depending on logistics all approach you mean to know when, where, why, I think it very much depends on what type of materials, product, and components needed. If it large construction structural elements it is different thing. I do not think that there are straight answer to what knowledge you need. It is context depended. The basics is to know when it need on site, where to store them there, you need to know how to get there, through the roads. You should know how it can be transported. Different type of material have different properties that makes boundaries for logistical potential. For example concreate is heavier than wooden piece, those type of componential product specific knowledge.
PS: What is the knowledge for collaboration between different parties?
KW: Knowledge is about how to keep logistics smooth, keep logistics in certain boundaries, for instance designer needs such knowledge to design components, for instance the component should fit in the size defined by the rules of transport regulations.

2. Business management tools:

PS: What kind of business management tool is needed for construction logistics manager?
KW: communication tools of course, they need to have, I think one of the crucial aspects is that they need to be able to see whole pictures, they need comprehensive understanding of all the different aspects that may influence the logistics such, lot of different people, organizations, technical parties, that would affect logistics, and logistical managers should be able to grasp that communicate that to different stakeholders that they also understand that. I would say ability to communicate rather complex situations in a way that people can understand it, it is most of important business tools, and also they need to be able to see time but it is ordinary manager roles as long as they can see complete picture in mind that is core.
PS: How do you think where current logistics managers are lacking, how much disciplines they have to know?
KW: Logistics manager they do not need deep understanding of technical parts but they have to understand main sequence of construction. Role of construction process, different actors are involved and how they can be influenced or influence logistics from construction site. They should understand specific characteristics of construction process that means create facilities, if you have engineering background, then you need to know different logistics approaches, from my experience at list in SW, Denmark, and UK they have mainly engineering background and they know one or two logistics approach and they should stick with them. And they are not dear to experiment other logistical approaches because it cost huge money.

3. ICT:

PS: What are the core tools and knowledge for application of ICT within construction logistics?
KW: IFC - BIM model could be useful, so it is open standard for BIM. Reason for that is you have all the information you need about different components. I do not believe when humans are using different software and transferring information from one program to another, because there are always risk for human error.
PS: what would you recommend as a future ICT tool?
KW: If you do time planning in BIM model you would be able to link JIT delivery to logistics manager of the supplier would just be able to get the information from the system. To take out human error that's would be very interesting tool to look at for the future. Automatic order to goes to the supplier would be interesting. When you can link task the building components and when automatically tells your BIM model to crane which components should be lifted and located on right spot. We will see a lot of those and us as a humans should control it in a complete different way than we are doing it today.

4. Reverse logistics:

PS: What knowledge is needed for application of reverse logistics (RL) in construction?
KW: You need to know what the materials is, what type of materials consider hazardous, what can be reused, what can be stored and etc. material sort out. Knowledge of best way to deconstruct the building, to manage the residue of waste materials in the best way. Classification of materials after deconstruction, to place them separately according to typology. Company deconstructing the house they made money by selling the materials to other parties. And this kind of knowledge will be demanded in the future, especially if we talk about circular economy or shared economy.
PS: What new processes you can see in the future based on your experience?
KW: I think they know what they should do, but many external factors make RL not to do it.
PS: What external factors?
KW: For example: time, if you gone deconstruct building to build the new building you want to get property quickly, the risk involved in deconstruction of house, if you take out it piece by piece you have a people running around with different equipment, and it is dangerous (safety issue), if you have public policy or national policy or legislation that would probably make businesses to do it accordingly.

5. Delivery management:

PS: what are the most common strategy for service and material delivery?
KW: Large companies have framework contract with supplier materials and they have fixed price and they just order the amount what they need and it will be delivered. In the city project this will usually will not be deliver during the rush hours. Traditional delivery when you store things on site, increasing new version of delivery is when you have storage facility either from company or provider and you can make JIT delivery of materials you need, it depends on context of site, if you are within the city then JIT is suitable. But if you are country side then you prefer to store materials on site. In the city condition various ways JIT where you do not need to store it onsite. JIT traditional provider or someone facilitates the JIT delivery. In Goteborg for one project we had company who delivered materials to night. This providers are using materials hubs - this is place where you can collect materials you need and distribute from there.
PS: Do you expect any new methods of delivery for the future, in the context of smart cities for instance?

KW: I am working for a strategy of smart city for my university. We might see robots, drones in the future one thing is we do see is autonomous transport beings that is already existing. I think also much integrating autonomous if you look at hubs specifically there will be different type of robotics. The logistics of construction sites is very context dependent. And answer on your questions could be absolutely different if we would talk about small construction sites and big construction sites outside of cities.

Summary of potential topics

Collaboration: Definition of Logistical potential for materials.
Business management tools: Communication in rater complex situations. Main sequence of construction, knowledge of different logistical approaches.
ICT: IFC - BIM tool (open BIM), integrated BIM model with planning and JIT delivery, BIM - Automatic order system (with supplier, crane onsite),
Reverse logistics: Knowledge of materials, segmentation of materials, knowledge of building deconstruction, safety issues. Knowledge of national legislation about deconstruction.
Delivery management: Hubs, autonomous transport.

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1. Collaborative behavior:

PS: What is the core knowledge for collaboration within construction logistics?
AV: construction culture is important for collaboration. Power distribution among supply chain. Integrated change, much more standardize items. Lean construction is all parts of critical chain of events. Early involvement. Last planer system. Incorporation of buffer. Power distribution in supply chain. Levels of integration.

2. Business management tools:

PS: What business management tool is needed for construction logistics?
AV: Sticking to agreement - with information sharing. Translating logistics demand into other functions. Production balance between demand and supply, setup production line. Negotiation with suppliers. Understanding how production logistics works. Innovative way of thinking. Onsite distribution logistics to eliminate waste. Setup plan of action for client. Understanding the technical staff such as drawings, specifications. Economic prospective. Organization of activities (who is doing what, why and how). Legal regulations (cities, countries) general principals do not apply. Innovative way of thinking.

3. ICT:

PS: What are the core tools and knowledge for application of ICT within construction logistics?
AV: ERP. WMS (control inventory). TMS (transport management system). Some apps should be developed for smartphones. Shared solutions ED control. ICT should become highly integrated. 3D hologram visualization on site (to predict following distribution of materials)

4. Reverse logistics:

PS: What are the most common strategy for service and material delivery?
AV: Avoidance extra materials purchasing. Waste categorizations. Design for demolition. Quality control.

5. Delivery management:

PS: What are the most common strategy for service and material delivery?
AV: Hubs. Water ways should be used din NL. Delivery according to product type.

Summary of potential topics

Collaboration: Construction culture (Power distribution, early involvement, last planner system, integrated change).
Business management tools: Innovative way of thinking, Negotiation with suppliers, translation logistics demands into other functions, setup plan of action for client, understanding technical drawings and specification, economical prospective, legal regulations.
ICT. ERP, WMS, TMS, shared solution ED control. 3D hologram visualization onsite (to predict future distribution of materials)
Reverse logistics: Avoidance extra materials purchasing. Waste categorizations. Design for deconstruction. Quality control.
Delivery management: Hubs. Water ways should be used in the Nederlands. Delivery according to product type.

Candidate No: 24
Name:
Name and affiliation:
Date of interview:
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Editing index:
Date of edit:
Editor's name:

1. Collaborative behavior:

PS: What is the key knowledge in this category?
FK: Collaborative is complicated because of many number of contractors and sub-contractors. Collaboration is difficult because there are demand and constrictor should follow it. Also there are suppliers 10 or 15 and in most cases the main contractor makes logistical plan. Usually, the collaboration on the paper is ok, but in practice if something is changed in the schedule then not all the participants are informed timely, they can get information week later and it will have consequences. So, the organization of logistics plan is not directed in a concrete way only to main participants (sub-contractors, or transporters) and this happens in logistics sector usually, the participant are waiting right moment to pick up the containers. It happens because of one reason: management of contractors is not aware of the operational impact of the logistics, they only take strategic decisions for instance organization of hubs, temporary storage for goods, but when the

system is operating it do not answer building planning. Lean planning can be made in some spaces but not in all the details this is also problem. It requires completely new collaborative system.
PS: Do you mean complete new collaborative system?
FK: Yes. Operations requires actors re-plane the chain, if you combine logistical system with planning then you have step forward, because then all actors can see the schedule. Management of contractor is not aware about operational impact of logistics, they only takes strategic decisions.

2. Business management tools:

PS: What are the core business management tools for construction logistics?
FK: We had educational gap in construction in the early 1990 there were management of construction they had tools in construction management themselves but in this period became very important business management tools that is close to economics, circulations, construction operational level, construction technical level, leading, operational tools in the structure itself, managing supplies of construction itself. Tools should be in the context of construction, on the levels of strategical, technical and operational.

3. ICT:

PS: What ICT tools and knowledge can be used for construction logistics?
FK: ICT systems is useful for calculation of budget, or for planning. Major contractors is using BIM for different stages in the construction. Also, lean transport system is applied for different stages in the construction. BIM is suitable only for major construction companies, because it is expensive for small companies. I was myself busy with tool to respond, predict construction supply chain calculation, amounts of materials, labor hours. There is no so much ICT for specific logistics only BIM.

4. Reverse logistics:

PS: What is the core knowledge for application of reverse logistics (RL) in construction logistics?
FK: I do not know so much about waste management. I did self-study in early 1990 for waste reduction in construction. In that times government has high prices for waste which has direct influence on the contractor. Government ruled reduction of waste. Waste reduction is all about government and contractor interaction.

5. Delivery management:

PS: What is the most common strategies for service and material delivery?
FK: Storages of delivery. Delivery management of different materials are different. Delivery is divided by materials typology.

Summary of potential topics

Collaboration: Collaboration on the operational and technical levels, combination of planning and logistical systems.
Business management tools: Economics, circulations, construction operational level, construction technical level, leading, operational tools in the structure itself, managing supplies of construction itself.
ICT: BIM for different stages of construction.
Reverse logistics: Interaction between government and contractor.

Delivery management: Delivery according to material typology.

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Name and affiliation:
Date of interview:
Location of interview:
List of acronyms:
Editing index:
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1. Collaborative behavior:

PS: What tools or processes are needed for collaboration for construction logistics?
RP: Key elements in construction logistics are to cope to fundamental changes in construction sector. Collaboration between main contractor and sub-contractor should be re-invented and re-arranged contractually. They should enter into the cooperation agreements. Also, in business cases they help each other optimize the chain this have benefit to all the parties. Cooperation is the key instead of main contractor determining the order to sub-contractors who is actually optimizing in terms of construction logistics. BIM is implemented in various projects that helps to re-think further optimization of construction. In addition, collaboration in construction can be achieved by implementation of complete transparency and standardized systems.

2. Business management tools:

PS: What are the core business management tools for construction logistics?
RP: What you see in the construction sector. Delivery of project in time, in quality, and in defined budget are kind of key project management tools what you see in the construction chain. However, this has saturations which has just explained, when you run project you might mitigate all project risks. Project management tools are used now is to mitigate risk as soon as possible. The new way of management needs different tools and competences, new tools should be focused and try to optimize complete chain of construction activities, from design, into procurement, into delivery of materials. New tools that are needed are more like a business people, having holistic view. They should try to motivate all parties to cooperate and optimize project. This means re-thinking of construction project. The new tools are cooperation and trying to motivating parties of all roles in construction chain.

3. ICT:

PS: What are the core tools and knowledge of ICT within construction logistics?
RP: 3D model of design, behind the 3D model the data base application is needed. Kind of say, determined materials needed. Specifications of materials and equipment. New things is BIM model should be combined with ware house management systems and transport management systems. BIM it enhanced tools that really managed from the 3D model. They use tools to determine what materials in needed.

4. Reverse logistics:

PS: What is the knowledge is needed for application of reverse logistics (RL) in construction?
RP: What do you mean under RL?
PS: when you deconstruct the building after life cycle is finished and reuse the materials again.

RP: Circulate business element in construction, you see so many initiatives in construction that they already change second line of materials and those materials can be reused. The design of new building take into account that using materials can be used second times. The reverse thinking still needs to be developed.

5. Delivery management:

PS: What are the most common strategies for service and material delivery?
RP: Most common strategy in construction is go to lower price.
PS: Would you add anything else to this category based on your experience?
RP: logistics in small construction industry is not a science, many valuable followers optimizing construction logistics. Main contractor's key issue is cultural, how people work together in construction industry, collaborative point of view, and cultural way of working in the construction industry. Cultural element in which construction industry is not really moving forward, because of cultural reasons, it can influence the way people work and behave in construction industry. You have to address the issue to get more innovations there. Another element is you did not mention at all is freedom. 50 % of all work is initiating by government roads, housing cooperation, the role of construction industry determined by procurement and government, how should governmental bodies use their procurement procedure that they actually stimulate innovations in construction industry. How construction companies are being asked to offer for a job in the way to implement the innovations.

Summary of potential topics

Collaboration: Adaptability to changes.
Business management tools: Optimization of complete construction chain, cooperation and motivation of all parties in the construction chain, holistic view of processes.
ICT: BIM model (combined with ware house management systems and transport management systems).
Reverse logistics: Reverse thinking in all phases of project development
Delivery management: Innovative procurement.

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1. Collaborative behavior:

PS: What tools or knowledge are needed for collaboration within construction logistics?
AV: I believe, people are important thing that can break good communication that is most important for good cooperation.
PS: Why do you think so?
AV: people can disturb or help on cooperation.
PS: How do you think where is the mismatch?

AV: I believe, youngsters are more open to cooperation and I think youngsters are not problem but old people who has big resistance towards to change are most of problem. Because most of people do not want to change and adapt themselves to new business life.

2. Business management tools:

PS: What are the core business management tools for construction logistics managers?
AV: most important thing is to collaborate, and to know about your competitors, about market.
PS: Do you mean some tools of business espionage?
AV: Yes. What kind of differences they can bring, what is good/ bed things as a company. This is important of competitions. Besides, of soft tools you have to know about figures and calculations. Construction logistics are very difficult sport you have to change every year, they are all about economics.

3. ICT:

PS: What re the tools or knowledge for ICT application within construction logistics?
AV: general knowledge of ICT is important. But, this is not common among the old generation.
PS: Are you using BIM for instance?
AV: Yes. We are all using BIM.

4. Reverse logistics:

PS: What is the knowledge for application of reverse logistics (RL) within construction?
AV: That's difficult. I have no information. I think you have to share with your partners, this is part of circular economy.

5. Delivery management:

PS: What is the most common strategies for delivery materials and goods?
AV: I think that last mile distribution. Last mile delivery in the cities is important for future. Large where houses combination. Communication between where house and last mile delivery system.

Summary of potential topics

Collaboration: People, adaptability to new business life.
Business management tools: Collaboration, tools for business espionage.
ICT: BIM
Reverse logistics: No information.
Delivery management: Last mile distribution, last mile delivery, combination of large ware houses, communication between large ware houses and last mile delivery system.

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Name and affiliation:
Date of interview:
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1. Collaborative behavior:

PS: What tools, processes or knowledge are needed for collaboration within construction logistics?
RH: Construction Company do have partnership with all over companies that is reasons for cooperation in construction industry. If you select projects within big cities and subcontractors you can see that there are companies that have capacity and knowledge that is unique from others. However, you can see that for other tasks big construction companies are taking other suppliers or subcontractors because they have different skills and knowledge then other companies. Logistics managers should be aware about impact of construction logistics, on the operational level.
PS: Does it means that suppliers and sub-contractors are segmented?
RH: In construction industry there are really specialized companies.
PS How logistics managers should be prepared to handle collaboration process within the project?
RH: In my opinion people who working on construction project are aware of impact of logistics, only gap is materials are on time yes or no.
PS: Would you add any new processes for collaboration?
RH: People should be aware about logistics impact on the project, and this should be on the operational level.

2. Business management tools:

PS: What biasness management tools are required within construction logistics from managers?
RH: Understanding the impact of the process. So, logistics manager should have clear understanding of sequences of construction tasks on site and he should have full picture of his role on site.
PS: Many universities preparing separate logistics managers without specific construction education, are they applicable for construction industry?
RH: Construction - is transporting. Buy materials, manage all people on site, and build the building.

3. ICT:

PS: What are core tools and knowledge for application of ICT within construction logistics?
RH: Do you means new type of systems?
PS: yes.
RH: Afbouw box system it is a small container which includes all materials for special project task onsite, it is for minimizing preparation work for workers. Ticket system on site in order to book crane for instance.

4. Reverse logistics:

PS: What is the core knowledge for application of reverse logistics (RL) in construction?
RH: I think, a lot of project are about renovation, some materials can be reused, and some cannot. It depends on type of material and use of building. Difficult to discover what materials are in the building.
PS: So, that's means typology or categorization materials are very important.
RH: Yes. Categorization of materials, typology of materials important.

5. Delivery management:

PS: What are the most common strategy for service and materials delivery?

RH: JIT, the general contractor should control the site and see the sub-contractors action, because they are bringing own materials onsite by them self and major contractor has to controls theirs delivery process in order to avoid conflict on site. Controls tower system helps to manage and collects information about all sub-contractors in order to improve all logistics on site.
PS: Do you recognize any educational gap when you moved from university into industry?
RH: In the industry workers on the operational level do not have vide overview on the activities. However, in the university you are looking at things from helicopter view and it gives you vide understanding. During the tender phase you have to improve your logistics process. If you cannot distinguish yourself from other company then you cannot create value for client, therefore you need all those different ideas but in the time construction company do not want to evaluate any good new ideas or systems or innovations. They prefer to do things as they do or did. They are close to the new ideas people do not want to cope with new systems or software. As universities they know all concept about construction logistics. But site workers do not want to change construction logistics and this is the gap.
PS: So, they have no pro-active thinking.
RH: Yes. They are not pro-active.

Summary of potential topics

Collaboration: Understanding an impact of logistics on the project.
Business management tools: Understanding sequence of the tasks. Pro-active thinking.
ICT: Afbouw box system, ticket system.
Reverse logistics: Categorization of materials, typology of materials.
Delivery management: JIT.

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1. Collaborative behavior:

PS: What tools, processes or knowledge are needed for collaboration within construction logistics?
LS: Between different contractors on site, it is important that everybody know theirs task. main contractor should make clear that what they expect from sub-contractor, capability to meet and speak with each other, face to face communication, not only by email. for example if am building a bridge, I am buying specific part is very important to know for me what kind of conditions this part is made and what kind of team are doing this onsite. You should know how parts are produced. Use full people to know each other and see each other rather than contact them only by email.

2. Business management tools:

PS: What kind of business management tool is needed for logistics managers?

LS: flexibility is important, because construction industry is making clear planning and looking forward and it changes every day very rapidly. Therefore, this is important to have. It makes you able to get better results.

3. ICT:

PS: What are the core tools and knowledge for application of ICT within construction logistics?
LS: Planning system will be most of important for logistics not BIM, not ERP I thing planning is most important thing. You use high level BIM to make planning difficult, may be good planning program can combine ERP system help you to have smooth process. Planning program for construction industry primavera, Microsoft programs. It depends on site and project. Primavera is more for complex projects.

4. Reverse logistics:

PS: What is the core knowledge for application of reverse logistics (RL) in construction?
LS: what is needed to make it more successful is very good separation of projects to know which existing part of building you can reuse where. Also specific information about materials, plastic, wood, metal etc.

5. Delivery management:

PS: What are the most common strategy for service and materials delivery?
LS: JIT - for big parts. And for small parts - stock is used. I think in large scale Hubs are good idea, but for small scale it is very hard to make good business case. Because companies are bringing staff to you and they earn money with transportation as well. So if you take away this money from them then they will take this money from other place. So, there are doubt that hubs will be successful in small scale. But in big scale with multiple companies you can make good business with that.
PS: Based on you experience what would be the new delivery method for the future?
LS: I do not think that things will change for the next ten years, to be honest. I am very sceptic about new delivery methods in the future. I do not thinks that delivery methods will be change in the future. May be system like a hub will be use full for the future.

Summary of potential topics

Collaboration: Face-to-face communication.
Business management tools: Flexibility.
ICT: Planning programs (Microsoft, Primavera)
Reverse logistics: Separation of projects, information about materials.
Delivery management: JIT, Stock, hubs.

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Name and affiliation:
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1. Collaborative behavior:

PS: What tools, processes or knowledge are needed for collaboration within construction logistics?
BG: That capabilities people should have in order to collaborate - maybe itis good to do small introduction from my side to understand prospective I am thinking. Alexanders was my teacher we did some research for logistics. I started to work for DHL and I do not have specific construction logistics knowledge. Important to understand technical difficulties of each other disciplines. the fact that I do not know much about construction logistics it do not limit me to plan the logistics but other parties who has technical knowledge of construction disciplines has doubt about this. Mainly is important to know building methods, what activities should follow each other what is first, and what second, sequence of construction. With my experience every contractor does it in own way and that's basically thing to know how to process is go to say something. Knowledge of process is important to synchronize the processes.

2. Business management tools:

PS: What kind of business management tool is needed for logistics managers?
BG: most of important tool is personal one to speak with all levels easily, and it is quite a gap how to communicate with it. Most of difficult not to convince general director, but below the board director the people have to change the way of working and way of thinking. So, those are the people who is working for many years. There should be new people, new comers educated differently and other part is the existing part of population is to incorporate theirs behavior. Purchase management is also important part, what we are currently doing for customer is changing theirs purchasing contract with suppliers and in cooperating it multiple contracting with regarding constr. logistics. The supplier will say we are shifting full track and anything less will cost you money. In normal logistics production environment when people know how packaging area works for instance car manufacturing which is the rally top of lean production.

3. ICT:

PS: What are the core tools and knowledge for application of ICT within construction logistics?
BG: The main difficulties in this moment is still no good collaboration between different system every contractor using ERP system and most of time they use phone or email for their suppliers, and integration of purchasing and design of building something needs to be developed. How deep you can go 3D model, if it is made correctly you can calculate exact amounts of materials and tracks you need. There are some parties who has some calculation methodologies linked to their 3D model and linked to the orders they are going to place suppliers. There really gaps at the moment there are other contractor who is going to calculate cost based his assumptions and as soon as they got project they going to make the same again and if you do 3D model correctly you will be able to use it for multiple purpose. Mostly they're using excel tool, transport planning tools. Good base to know how 3D model is modeled, but also good to know how production schedule and material requirement planning really opens up the view for them I think.

4. Reverse logistics:

PS: What is the core knowledge for application of reverse logistics (RL) in construction?
BG: Architects are some weird guys they only use their imagination but they do not have RL in mind, how to reuse theirs materials. You see a lot of brilliant green certificate from buildings, they focus of building materials but not on how building is made. There is no certificate for logistics processes to

notices that how efficient is logistics process itself, the way how building is build. (no certifications for logistics processes)

5. Delivery management:

PS: What are the most common strategy for service and materials delivery?
BG: what you can see is to get better prospective, what materials can be used and at what quantities that is coming from 3D model. auto transport system when you get material on JIT, I think purchasing and engineering department of project can make difference, if you stop outside people placing order they start thinking more what they need for the next couple of days , you can consolidate your order and you do not need same truck eight or nine time on your building site. distribution network, truck can never get on building site any more, on its on time, they will have tickets or they can discuss the time when they can come I think this is the biggest one. I expect there will be more collaboration between projects material vise, they synchronize materials they need for other projects , for example truck can drive for three different project site, life tracking and tracing will be also part, but I think it will not be useful, but it is something which discuss within construction logistics groups. I think making material packaging is more and more implemented one pallet for one room - combine the materials for same disciplines. Modular building will be used for areas where high need for housing such as Amsterdam, Rotterdam, etc. it is mostly for a city construction. Also simple technical activates which do not require specific education can be done by ordinary guy or worker which cost less than proffesional. So, innovative outscoring activities for service providers can that we are looking at.
Green certifications for logistics planning - to make efficient logistics plan there should be laws, regulations, and rules.

PS: what is the level of innovations and creativeness among the logistics managers, today?
BG: In comparison with ordinary logistics managers, nowadays construction logistics managers are layback, they do not use revolutionary systems or processes creativeness, and innovativeness, the way they are working is as they did fifty years ago. There are so many variations and possibilities which needs creativeness to make different scenarios more efficient. And creativity is not limited with what your suppliers can do or will do.
PS: Can you say something about risk mitigation?
BG: Risk mitigation - reducing the risks by not producing at the job sites. If you deign really tight process lean process with different steps, and if one is slacking then all the other parties slacking as well. Reducing the risk is all happening is most of important part of solutions we think of.

Summary of potential topics

Collaboration: Synchronization of processes, construction sequences.
Business management tools: Personal communication with all the levels.
ICT: Integrated 3D model with material requirements and with production schedule.
Reverse logistics: Certification for green logistics processes.
Delivery management: Consolidation of order, Ticket system, synchronization of materials, material packaging for the same disciplines, innovative outsourcing, knowledge of relevant regulations.

Candidate No: 29
Name:
Name and affiliation:
Date of interview:
Location of interview:
List of acronyms:
Editing Index:
Date of edit:
Editor's name:

1. Material management:

PS: What is the core knowledge or processes of material management within construction logistics?
FJ: Within my company, within my projects or generally what kind of answers are you looking for?
PS: you are industry representatives, right?!
FJ: yes. I am working on construction projects like North-South side of the Amsterdam Zuidostok. I am working on client side on a project. In the city of Amsterdam which is really crowded, most of important of material logistics is transportation without causing traffic jams, noise for people leaving there. We just finished our tendering process for construction of Zuidostok project, constructor that won this tender have number of smart approached how to get materials onsite. For instance, we are building tunnel for railway station, metro station and bus station, what they did is they going to build tunnel and they are going to use this tunnel after words to get all the materials to the train station and this smart approaches are very important since, cities becoming more crowded. The information we need is how to get materials to building sites, especially when building sites are in the crowded areas. We are looking for smart approached for construction logistics.
PS: Well. Is there any innovative ideas?
FJ: Some ideas are. You may know hubs close to the cities, and small vehicles to get materials from hubs to the site. What our constructor did at this moment he is actually building temporarily roads, to get materials into the city. Contractor said, ok we have to build project for next 10 years and instead of to getting all the traffic into the city we can build new road and avoid traffic difficulties. Also, in Holland some cities are next to the channel and a lot of construction happened next to the water channels.
PS: Do you use water ways as well?
FJ: Yes. I still think that we have to think how shell we transport materials on the roads without causing problems to the existing traffic. It can be travel to night, or travel without traffic jams.
PS: Thank you. Do you see any new method of delivery materials in the future?
FJ: I think we gain a lot when we use better planning, for instance when we are going to do concreate work, you need a constant supply of concrete to the building places, that you cannot really plan because you need right away in very continues streams of concrete trucks. Raw materials you are using only for a couple of days may be at the end of the project or at the beginning and you can plan when you needed them. Now, what is happened a lot of materials are transported to the building site and site becoming crowded. If you plan it for just-in-time, then you have to provide it in just-in-time. Also, roads are crowded when you do not need materials, so, why not to plan materials need better?!
PS: You mentioned that Amsterdam is very crowded city and there is a problem for delivery. How do you see logistics for the cites of future?
FJ: I think we are now testing a lot of vehicles without driver, and autonomous trucks. In this testing you can see that a lot of tucks are traveling very close to each other so they use less space on the highways. I think autonomous vehicles will also help to develop construction logistics. I think we need

to upgrade our rail system in Holland, freight trains are using the same rails as passenger trains and need to be sorted out. Also, we see a lot of development of electric vehicles and many things will be depended on clean material transportation.
PS: Were your education sufficient to start working with construction companys?
FJ: In Twente I learned a lot, the courses were very broad, you learn a lot of small things about the all subjects. University gave me good basic knowledge but when I go to work most I learn from experienced colleagues. As I noticed, in the industry they are quite happy and satisfied with people coming from universities. Civil engineering courses in Twente, Delft and Eindhoven are quite good. When people are coming with one of these universities degree they are quite good.
PS: So, you means educational gap is small?
FJ: There is a gap but, at the universities you learns a lot of thing, you have basic knowledge, which helps to close this gap easily in the industry.

2. ICT:

PS: What are core tools and knowledge for application ICT within construction logistics?
FJ: There are many tools, I think you know about BIM. However, this is not new anymore. Construction industry quite slowly adapting new ICT systems. But there are couple of Construction Companies they are using BIM successfully. I think BIM is quite known, and there are a lot of tools of supply chain as well. For purchase the goods, systems to manage suppliers, also, there are systems that make sure you have all the demand of the clients, requirement analysis tool, when you know requirements you know what you have to purchase.
PS: Regarding BIM how do you use BIM? 5D modeling or?
FJ: I am helping client to manage the project.
PS: Are you using traditional contracts?
FJ: No, we are using design and construct contract and in our contract it says that contractor should use BIM modeling and they have to deliver BIM model and we have to check and control how they met the design requirements. We are not using 5D modeling, but just 3D models.
PS: So, you are using the BIM to control whether design corresponds to the clients requirements.
FJ: Yes. BIM helps us to see if contractor implemented our requirements.

3. Reverse logistics:

PS: What core knowledge is needed for application of RL in construction logistics?
FJ: construction industry is a bit slow adapting to current recycling and reusing. If you walk at any given construction site you just see waste containers. But construction companies are now realizing that they can save not only environment by using recycling but also the money. For instance what happens, they are relocating sand from one construction site to another. What is happened, client is trying to motivate contractor to recycle materials, promoting them to make sure that there is no lose materials on site. What motivates Construction Company is to see if they can save money from that. We are using design and construct contracts and we motivate contractor to bring innovative solutions. Make contractor to think out of box. But every new innovation cost money at the beginning. But if all the clients say to contractor that you only getting job if you are going to reuse materials. We are depended on construction industry to think about smart solutions about reusing recycling, on the other hand was a clients also have to think to promote this process and put incentives.
PS: You mentioned you were doing quality management, do you check logistics plans?
FJ: What we do, many of the construction projects when they have design and construct approach they have 'System Orientated Contract Management' and basic idea is to ask contractor to [...] contractor

has to demonstrate quality of the work. They have to have quality management system, making sure that they are making work according to client's requirements. What we do as a client's we are testing, we just ask them to prove to us that you have this quality system management on site. And if this company are working according to law, safety and things like that. One of the subjects could be construction logistics, recycling management and things like that, for instance if we ask them to have recycling management then we ask them to prove whether system is working, present documents and visit construction sites. this what is called system orientated approach, we are not always looking at the contractors steps , but we make risk approach, where we thinks that somewhere there is a risk for us then we are asking and checking more.

Summary of potential topics

Material management: smart approach, hubs system.
ICT: BIM 3D modeling.
Reverse logistics: incentive contracts, innovative solutions.

Candidate No: 32

Name:
Name and affiliation:
Date of interview:
Location of interview:
List of acronyms:
Editing Index:
Date of edit:
Editor's name:

1. Collaborative behavior:

PS: What tools, processes or knowledge are needed for collaboration within construction logistics?
SS: I think it is all about attitude of people and culture in the construction. Because new possibilities of ICT force construction companies to work together, however they find difficulties to be transparent. This is mind set of people of course education will help a lot especially to new generation because old people are a bit behind.
PS: is it only transparency if everything will be transparent then will it be beneficial for construction companies?
SS: Yes! I think so, in general many organizations can benefit from transparency. Because they have a shared data.

2. Business management tools:

PS: What kind of business management tool is needed for logistics managers?
SS: technical knowledge of collaboration, to get people together and make a change.
SP: Can you mention some of those tools?
SS: Personal motivation of people, collaborative attitude, leadership, force change in the company, sharing the new strategy with people to get support and get everyone on track.

3. ICT:

PS: What are the core tools and knowledge for application of ICT within construction logistics?
SS: I can distinguish two category of software and hardware in construction. BIM becomes more and more important because of availability of data and consistency of data. Also, application of logistics are very much depended on detailing level of data, which also depends on regulations and contractual relationship of parties.
PS: So, mainly BIM? Do you mean integrated modeling when 3D model is connected with other activities?
SS: Yes.
PS: Is there any other tool that might become important?
SS: The amount of use of BIM is only grow, in the coming years. We have number of companies which are involved and theirs level should be aligned.
PS: Do you mean level of maturity?
SS: Yes.
PS: What should be level of maturity of MSc students in the BIM?
SS: There is always confusion what is the BIM, we see it as a comprehensive tool between parties. In practice we see always different levels of maturity and you have to see limitations of companies. Therefore it is difficult to mention maturity level for students.

4. Reverse logistics:

PS: What is the core knowledge for application of reverse logistics (RL) in construction?
SS: I think they have to know whole process of construction logistics and understand construction supply chain together with additional practice which is going on with other organizations. It is always project depended. For education is important to have wide range of knowledge. There is no theory is applicable for all the situations. When you start working at company you have your own bank of knowledge but at certain point you have to start over again, especially at first year of employment.

5. Delivery management:

PS: What are the most common strategy for service and materials delivery?
SS: Most of the courses are broader than focusing specific part of logistics. I think different methods of delivery there is not one aspect that I can describe.
PS: Do you have on mind new delivery methods for the future? May be drones, automatic tracks?
SS: Better to manage flow of materials that they are delivered on time.

Summary of potential topics

Collaboration: transparency.
Business management tools: Personal motivation of people, collaborative attitude, leadership, force change in the company.
ICT: BIM
Reverse logistics: understand construction supply chain together with additional practice.
Delivery management: Better to manage flow of materials that they are delivered on time.

Candidate No: 38
Name:
Name and affiliation:
Date of interview:
Location of interview:

List of acronyms:
Editing Index:
Date of edit:
Editor's name:

1. Collaborative behavior:

PS: What tools, processes or knowledge are needed for collaboration within construction logistics?
HW: I can give you answer with my experience, we are service party and we are suppling materials, also as we say *' If you want to make client happy, we have to do more than just sale. We have to give service that out client will get best solution, we help client to have more solutions, better and efficient logistics processes. 'There* is collaboration between us and other contractors. It is very important to share good information that is based on good communication.

2. Business management tools:

PS: What kind of business management tool is needed for logistics managers?
HW: Construction engineers are mainly focused on building processes. When you consider logistics you can do into two ways, many contractor know about logistics but they are all just part of building activities. Another side of logistics are business where you have a different approaches. In my opinion many contractor do not see logistics as business, they see it as part of building activates.

3. ICT:

PS: What are the core tools and knowledge for application of ICT within construction logistics?
HW: We have planning tools. We are using them to choose materials and order it, when you need it and where. We made that tool for our self to plan materials. BIM is other example, if contractor have a BIM then there is always an information what materials you need.

4. Reverse logistics:

PS: What is the core knowledge for application of reverse logistics (RL) in construction?
HW: I do not think that I have materials to answer. All this depends on the way you build you construction. For example when I worked for the Ballastnedam the designed the stadium. We looked the logistics to get materials on site to build the stadium and design considered that those materials were able to be reused for other stadiums as well. So, this is special way of design when you take into account to reuse your construction materials.

5. Delivery management:

PS: What are the most common strategy for service and materials delivery?
HW: It is important to take into account that you need materials just-in-time. Main approach is to get materials just-in-time, and to achieve this it is important to use hub location. Strategic approach is to create bases for material control. You can deal with fact that every site needs materials daily.

In addition, I think there is a demand for new knowledge in the logistics management, because there are chances to bring new approaches within the industry. However, if you ask average project managers what he things whether he needs specialists with supply chain management skills, he will answers that they do not need such a specialists.
PS: Do you means that there are demand on multidisciplinary people within logistics, who can see big picture?
HW: I think there should be a demand. Should be a question what is the impact from logistics on the execution process. But in practice they do not always have this question, they do not see that there is

a demand because they think they have very good practical experience and they have skills but I think they miss supply chain management skills. I think there is a demand but practitioners do not feel that demand. What you see on projects they do it in a traditional way. May be within next generation supply chain management will play more role in the construction industry. Nowadays there are few people that have supply chain management functions. Because they can bring different approaches, different information, vision and make construction logistics more efficient.

Summary of potential topics

Collaboration: good communication.
Business management tools: Logistics are business where you have a different approaches.
ICT: BIM.
Reverse logistics: special way of design when you take into account to reuse your construction materials.
Delivery management: specialists with supply chain management skills.

Candidate No: 45
Name:
Name and affiliation:
Date of interview:
Location of interview:
List of acronyms:
Editing Index:
Date of edit:
Editor's name:

1. Collaborative behavior:

PS: What tools, processes or knowledge are needed for collaboration within construction logistics?
IW: I am working in the international industry we are doing a lot of shipping of materials and it is important to understand procedural steps between items where it is manufactured, transported and handled.
PS: What is important to understand in collaboration?
IW: to build the network.

2. Business management tools:

PS: What kind of business management tool is needed for logistics managers?
IW: Most important there is networking. Maintaining awareness who is to what responsible. Also, organizational priorities order of tasks. So, organize, networking, and manage the time.
PS: do you have on mind new tools that might be important from business point of view?
IW: Let's keep awareness on development. It is very important to follow industry development, because industry is changing quickly and therefore to maintain continues development is an essential.
PS: when youngsters are coming into industry where the gap, where are they lacking?
IW: Most important is experience. After one year in practice they can achieve so much that they would not achieve in the theory.

3. ICT:

PS: What are the core tools and knowledge for application of ICT within construction logistics?

IW: My Company is currently implementing ERP system and it is very new for us. I would say the knowledge how those systems are working is absolutely necessary. We had no knowledge of BIM and it appears that knowledge of BIM together with service management is necessary.
PS: Is the ERP system for on-site or off-site usage?
IW: Intension is that it must be one system.

4. Reverse logistics:

PS: What is the core knowledge for application of reverse logistics (RL) in construction?
IW: I am not aware about that.

5. Delivery management:

PS: What are the most common strategy for service and materials delivery?
IW: We are talking about physical delivery from design to site. For instance if we buy materials from China there will be evaluation before building, cost analysis will be done, before materials arrive on site. Usually materials control processes takes a place.
PS: How would you divide logistics processes into categories?
IW: I say whole process, design and engineering, selection and approval, actual order, materials take off from design.
PS: How do you think on-site and off-site activities do they require different knowledge form specialists?
IW: Yes, really important. On-site logistics managers needs to know local market, regulations also very good feel of local market to identify good tender. Off-site manager should have hipper feel of enterprises.

Summary of potential topics

Collaboration: build the network.
Business management tools: maintain continues development.
ICT: ERP. BIM.
Reverse logistics:
Delivery management: materials control processes takes a place.

Appendix 4. Triangulation, topics list development

(1) Planning

Topic: 1.1 systems perspective / overview

Description: *The construction logistics is a system, it is a network of related activities with the purpose of managing the forward and reverse flows of materials and information. It states that all functions or activities need to be understood in terms of how they affect and are affected by other elements and activities with which they interact (Ellram et al, 2006).*

Data: Respondents No: 6, 12, 17.1, 19, 24, 25, 31; Job description list chapters: from 1 to 17; Papers: (Gunasekaran, 2004) (Irizarry et al., 2013);

Exemplary evidence: As stated by the respondent No: 12, The student should learn about systems approach/integration in the context of construction logistics because *'generally within construction logistics, all those factors are missing, such as network, the relationship in the network and competence'*. In addition, candidates No:19 and 31 argued about comprehensive education: *'I think one of the crucial aspects is that they need to be able to see whole pictures, they need comprehensive understanding of all the different aspects that may influence the logistics […] that would affect logistics, and logistical managers should be able to grasp that communicate that to different stakeholders.'* They also stated that logistics managers should be aware of impact of construction logistics, on the operational level. Majority of interweaves mentioned the lack of systems approach and integrated actions. *'If you combine the logistical system with planning then you have stepped forward because then all actors can see the schedule (No: 24)'*. There are *'lack of planning and sort of patterns of collaboration. In many cases when something happens during production they start collaborating (No: 17, 1).'*The respondent No: 25 argued that *'collaboration in construction can be achieved by implementation of complete transparency and standardized systems […] the reverse thinking still needs to be developed.'* In addition, respondent No: 6 stated that *'Innovation is needed at all the levels of logistics, how all the parties can share the information, goods and resources.'* Furthermore, all the responsibilities mentioned in the job description list (ch: 1-17) defines necessity of systems approach/ integration to manage logistical processes. In addition, scientific paper Gunasekaran, (2004) state that *'supply chain integration is the key business process from end user through original suppliers that provides products, services, and information and hence add value for customers and other stakeholders.'* In his paper Irizarry et al., (2013) argued that *'construction industry shows a considerable amount of waste produced by poor management of the materials supply chain (delivery, service, inventory, communications) in this regards use of information technologies (IT) is suggested to achieve better logistics processes and avoiding delays […] various IT application have been used in the literature as a way to improve integration process of supply chain management.'* Based on the interviews we claritied that, system approach /integration is recognized as a relevant topic for students' educational program.

Topic: 1.2 Enterprise Recourse Planning systems

Description: *Enterprise Resource Planning (ERP) is a system for the seamless integration of all the information flowing through the company such as finances, accounting, human resources, Supply chain, and customer information (Yang et al., 2007).*

Data: Respondents No: 9 and 37; Job description list, chapter: 3e) and 7a); Papers: (Wei et al., 2005) (Yang et al., 2007).

Exemplary evidence: Student should learn about Enterprise Recourse Planning systems because, *'for materials and resource planning I would expect ERP systems in construction sector '* argued respondent No: 9. The candidate No: 37 stated that '*The main difficulties in this moment is still no good collaboration between different system every contractor using ERP system and most of time they use phone or email for their suppliers, and integration of purchasing and design of building something needs to be developed.*' Furthermore, job description list for construction logistics managers also required integration information flow at all levels: *'Plan and integrate with key contractors to meet the needs of the planned program (ch: 3e); create a system to communicate information around the site (ch: 7a).'* The scientific paper Yang et al., (2007) described ERP system as a *'strategic and survival weapon for most firms in which Information Technology (IT) is widely used.'* According to Wei et al., (2005) ERP system *'improving responsiveness in relation to customers, strengthening supply chain partnerships, carrying out remote procurements and inventory management, enhancing organizational flexibility, improving decision-making capabilities, reducing project completion time, analyzing accurate business profile and lowering costs […]ERP system has ability to integrate the flow of material, […] and information and to support organizational strategies'* which is important for construction logistics. Given those, ERP system is recognized as relevant topic for students' educational program.

Topic: 1.3 BIM-based planning (e.g. 4D/5D modeling)

Description: *Building Information Modeling (BIM) is one of the most promising developments in the architecture, engineering, and construction (AEC) industries. With BIM technology, one or more accurate virtual models of a building are constructed digitally. They support design through its phases, allowing better analysis and control than manual processes. When completed, these computer generated models contain precise geometry and data needed to support the construction, fabrication, and procurement activities through which the building is realized (Eastman et al., 2011).*

Data: Respondents No: 12, 17.1, 19, 24, 25, 26; Job description list, chapter: 1 a, b, c); Papers: (Babic et al., 2010) (Irizzary et al, 2013).

Exemplary evidence: Students should learn about BIM- based planning, because *'we see BIM model as technical planning tool and operational planning tool'* argued respondent No: 12. The candidate No: 17.1 stated that *'It would be key thing if BIM could be connected with supply chain and use it in logistics.'* In addition, other respondents' also shared theirs positive opinion about BIM-based planning *'If you do time planning in BIM model you would be able to link JIT delivery to logistics manager of the supplier would just be able to get the information from the system. To take out human error that's would be very interesting tool to look at for the future (No: 19),' 'Major contractors is using BIM for different stages in the construction (No: 24).'* Furthermore, job description list for construction logistics managers also required knowledge of proper planning, where BIM-based planning would be appropriate tool, it requires: *'plan site set-up to move labor, plant, and materials around site efficiently[…] plan internal and external logistics routes through the project phases focusing on separation of vehicles, machinery and people […] pre-plan the usage of key assets such as hoists to ensure planned assets meet the needs of the program(ch:1 a,b,c).'* The scientific paper Babic et al., (2010) describes that BIM based planning improved overall performance by consolidation of on-site project management and project documentation related activities with manufacturing, which improved efficiency of logistics, on-site materials handling and overall project progress tracking. In his paper Irizzary et al,. (2013) argued that BIM application supports to define relevant parameters for each construction component by visualizing the relationship between actors and processes as well as their logical sequence in the supply chain process, which improves logistics perspective (warehousing and transportation). Given those, BIM-based planning is recognized as relevant topic for students' educational program.

Topic: 1.4 Demand forecasting/planning

Description: *Demand forecasting predicts future through qualitative or quantitative methods, or some combinations of those. It investigates firm's demand for the item, to include current and projected demand, inventory statues and lead- times (Ellram et al, 2006).*

Data: Respondents No: 17.1, 22, and 26; Job description list chapters: 3e) and f); Papers: (Aburto, 2007) (Cachon, 2001).

Exemplary evidence: Student should learn about demand forecasting /planning because, *'good planning is a key. Planning beforehand, important to see logistics routine as process […] if something happens you know what to do as an alternative way out […] also communicating demands is important'* stated interviewer No: 17.1. in addition, respondents No: 22 and 26 argued that *'translating logistics demand into other functions'* and *'to know about competitors, about market'* are important for construction logisticians, in order to better adapt them self to new business life. Furthermore, chapter 3 e) in the job description list requires explicitly *'plan and integrate with key contractors to meet the needs of the planned program.'* In addition, scientific paper Aburto, (2007) shared the statements of interviewers and industry demand, because of *'based on data flow the logistics manages can decide what, how much, and when to buy.'* The Cachon, (2001) in his paper argued that demand forecast is important within a supply chain, because, supplier can build his capacity only based on an initial demand forecast, which allows to better manage their inventories. Given those, demand forecasting/planning is recognized as relevant topic for students' educational program.

Topic: 1.5 Return planning

Description: *Return planning is a part of reverse logistics supply chains where product return are a function of past sales and effective use of returns can maximize the value of product itself as well as the value of this service. At strategic, tactical and operational levels of construction logistics should explicitly incorporate information about return flow characteristics, primarily quantity and quality of construction components.*

Data: Respondents No: 12, 19, 22, 25, 33, 37; Job description list, chapter: 13a); Papers: (Toktay et al., 2004) (Srivastava, 2006).

Exemplary evidence: Student should learn about return planning, because *'Circular model for construction of cities it is logical step. Waste in the city is construction related if you make logistics substantive and you do not have money to rework materials then you need to link existing sites to new sites. This is necessary needs careful process, then you can use materials from one project for another one, this process should be exactly synchronized'* argued respondent No: 12. The candidates No: 37 and No:25 stated that *'Architects are some weird guys they only use their imagination but they do not have reverse logistics in mind, how to reuse theirs materials […] design of new building should take into account that using materials can be used second times.'* In addition, *'you need to know what the materials is, what type of materials consider hazardous, what can be reused, what can be stored and etc.'* argued respondent No: 19. Interesting suggestions were also 'design for demolition approach (No: 22)' and *'project separation to know which existing part of building you can reuse where (No: 33).'* Furthermore, chapter 13 a) in the job description for construction logistics managers requires *'complete environmental risk assessment'*. The scientific paper Toktay et al., (2004) describes that return planning should be managed at different levels for example, *'for network design at the strategic level; for procurement decisions, capacity planning, collection policy and disposal management at the tactical level; and for production planning and inventory control at the operational level.'* In addition, Srivastava, (2006) offers integrated framework that helps in *'estimating returns for select categories*

of products and thereafter taking simultaneous decisions on their disposition, location and capacity of facilities and flows of returned products for a given time horizon under various strategic, operational and customer service-related constraints.' Given those, return planning is recognized as relevant topic for students' educational program.

Topic: 1.6 procurement

Description: *The procurement is a purchasing activities to a more strategic and process orientated level, and includes selection of supply source location, determination of forms in which materials to be acquired, timing of purchase, price determination and quality control (Ellram et al,. 2006).*

Data: Respondents No: 9 and 25; Job description list chapters: 3c); Papers: (Tassabehji, 2008), (Beukers et al., 2006).

Exemplary evidence: Student should learn about procurement and purchasing functions because, *'It managing the relationship with 3rd party service program'* stated respondent No: 9. in addition, candidate No: 25 argued that *'role of construction industry determined by procurement.'* Furthermore, chapter 3 c) in the job description list requires explicitly *'Understand procurement arrangements.'* In addition, scientific paper Tassabehji, (2008) shared the statements of interviewers and industry demand, because of *' strategic purchasing function leads to better supply integration […] strategic purchasing can create a win–win situation for both buyer and supplier firms which impacts positively on overall supply chain performance.'* The Beukers et al., (2006) in his paper argued that *'Implementation of a procurement aimed information system to improve the effectiveness of data/information retrieval, to reduce manual transactional activities, and to improve reporting.'* Given those, procurement and purchasing functions is recognized as relevant topic for students' educational program..

Topic: 1.7 Construction site layout planning

Description: *Most construction resources require space on site. This is the case for materials and equipment, support facilities (e.g., trailers or parking lots), and demarcated areas (e.g., laydown areas, roads, or work space), but also for obstacles (e.g., trees or existing buildings). Allocating site space to resources so that they can be accessible and functional during construction, known as site layout planning (Zouein, 1999).*

Data: Respondents No: 6, 17.1, and 19; Job description list, chapter: 1a), b). 2c). 5i) and 13 b); Papers: (Elbeltagi, 2001) (Tommelein, 1993) (Tam et al., 2002).

Exemplary evidence: Students should learn about construction site layout planning because, in practice according to respondent No: 6 *'many materials are wasted, because of whether, or they are stolen, damaged and also it takes a lot of space on site.'* This indicates that there is a lack of proper site layout planning, especially if contractor applies *'traditional delivery when you store things on site (No: 19).'*In addition, candidate No: 6 stated that *'preparation of construction site, material supply, crews, and resources should be processed at the same time,'* which means site layout planning becomes responsibility of logistics manager. This statement can be supported by the chapters of job description list that requires, *'Plan site set-up to move labor, plant, and materials around site efficiently […] Plan internal and external logistics routes through the project phases focusing on separation of vehicles, machinery and people. Lay down areas and offloading points (ch: 1a, b).'*Moreover, *'manage installation of site accommodation and manage these facilities (ch: 2c),' 'Safeguard vulnerable road users from traffic and transport created by the site (ch: 5i),'* and *'Create, maintain and regularly update the Site Waste Management Plan to ensure the safe and efficient removal of waste from the project*

(Ch: 13 b).' Furthermore, scientific paper Elbeltagi, (2001) argued that *'the basic consideration in an effective site layout plan is the smooth and low-cost flow of materials, labor, and equipment within the site, in addition to satisfying various work constraints and safety requirements.'* The good site layout planning allows to use site space for different phases of construction (Tommelein, 1993). Proper site layout planning *'can affect productivity and is crucial to project success (Tamet al., 2002).'* Given those, construction site layout planning is recognized as relevant topic for students' educational program.

Topic: 1.8 Inner city deliveries (e.g. hubs, control tower systems)

Description: *Inner city deliveries includes site facilities and proper control center to ensure that the respective parts of the construction logistics chain are geared to one another, focusing on a selected number of projects or pilot projects (Bogers et al., 2017), also it organizes optimal warehousing network for the firm's products and customers. It consists of size and numbers of warehouses, and their location (Ellram et al, 2006).*

Data: Respondents No: 12. 17.1, 26, and 29; Job description list chapters: 9a); Papers: (Owen, 1998).

Exemplary evidence: Student should learn about inner city deliveries because, it ensures safe, timely and cost effective materials delivery on site. The respondents No: 12 and 17.1 argued that *'each sub-contractor have responsibility ordering their own materials and in terms to delivery on site each actor on site is responsible on own logistics. This cause lot of problems, planning, waiting hours on site, and a lot of moving around materials.'* Therefore, *'emerging construction hubs for all materials are very effective […] in terms of bringing materials from there.'* The candidate No: 26 suggested that combination of large warehouses with delivery control system would be the best solution for improvement of materials delivery on-site. The respondent No: 29 stated that *'most of important of material logistics is transportation without causing traffic jams.'* The chapter 9 a) in the job description list for logistics managers requires from decision makers to *'Select a delivery management technique, process and system.'* The above mentioned statements are shared by scientific paper Owen, (1998) he argued that *'decision makers must select sites that will not simply perform well according to the current system state, but that will continue to be profitable for the facility's lifetime, even as environmental factors change, populations shift, and market trends evolve.'* Given those, inner city deliveries is recognized as relevant topic for students' educational program.

Topic: 1.9 Delivery strategies (e.g. JIT)

Description: *Delivery strategies in the service and product support are important for achievement of customer satisfaction and winning new markets. The success of a service and product support strategy depends on how effectively these services and products are delivered. In service and product delivery strategies the most of critical is service-related contracts that, in turn foster customer satisfaction, based on production systems in a multinational environment.*

Data: Respondents No: 45, 38, 37, 33, 24; Job description list chapters: 9 a-f); Papers: (Das, 1997) (Stock et al., 1998) (Martinez, 2001).

Exemplary evidence: Student should learn about delivery strategies because it refers to maintain a competitive advantage within the construction industry and stimulate customers' satisfaction. Candidate No: 24 argues that *'Delivery management of different materials are different. Delivery is divided by materials typology.'* And therefore *'on-site logistics managers need to know the local market, regulations also a very good feel of the local market to identify good tender. The off-site manager should have a hipper feel of enterprises (No: 45)'* in order to *'consolidate the orders and do not have same truck eight or nine time on building site (No: 37).'* According to respondent No: 38, *' the*

Main approach is to get materials just-in-time and to achieve this it is important the to use hub location. A strategic approach is to create a base for material control. You can deal with fact that every site needs materials daily.' Therefore, *'just-in-time delivery is appropriate for big parts, but for small parts - stock is used,'* argued candidate No: 33. The chapter 9 a-f) in the job description list for logistics managers requires to *'select a delivery management technique, process and system; provide logistics instruction to all project suppliers; Manage all movements to and from site and keeping associated records; Enforce the full use of the organization's delivery management system; Plan to and maximum load capacity of all vehicles arriving at site where possible, ensure suppliers use appropriate vehicles for delivery; Ensure that drivers and vehicles meet the required standards before being accepted to site.'* Furthermore, scientific paper Das, (1997) describes just-in-time delivery as a *'philosophy which encompasses almost all business processes and functions within the supply chain.'* Stock et al., (1998) in his paper describes two dimensions of delivery strategy *'first is speed - delivering product to a customer quickly can offer a number of competitive advantages. Second is […] reliability or capability to deliver the product to the customer on time when it is promised.'* Both dimensions are depended on manufacturing strategy where lean production takes a place for increasing productivity, reducing lead times and costs (Stock et al, 1998; Martinez, 2001). Given those, delivery strategies are recognized as a relevant topic for students' educational program.

Topic: 1.10 Routing and scheduling techniques

Description: *Routing and scheduling techniques are the process of totally optimizing the logistics and transport activities by private companies in urban areas while considering the traffic environment, traffic congestion and energy consumption within the framework of a market economy (Barcelo et al., 2007).*

Data: Respondents No: 12, 22; Job description list chapters: 2 b); Papers: (Barceló et al., 2007) (Nagy, 2007).

Exemplary evidence: Student should learn about routing and scheduling techniques because it is related to private and public interests. According to candidate No: 12 *'proper monitoring of transportation system is missing, which cause safety issues in the city.'* In addition, respondent No: 22 argues that *'in the Netherlands, water ways should be used for transportation of construction materials, as it is, more cost-effective.'* The chapter: 2 b) in the job description list for logistics managers requires being *'responsible for all traffic management internally and externally, weighbridges and road network cleanliness (ch: 2b).'* Furthermore, scientific paper Barcelo et al., (2007) argues that *'among the special characteristics of urban freight transport there are two of particular relevance: its contribution to the traffic flows, and the subsequent environmental impacts […] from a systems approach City Logistics systems have many components usually related to the stakeholders […] public stakeholders will usually be interested namely in achieving social, economic, environmental or energetic objectives. While private stakeholders, namely private shippers, and freight carriers, are aimed to reduce their freight costs and to optimize their traffic flows in accordance to their specific needs, which aren't conforming to the objectives of an overall optimization.'* That means possible conflicting situation among the stakeholders should be regulated by highly qualified specialists. According to Nagy (2007) distribution management is a logistical problem that needs to be studied by integrated approaches that cover both the location and the routing problems. Given those, routing and scheduling techniques are recognized as a relevant topic for students' educational program.

Topic: 1.11 Circular business models

Description: *The process of planning, implementing, and controlling the efficient, cost-effective flow of raw materials, in-process inventory, finished goods, and related information from the point of consumption to the point of origin for the purpose of recapturing value or proper disposal (Ellram et al, 2006).*

Data: Respondents No: 9, 12, 17.1, 19, 25, and 33; Job description list, chapter: 13; Papers: (Sobotka, 2015).

Exemplary evidence: Students should learn about circular business models because, *'company, by deconstructing the house they made money by selling the materials to other parties. And this kind of knowledge will be demanded in the future, especially if we talk about circular economy or shared economy'* stated respondent No: 19. However, *'you can use materials from one project for another one, and this process should be exactly synchronized'* argued respondent No: 12. This means that in the future implementation of circular business models will become responsibility of logistics managers, and according to candidate No: 9 '*inspection of environment should be important part*' of this responsibility that will include *'new rules and regulations for waste management (No: 17.1).'* Therefore, respondents No: 25 and 33 stated that *'the reverse thinking still needs to be developed'* and *'very good separation of projects to know which existing part of building you can reuse where.'* The statements of interviewers can be supports by the 13th chapter of job description list for logistics managers that requires *'complete environmental risk assessment; Create, maintain and regularly update the Site Waste Management Plan to ensure the safe and efficient removal of waste from the project; Update environmental reporting on site communications boards and other media; Ensure duty of care certificates from all contractors are kept as required by project director; Ensure Safety, Health and Environmental monitoring is completed.'* Furthermore, scientific paper Hosseini et al (2015), states that *'the European Commission standard calls for initiatives resulting in an increase in resource management efficiency in construction industry and in reduction in their negative impact on the environment throughout the building life cycle.'* Therefore, during the entire building life cycle, company should be aware of construction waste management issues, as recovery of raw materials and construction products at all phases of construction is possible. Moreover, circular business models have number of advantage such as: *'lower costs associated with transport of virgin materials to building sites, while many salvaged items could be available in the vicinity of the site […] it could save cost in terms of inventory of virgin items, equipment maintenance and procurement […] reducing the amount of residual waste that could end up in landfills lowers the landfill cost, including transportation (Sobotka, 2015).'* Given those, key elements of circular business model recognized as relevant topic for students' educational program.

Topic: 1.12 Site waste management

Description: *Site waste management is collection, transportation and disposal of garbage, sewage and other waste products. Site waste management is something that every construction company needs to have. Construction Companies have a policy with the aim of managing waste generated on site and, thereby, reducing the amount deposited in landfill sites. This is a process of treating solid wastes and offers variety of solutions for recycling items that don't belong to trash. It is about how secondhand materials can be used as a valuable resource.*

Data: Respondents No: 29, 37, 26; Job description list, chapter: 13b); Papers: (Tam, 2008) (Shen et al., 2004);

Exemplary evidence: Student should learn about site waste management, because according to respondent No: 29 *'construction industry is a bit slow adapting to current recycling and reusing of waste materials.'* Which results in a negative environmental impact. Candidate No: 37 argues that *'you see a lot of brilliant green certificate from buildings, they focus of building materials but not on how building is made. There is no certificate for logistics processes to notices that how efficient is logistics process itself, the way how building is build.'* This means there is a lack of attention towards waste management in the construction logistics domain. In addition, respondent No: 26, could not answer question about waste management *'that's difficult. I have no information.'* However, job description list for logistics managers, in the chapter 13b), requires *'create, maintain and regularly update the Site Waste Management Plan to ensure the safe and efficient removal of waste from the project.'* There is a clear demand for specific knowledge of waste management. This statement can be strengthened by scientific paper Shen et al., (2004) where he states that *'the increase awareness of environmental impacts from construction wastes has led to the development of waste management as an important function of construction project management.'* In addition, scholar Tam (2008) argues that *'there is an urgent need to discover ways of waste management.'* Given those, topic is recognized as relevant for students' educational program.

(2) Implementation

Topic: 2.1 Total Quality Management

Description: *TQM has particular importance to materials flow within logistics. It stress long-term benefits resulting from continues improvement to systems, programs, products and people. Improvements most often results from a combination of small innovations (Ellram et al, 2006).*

Data: Respondents No: 6, 31, and 29; Job description list, chapter: 15 d); Papers: (Irani et al., 2004) (Pheng, 2004).

Exemplary evidence: The students should learn about total quality management because *'contractor has to demonstrate a quality of the work. They have to have a quality management system, making sure that they are making work according to client's requirements'* admitted respondent No: 29. In addition, candidate No: 25 argued that *'current professionals prefer to do things as they do or did. They are close to the new ideas, people do not want to cope with new systems or software. As universities, they know all concept about construction logistics. But site workers, do not want to change construction logistics and this is the gap.'* This means practitioners do not have enough courage to innovate, *'Logistics is also innovation. Innovate all the times. Innovation is needed at all the levels of logistics, how all the parties can share the information, goods, and resources,'* stated respondent No: 6. Furthermore, job description list for construction logistics managers required *'Intellectual capacity to deal with complex logistics issues, and to implement […] a driver of performance improvement (ch: 15d).'* The scientific paper Irani et al., (2004) described that total quality management *'facilitate improved organizational success, growth, and competitiveness. Many companies are now complementing continuous improvement with innovation, which is seen as the successful exploitation of new ideas.'* In addition, Pheng, (2004) stated that total quality management is *' developing a total quality culture in […] a construction team of the main contractor and subcontractors who would commit to the quality process and develop a true quality attitude.'* Given those, total quality management is recognized as a relevant topic for students' educational program.

Topic: 2.2 Supplier relationship management

Description: *A partnership is a tailored business relationship based on mutual trust, openness, shared risk and shared rewards that yields a competitive advantage, resulting in business performance greater than would be achieved by the firms individually(Ellram et al, 2006).*

Data: Respondents No: 9, and 22; Job description list, chapter: 9 a-f); Papers: (Jiang et al., 2011) (Bemelmans et al., 2011).

Exemplary evidence: The students should learn about supplier relationship management because, in construction logistics *'important to have a parties who's willing to cooperate. Willingness to benefit from each other and reach some kind of goals,'* stated respondent No: 9. However, relationship with suppliers can include *'a lot of opportunistic behavior, not only among the construction companies, but also among the principals, in the tender processes,'* argued candidate No: 22. Therefore, knowledge of supplier's relationship management became essential for construction logisticians. Furthermore, in job description list, all requirements which are related to delivery management in chapter 9, can be related to supplier relationship management, such as: *'Provide logistics instruction to all project suppliers (ch: 9b).'* The importance of above mentioned topic are supported by argumentation from scientific paper, Jiang et al., (2011) he stated *'the industry has recognized the importance of trust for effective communication […] higher levels of commitment are expected to be linked with relationship success since more committed partners will endeavor to balance short-term problems with long-term goal achievement.'* In addition, Bemelmans et al., (2011) stated that *'It is necessary to classify suppliers into various categories (e.g., supplier, preferred supplier, co-maker, or partner) to focus attention on the most important suppliers, to set the correct priorities, and to manage all suppliers according to their importance to the business. Successful relationships with strategic suppliers require very high levels of coordination, trust, information sharing, creativity, and senior management support to fully exploit joint opportunities.'* Given those, supplier relationship management is recognized as relevant topic for students' education.

Topic: 2.3 Risk management in supply chains

Description: *Nowadays, the management's challenges are increasingly formed from a complex network of suppliers that can do threaten the business and the creation of new opportunities for agency management. To understand the supply chain risks which the companies are faced to makes possibility for agencies managers to make more power to realize and challenge against unexpected happenings. In the unsecure and unstable terms of competitive environment, recognizing of above mentioned risks cause the adaptation and act as a strategic lever in the organizations competitive process (ZandHessami, 2011).*

Data: Respondents No: 37; Job description list, chapter: 3 a-j); Papers: (ZandHessami, 2011) (Juttner, 2003).

Exemplary evidence: Students should learn about risk management in supply chains, because it can help during the construction. According to respondent No: 37 *'If you deign really tight process lean process with different steps, and if one is slacking then all the other parties slacking as well. Reducing the risk is all happening is most of important part of solutions we think of.'* In addition, job description list for construction logistics managers in chapter 3 a-j) requires proper arrangement of supply chain, in particular *'describe the characteristics of the site, including site access /egress, storage capacity and arrangement by program, labor, hoists, cranes etc.; Use the description to produce daily, weekly and long term movements plans; Understand procurement arrangements; Control materials in and out of site; Plan and integrate with key contractors to meet the needs of the planned program and de-*

confliction of on-site space and time where appropriate; Assist in the evaluation of potential logistic suppliers and appropriate delivery management booking systems; Be capable of managing sub-contractors to deliver their package of goods or services; Variation control and early communication of foreseeable change; Commercial/contract basic understanding; Utilize business management system procedures.' Furthermore, scientific paper Juttner (2003) argues that supply chains represents hundreds of companies over several tiers and if something happens with one of those companies it will initiate domino effect among the whole chain that will reduce outcome predictability. Scholar ZandHessami, (2011) defines in his paper different type of risks that can affect supply chain they are, *'Financial risk It is a kind of risk which indicates that the organization has no enough money to face to its financial consequences; Strategic risk Strategic risk means the profit at the present and in the future of organization; Operational risk Nowadays, organizations are trying to upgrade the techniques for measurement, monitoring and decreasing of operational risks; Human resources risk There are two kinds of human resources risks; Technological risk Informational systems and organizational activities; Fame risk Fame risk has been described as a current or future risk for earning and increasing capital from different viewpoints of financial firms and commercial beneficiaries; and Laws risk At any environment which is changeable.'* Given those, risk management in supply chains is recognized as relevant topic for students' education..

Topic: 2.4 Sensoring technologies

Description: *Integrated order processing system sets many logistics activities in motion, it process flow of information from one department to another, as well as accessing several files or databases, such as customer credit status, inventory availability and transportation schedules. the quality and speed of information flow affecting manufacturer's ability to provide fast and consistent order cycle times and to achieve transportation consolidations and the lowest possible inventory levels (Ellram et al,. 2006).*

Data: Respondents No: 19; Job description list, chapter: _; Papers: (Zhang et al., 2010) (Mukhopadhyay, 2002).

Exemplary evidence: The student should learn about sensoring technologies, because according to respondent No: 19 *'automatic order goes to the supplier would be very interesting tool to look at for the future, because, it can take out human error from the system.'* However, job description list do not requires given systems explicitly, it seems an emerging approach in construction logistics, but scientific paper (Zhang et al., 2010) are quite positive about implementation of integrated order-processing system because, *'in recent several decades, the diverse customer requirements Along with the short delivery times have pushed manufacturing companies to pursue other strategies, rather than the mass production of standardized products, to guide their daily activities. Aiming to quickly provide customers with tailor-made products at low costs.'* In addition, (Mukhopadhyay, 2002) states that *'A significant finding is that the supplier derives large strategic benefits when the customer initiates the system and the supplier enhances the system's capabilities. With respect to operational benefits, we find that when suppliers have advanced electronic linkages, the order-processing system significantly increases benefits to both parties.'* Given those, sensoring technologies is recognized as relevant topic for the logisticians of 21st century, and it should be included in the students' educational program.

Topic: 2.5 Transport regulations

Description: *Regulations and deregulations of freight transport are one of the key factor public policy, which consist of Transportation planning, environmental planning and economic planning. The policy regulates combination of key factors such as, congestion, air pollution, noise, safety and environmental intrusion within urban areas (Visser et al., 1999).*

Data: Respondents No: 37 and 19; Job description list, chapter: 5 c), i); Papers: (Friedlaender, 1981) (Browne et al., 2012).

Exemplary evidence: The student should learn about regulations and deregulations of freight transport because, *'Urban goods transport is responsible for a number of social and environmental impacts that threaten the livability in […] urban areas (Friedlaender, 1981).'* According to respondent No: 37 *'for effective logistics plan should be laws, regulations and rules,'* he suggested *'green certifications'* for construction logistics plan in order to minimize negative environmental impact. In addition, candidate No: 19 stated that *'construction components should be designed in a way that fits in the size defined by the rules of transport regulations'* in order not to cause accidents on the road and keep transportation safe. Given statements is supported by job description list for construction logistics managers, which requires *'that material movement to and from the workface does not cause damage to the works, the workforce or the public (ch: 5 c) […] safeguard vulnerable road users from traffic and transport created by the site (ch: 5 i).'* Furthermore, scientific paper Browne et al., (2012) argues that regulations and deregulations of freight transport is important, in order to avoid '*a variety of social, environmental and economic Impacts […] including traffic congestion, air pollution, noise pollution, and the consequences of traffic accidents.'* Given those, abovementioned topic is recognized as relevant for students' educational program.

Topic: 2.6 Transport modes and intermodality

Description: *Any one or more of five transportation modes – truck or road, rail, water and pipeline may be selected to transport products. In addition, intermodal combinations are available. Intermodal movement's combinations combine the cost and/or service advantages of two or more modes in a single product movement (Ellram et al, 2006).*

Data: Respondents No: 22 and 19; Job description list, chapter: 9e); Papers: (Caris et al., 2008) (Macharis, 2004).

Exemplary evidence: The students should learn about transport modes and intermodal combinations, because *' goods delivery depends on context of site, if you are within the city then just-in-time is suitable, but if you are country side then you prefer to store materials on site,'* argued respondent No:19. The candidate No: 22 stated that *'delivery should be according to product type'* and this requires proper selection of transportation modes and if necessary intermodal combinations as well. Furthermore, job description list in the chapter 9e), requires *'ensure suppliers use appropriate vehicles for delivery.'* Given statements can be supported by scientific paper Caris et al., (2008) where he argued that *'intermodal freight transport has received increased attention due to problems of road congestion, environmental concerns and traffic safety […] a growing recognition of the strategic importance of speed and agility in the supply chain is forcing firms to reconsider traditional logistic services.'* In addition, Macharis, (2004) supports importance of given topic by stating that *'a further market share for intermodal transport Would mean a shift towards more environmental friendly transport Modes, less congestion and a better accessibility […] The European Commission expressed in several of their policy papers a wish to have a further stimulation of intermodal transport.'* Given those transport modes and intermodality is recognized as relevant topic for students' education.

Topic: 2.7 Robotization and automation (e.g. autonomous vehicles, 3D printers, drones)

Description: *The automation of logistics services is a consequence of the need to adapt to a customer-driven economy which demands more flexibility and speed than ever before. Robotization and automation represents devices with their different sensory capabilities, their varying degrees of autonomy and mobility, and their different handling capabilities. Thus it is that we are calling such*

highly different devices as a self-driving vehicle, a drone or a 3D printer, "robots". (Robots in the future of logistics, 2017).

Data: Respondents No: 19 and 17.1; Job description list, chapter: 10 a-e); Papers: (Singh et al., 2011) (Irizarry et al., 2013).

Exemplary evidence: The student should learn about Robotization and automation in construction logistics because, *'we might see robots, drones in the future one thing is we do see is autonomous transport beings that is already existing. I think also much integrating autonomous if you look at hubs specifically there will be different type of robotics […] I am working for a strategy of smart city'* stated respondent No: 19, he continued discussion about artificial intelligence in construction logistics domain, *'when you can link task the building components and when automatically tells your BIM model to crane which components should be lifted and located on right spot. We will see a lot of those and us as a humans should control it in a complete different way than we are doing it today (No: 19).'* In addition candidate No: 17.1 stated that *'it would be key thing if BIM could be connected with supply chain and use it in logistics.'* This was a vision of logistics for 21st century, which is barely included in the current job description list, however can be assumed that in chapter 10 *'Vehicles, plant, equipment and vertical transport,'* will be managed by the artificial intelligent in the future. This suggestion can be supported by the scientific papers, such as Singh et al., (2011) argues that *'BIM is an advanced approach to object-oriented CAD, which extends the capability of traditional CAD approach by defining and applying intelligent relationships between the elements in the building model.'* Moreover, paper Irizarry et al., (2013) stated that *'IT-based model was developed to support decision making during the construction supply chain management process […] IT based tools such as BIM, supply-network visibility and accurate information concerning the status of material at different stages can be enhanced […] the proposed model uses BIM capability […] and GIS to support the wide range of spatial analysis used in the logistics perspective (warehousing and transportation) of the supply chain management.'* Given those, perspectives Robotization and automation are recognized as relevant topic for students' educational program.

Topic: 2.8 Construction sequences

Description: *Construction sequences includes many things , among others, the area of the country where it is being built, the design of the facility, the availability of subs and materials, and the preference of the contractor, which means actual sequence of construction.*

Data: Respondents No: 19, 25, 31; Job description list, chapter: 3 e); Papers: (Riley, 1997) (Guo, 1997).

Exemplary evidence: Students should learn about construction sequences, because it helps to optimize forward logistics chain. The respondent No: 25 stated that *'new way of management needs different skills and competences, new skills should be focused and try to optimize complete chain of construction activities, from design, into procurement, into delivery of materials.'* In addition, the candidate No: 31 argued *'logistics manager should have clear understanding of sequences of construction tasks on site and he should have full picture of his role on site.'* The respondent No: 19 supports his colleagues by stating that 'logistics manager […] have to understand main sequence of construction. Role of construction process, different actors are involved and how they can be influenced or influence logistics from construction site.' also *'understanding the technical staff such as drawings, specifications.'* The job description list for construction logistics managers in chapter: 3e), requires *'plan and integrate with key contractors to meet the needs of the planned program and de-confliction of on-site space and time where appropriate.'* Furthermore, scientific paper Riley, (1997) emphasize importance of knowledge of construction sequences, which helps to develop proper site logistics plan, he stated *'Site logistic plans are the most common form of space management found in*

the industry […] site managers develop different plans for each phase of construction, which can be updated weekly.' According to Guo, (1997) *'Detailed site layout plan with space allocation for subcontractors reveals the space conflicts in advance, and thus improves the overall work flow and efficiency.'* Given those, perspectives construction sequences is recognized as relevant topic for students' educational program.

Topic: 2.9 Deconstruction sequences

Description: *Deconstruction is the selective dismantlement of building components, specifically for reuse, recycling and waste management. The requirement for this to be an option in construction has increased due to the increased ability to recycle materials deconstruction sequences includes many things, among others, the area of the country where facility should be break down, the design of the facility, the availability of subs and equipment, and the preference of the contractor, which means actual sequence of deconstruction.*

Data: Respondents No: 17.1, 19; Job description list, chapter: 3 e); Papers: (Smith et al., 2011) (Crowther, 2002).

Exemplary evidence: Student should learn about deconstruction sequences, because it helps to optimize reverse logistics plan and manage the waste. Respondent No: 19 argues that it is important to know *'best way to deconstruct the building, to manage the residue of waste materials in the best way. Classification of materials after deconstruction, to place them separately according to typology.'* Candidate No: 17.1 stated *'if you have old information about how to build structure and all the components, this is something you can use during the deconstruction, you have an overview of buildings, and then you know what to do with all bits and pieces.'* In addition, the job description list for construction logistics managers requires *'safe and efficient removal of waste from the project (ch: 13 b).'* Furthermore, scientific paper Smith et al., (2011) emphasized importance of deconstruction he stated *'the major aim of the deconstruction is the removal of all members safely with minimal damage.'* According to Crowther (2002) *'one third of all solid waste going to landfill comes from building construction and demolition. The negative environmental impacts of this waste are substantial. Such waste can be avoided or reduced by increasing the current rates of reuse and recycling of building materials and components.'* Therefore, knowledge of deconstruction sequences became important in order to reduce the waste. Given those, deconstruction sequences is recognized as relevant topic for students' educational program.

Topic: 2.10 - Site-specific safety management (e.g. fire, health, crime)

Description: *This is an attitudes, beliefs and perceptions shared by natural groups as defining norms and values, which determine how they act and react in relation to risks and risk control systems (Choudhry et al., 2007).*

Data: Respondents No: 19; Job description list, chapter: 5 a-i); Papers: (Choudhry et al., 2008) (Hallowell, 2009).

Exemplary evidence: The student should learn about site-specific safety management because, *'if you gone deconstruct building to build the new building you want to get property quickly, the risk involved in deconstruction of house, if you take out it piece by piece you have a people running around with different equipment, and it is dangerous (safety issue), if you have public policy or national policy or legislation that would probably make businesses to do it accordingly'* stated by the respondent No: 19. His statement was supported by the job description list requirement *'Ensuring the organization's safety policies are followed […] creating of site-specific safety manual, ensure first aid cover and*

equipment is present […] produce method statements, risk assessments ensure lifting plans are produced […] safeguard vulnerable road users from traffic and transport created by the site (ch:5 a,b-i).' The scientific paper Choudhry et al., (2008) argued that *'Safety issues have gained vital importance throughout the construction industry […] some countries, […] have published guides for safety management systems such as the Occupational Safety and Health Administration Standards for the construction industry OSHA 2005 […] in order to ensure a safer working environment.'* In addition, paper Hallowell, (2009) described that *'construction safety and health management has improved significantly following the Occupational Safety and Health Act of 1970. In response to this legislation, contractors began implementing safety programs to reduce occupational safety and health hazards on construction sites.'* Given those, site-specific safety management recognized as relevant topic for students' educational program.

(3) Control

Topic: 3.1 physical distribution cost

Description: *The goal of the organization should be to reduce the total cost of logistics activates, rather than focusing on each activity in isolation. The logistics activities are driven by six major cost categories, they are: Channels of distribution, transportation cost, warehousing cost, order-processing information cost, lot quantity cost, and inventory carrying cost (Ellram et al,. 2006).*

Data: Respondents No: 22, 24, and 25; Job description list, chapter: 1-13; Papers: (Fang, 2011) (Cavinato, 1992).

Exemplary evidence: The student should learn about physical distribution cost because it gives *'understanding of the […] economic perspective of organizational activities'* stated respondent No: 22. In addition, candidate No: 24 explained that *'in this period became very important business management skills that are close to economics,'* and *'new skills that are needed are more like a business people, having a holistic view. They should try to motivate all parties to cooperate and optimize project (No: 25).'* The requirements on total cost concept were not explicitly mentioned in job description list, however, the cost related to all activities mentioned in chapters, from 1 to 13, would need optimization within the project development. Furthermore, scientific paper Cavinato, (1992) argued that *'inter-functional total cost is the core concept of logistics.'* In addition, paper Fang, (2011) argued that *'managers and planners on construction logistics activities and their related costs, so as to increase their bid competitiveness or improve the chance of success at the construction stage by minimizing the construction logistics cost.'* Given those, physical distribution cost is recognized as a relevant topic for students' educational program.

Topic: 3.2 - Materials flow control methods (e.g. early involvement, 3TP)

Description: *Materials management activities must be properly administered and controlled. A firm must be able to measure, report and improve performance. In measuring the performance of materials management, a firm should examine a number of elements, including suppliers service levels, inventory, prices, quality levels and operational levels (Ellram et al, 2006).*

Data: Respondents No: 12, 6; Job description list, chapter: 9 c).3 d); Papers: (Agapiou et al., 1998) (Sobotka, 2005).

Exemplary evidence: The student should learn about materials flow control methods because, this helps them to *'support best solution […] in terms of supply chain relation'* stated respondent No: 12, in addition he argued that in practice *'project leaders from the tactical and operational levels […] have zero awareness about logistics, they just want to finish project on time,'* because '*tender procedures is*

not collaborated with subcontractors, service providers and suppliers […] coordination which is last thing important for construction.' In addition, candidate No: 6 supported statement of previous interviewers and said *'Important is that all the parties should combine production with each other. The preparation of construction site, material supply, crews, and resources should be processed at the same time.'* Furthermore, job description list also requires management of *'all movements to and from site and keeping associated records […] understand procurement arrangements[…] control materials in and out of site (ch: 9 c; 3 c, d).'* Given opinions were supported by the scientific paper Sobotka, (2005) he argued that *'at the present time of well-developed market for building materials and services, centralizing and outsourcing the project supply logistics is considered to be a more efficient solution.'* In addition, paper Agapiou et al., (1998) suggested that *'primary focus of the logistics concept in construction is to improve coordination and communication between project participants during the design and construction phases particularly in the materials flow control process […] a new role for materials suppliers, including early involvement in the design phase and overall responsibility for the flow of information relating to materials.'* Given those, materials flows control methods is recognized as relevant topic for students' educational program.

Topic: 3.3 Progress monitoring (e.g. dashboard systems, scorecard systems, supplier performance reporting, KPIs)

Description*: The progress monitoring systems supports decision making by visually displaying in true time leading and lagging indicators in a supply chain process perspective. It integrates information from number of automated equipment to a high level process model. It represents performance metrics in a graphical form and shows when key indicator are nearing a problem level (Dreyer et al., 2009).*

Data: Respondents No: 6 and 12; Job description list, chapter: 3 h); Papers: (Dreyer et al., 2009) (Bates et al., 2012).

Exemplary evidence: The students should learn about progress monitoring, because it allows to measure *'where you stand and make necessary changes through out of processes […] Dashboard system is for process arrangement it can check and control efficiency of movement and capacity of trucks. It gives information prior to processes and allows to change them timely,'* stated by respondent No: 6. in addition, candidate No: 12 stated that *'companies should create dashboards system that is necessary for single site logistics.'* The job description list for construction logistics managers also requires fulfilment of above mentioned function *'Variation control and early communication of foreseeable change (ch: 3 h)'* within supply chain. Furthermore, scientific paper Dreyer et al., (2009) argued that Dashboard systems is a *'complete business information system that is built on a business intelligence and data integration structure[…]It communicates strategic objectives and enables business people to measure, monitor, and manage the key activities and processes needed to achieve their goals.'* In addition, paper Bates et al., (2012) describes Dashboard systems as real-time event management tool, which*' allow hedge funds to monitor trades, logistics operators to monitor locations and delays in a shipment.'* Given those, progress monitoring is recognized as relevant topic for students' educational program.

Topic: 3.4 Tracking technologies (e.g. GIS, tagging)

Description: *Tracking technologies can be used as a source of key performance indicator data for the measurement of road transport efficiency. In addition it can be used for better traffic management, improved road safety, and road charging through electronic toll collection (Ellram et al,. 2006).*

Data: Respondent No: 29; Job description list, chapter: 9 c, e); Papers: (Ellram et al,. 2006).

Exemplary evidence: Student should learn about tracking technologies, because it can measure road transport efficiency (Ellram et al,. 2006). The respondent No: 29 stated that *'I still think that we have to think how shell we transport materials on the roads without causing problems to the existing traffic. It can be travel to night, or travel without traffic jams.'* The requirement for traffic efficiency was also stated in the job description list *'manage all movement (ch: 9c) […] plan to and maximize load capacity on all vehicles arriving at site […] ensure suppliers use appropriate vehicles for delivery (ch: 9 e).'* Furthermore, scientific paper Reilly, (2002) argues that *'vehicle tracking system occur as distributed heterogeneous systems, which […] gathering information about the operational context and mobile communication environment to (auto configure) systems by adapting behavior according to context and environment.'* In addition, paper Zhao, (2002) argues that *'All these wired and wireless connections and technology advances […] will make our transportation systems operate more safely and efficiently, with less congestion, pollution, and other environmental impact.'* Given those, can be concluded that topic is important and therefore tracking technology is recognized as relevant topic for students' educational program.

Topics: 3.5 Site storage space management

Description: *Warehousing has three main functions: movement, storage and information transfer. Fast and efficient movement of large quantities of raw materials, component parts and finished goods through the warehouse, coupled with timely and accurate information about the product being stored, are the goal of every logistics system (Ellram et al,. 2006).*

Data: Respondent No: 17.1; Job description list, chapter: summary; Papers: (Ackerman, 1999).

Exemplary evidence: The student should learn about site storage space management functions because, *'Important is scale of economy full track on site with a lot of materials, but what is happened that not all materials are used on site some of them you have to keep in storage. However, in storage many materials are wasted, because of whether, or they are stolen, damaged and also it takes a lot of space on site. I think for the future huge densification of cities in Sweden, lack of space and other pedestrians, create new trend, which is also forcing construction industry for improvement.' 'suddenly you cannot store lot of materials on site and connect of this pre-brand small delivers coming all the time on site, what we see industry try to cope with this conditions, and we both have logistics specialists who taking full responsibilities for delivery planning systems but we also have seen consolidation centers, in terms of bringing materials from there.'* argued respondent No: 17.1 This means, logistics managers should be aware of site storage space management, in order to decide how site storage should function for particular project development. The summary of job description list also supports this statement *'Construction logistics manager is responsible for all aspects of the logistics supply chain, storage management, development and optimization of site logistics solutions to meet the needs of the project.'* Furthermore, scientific paper Ackerman, (1999) advised that *'If warehousing is part of your future, consider challenges of designing for tomorrow but doing it today […] critical step is to determine just exactly what the operation will look like from inside out […] what warehouse you really need.'* In addition, paper (van den Berg, 1999) also stressed that *'new market forces, together with the fast technological developments in material handling, have affected the operation within warehouses tremendously.'* Given those, can be concluded that site storage space management is relevant topic for students' educational program.

Topic: 3.6 End-of-life-cycle scenarios (e.g. refurbishing, reusing, recycling, disposing)

Description: *End of life cycle scenarios fall into three main categories 1) Immediate Reuse, 2) Process Further, and 3) Dispose of. In addition, materials are categorized in terms of product size, method of processing, end-use, and origin (Kibert, 2000; McNally, 2002).*

Data: Respondent No: 19; Job description list, chapter: 1 a); Papers: (Parsanejad et al., 2010) (Kibert, 2000).

Exemplary evidence: The student should learn about categorization of deconstructed materials because, *'company deconstructing the house they made money by selling the materials to other parties. And this kind of knowledge will be demanded in the future, especially if we talk about circular economy or shared economy,'* stated respondent No: 19. The requirement for waste management strategy also was stated in the job description list *'plan site set-up to move labor, plant, and materials around site efficiently […] material delivery and waste management strategy (ch: 1 a).'* Furthermore, scientific paper Parsanejad et al., (2010) argued that *'Convenient strategies should be founded for improving waste production […] each material has its own source of waste, therefore exact identification of any material and after that its source will help to develop waste minimization strategies.'* According to paper Kibert, (2000), *'deconstruction is defined as the disassembly of structures for the purpose of reusing the Structures components and building materials. The primary intent is to divert the maximum amount of building materials from the waste stream.'* Given those, end-of-life-cycle scenarios can be recognized as relevant topic for students' educational program.

Topics: 3.7 Asset information models (e.g. material passports)

Description: *An Asset Information Model (AIM) is a model that compiles the data and information necessary to support asset management, it provides all the data and information related to, or required for the operation of an asset (plans, calculations, lists and declarations of materials and products used, operating and maintenance guidelines etc.). It can provide graphical and non-graphical data. It can be created from existing asset information systems, from new information, or from information in a project information model that was created for the construction of a new asset.*

Data: Respondents No: 12, 17.1, 19, 25, 33; Job description list, chapter: 7a); Papers: (Blum, 2001) (Love et al., 2014).

Exemplary evidence: Student should learn about asset information models, because it is *'seen as technical planning tool (BIM model) and operational planning tool (BIM model)'* stated respondent No: 12. It integrates *'all cycle from design till final stage, project management, asset management and maintenance (No: 12).'*According to candidate No: 17.1 *'BIM model you can use for planning of waste management processes, for deconstruction and risk management'* and it is useful because of *'you have all information you need about different components (No: 19).'* Respondent No: 25 names it *'circulate business element in construction, you see so many initiatives in construction that they already change second line of materials and those materials can be reused.'* Asset informational model includes data about *'existing part of building you can reuse […] also specific information about materials, plastic, wood, metal etc.'* argues candidate No: 33. The job description list for construction logistics managers requires in chapter: 7 a), *'create a system to communicate information around the site (e.g. noticeboards, email distribution lists, monitor displays, web pages).'* Furthermore, scientific paper Love et al., (2014) explains that *'implementation of BIM should not be seen as a discrete information technology (IT) project, but a business change program that can potentially impact the organization's value proposition.'* BIM model also can be seen as a building passport that is defined as an instrument to show both *'information on building quality in general as well as open a perspective on environmental characteristics and performance criteria (Blum, 2001).'* Given those, asset information models is recognized as relevant topic for students' educational program.

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Appendix 5. Crosscheck feedback from respondents on comprehensive framework

Candidate No: 12
Name:
Name and affiliation:
Date of feedback:

Letter: From construction companies perspective it covers almost everything. I am missing: the role of construction logistics in successful tenders. Construction logistics is more often part of the EMAT procedure. Students need to understand this and their role in writing the proposal. In general I miss the role of government/governance (and regulations) and the role buyers play in tendering for projects that are better organized from a logistics perspective. You can find our latest research here:

https://www.researchgate.net/publication/317579423_Exploring_criteria_for_tendering_for_sustainable_urban_construction_logisticshttps://www.researchgate.net/publication/317579423_Exploring_criteria_for_tendering_for_sustainable_urban_construction_logistics

and

https://www.researchgate.net/publication/317579322_Exploring_criteria_for_tendering_for_sustainable_urban_construction_logisticshttps://www.researchgate.net/publication/317579322_Exploring_criteria_for_tendering_for_sustainable_urban_construction_logistics

Potential example that can be included in the procurement topic: EMAT *(economically most advantage tender)* procedure.

Candidate No: 37
Name:
Name and affiliation:
Date of feedback:

Letter: Please find some quick remarks attached. Not included in the remarks, but definitely overshadowing these topics, is dealing with change management. Since the construction business is such a traditional field, change management should be a big part of the educational process. Besides this, are you perhaps visiting the symposium on construction logistics in Amsterdam this Friday?

Planning:
'Include "Communication through systems" e.g. systems like "KYP", and ticketing systems like "ILIPS" are going to play a major part in your planning and contract negotiations, as not all parties are willing to use systems.'

1.6 Procurement: Procurement not only concerning labor and materials, but also: Transport, Packaging/sequencing of materials, prefabrication.
1.9 Delivery strategies: Asset capacity calculations (e.g. towercrane capacity and usage, elevator capacity usage etc.) transport frequency and volumes.

Control:
3.3 Monitoring of progress: Maybe include "supplier performance reporting" and "management through KPI's" here.

Potential topics that can be included in the topics list: Change management; Asset capacity calculation *(e.g. tower crane capacity and usage, elevator capacity usage etc.);* Supplier performance reporting.

Candidate No: 24
Name:
Name and affiliation:
Date of feedback:

Letter: Nice you asked to comment your matrix. The list topics suited me for these comments as well. I will send you the PDF supplied with bookmarks. Please check of my remarks are included in the file I send you. I hope that you don't mind that some comments are beyond the assessment of the topic itself. Some of these refer to my own Phd study: How do management theories fit to construction and construction logistics. In my opinion sometimes they don't. Lauri Koskela & Glen Ballard (2012) wrote also on this subject: Is production outside Management - Building Research and Information 40.6. But let these considering not obstruct you too much.

Planning:
1.1 Systems theory: is very popular is construction supply chain management, but planning, implementation and control have their own systems approach. Systems theory does not cope with the production process of construction.

1.2 Enterprise Recourse Planning: is OK.
1.3 Integrated planning (e.g. BIM): it exist as long as a there is construction modeling. Drawings, materials design, cost, quality calculations, time frames. It takes more than BIM to integrate all the participants, an interactive model for instance organizing interaction and feedback between the participants in planning demands and interactive systems.
1.4 Demand planning: is OK.
1.5 Return planning: should be connected to core planning of the construction process.
1.6 Procurement: Important. Not only cost oriented, but also to the service level.
1.7 And 1.8 inner city deliveries (e.g. hubs allocation, control tower): the accessibility and the (store-hauling) capacity of the construction site should be regarding in the planning process.
1.9 Delivery strategy: Good idea, implementation depending on the type of construction and the type of materials
1.10 Routing and scheduling of freight transport: Useful in any case.
1.11 Circular business models: Seems OK not so familiar with it.
1.12 Site waste management plan: in Holland mandatory for many local authorities, but depending on the local waste recycling industries.

Implementation:
2.1 Total quality management (e.g. law, rules): OK, but what is under control of TQM, and what is controlled by other authorities, like infrastructure, allocation, site layout?

2.2 Supplier relationship management: Good topic, works with continuous relations between contractors, subcontractors with suppliers. Tendency to conflict with low cost procurement.

2.3 Risk management in supply chain: Main topic. Means turning between producer, contractor, subcontractor, supplier and transporter.
2.5 Regulations regarding freight transport: Regulations by local authorities may conflict with possibilities for transport of deliveries. In planning the project these extra provisions, demanded by local authorities should be included in tendering the project. This is fair to the extra costs the contractor has to make.
2.6 Transport modes and intermodal combination selection: Good topic.
2.7 Robotization and automatization: Not a main topic for construction, many robots need a perfect conditioned area to operate.
2.8 Sequence of construction/deconstruction tasks: Main topic.
2.9 Site specific safety management (e.g. fire, health, crime): Also a governmental topic, in Holland there are two sequential assessment the building permit and the permit to construct at the building site. By plane crashes that cause is particularly investigated and made publicly. So all concerned will learn from it and improve. In construction it is not seems the case. A lawyer's bargain about the responsibility for the damage, but not the mistakes in material design or constructive design. Recently a parking garage at Eindhoven airport collapsed obvious to see that the slim pillars under the ramp did not provide enough torque stability. Like their failures in construction not to make public, especially when there were no casualties. The call for integration in construction and construction logistics in my opinion is due to continues segregation of functions in construction. Designers have little knowledge of mechanics in construction, which is taken over constructors, who have limited knowledge of materials, like sustainability and flammability, procurement offices make their decisions cost-based without profound consideration of materials quality and properties, etc. Given topic fractured process of construction calls for integration and full access to information at any stage. BIM provides such, it makes visible again what got out of sight by this segregation, but is in essence no new quality added to construction, it will replace something that already occurred, but got obsolete: design, material definition, construction schedule, time frame and table of delivery and transports at the site.

Control:
3.1 Transaction coordination: The topic of control is more difficult to supply with priorities according to the sequence of planning and implementation of the construction process and its logistics. Does given topic not apply also to planning an implementation?
3.2 Materials flow control methods: Important. The essence of logistics is controlling the transport of supplies of supplies (materials and labor) in the most efficient ways.
3.3 Monitoring of progress: Important. But who is the controller what position he held in the project / construction.
3.4 Vehicle tracking technologies (e.g. GIS, RFID): Useful, when contest of deliveries is also known, and there is feedback between suppliers and client. Commonly done by exchanging mobile phone numbers. As in more cases topics for construction logistics are introduced from other logistics industries or communication systems.
3.5 On site space management (e.g. site space utilization): Important. This starts from the preparation for the project.
3.7 Disposition scenarios for secondhand materials (reuse, processed further, dispose of): The items will also be decided in an early stage of the project development, and applied into actions during the construction, special officers to manage these operations are needed with knowledge of technics to apply second hand materials and the market for reverse logistics.
3.8 Sorting of secondhand materials: The same remarks as earlier.
3.9 Managing material compositions (e.g. material passports): So this will be very useful, but they need a long jurisdiction subject. At the moment an effort to realize this product identification is done by the EU authorities.

Potential topic that can be included in the topics list: Well, none of the topics are explicitly rejected, most of them are commented as *important, OK* or *useful*. Therefore, I conclude that topics list is fine.

Candidate No: 19
Name:
Name and affiliation:
Date of feedback:

Letter: Looks ok.

Potential topic that can be included in the topics list: Well, none of the topics are explicitly rejected, all of them are commented as *OK*. Therefore, I conclude that topics list is fine.

Candidate No: 6
Name:
Name and affiliation:
Date of feedback:

Letter: I've looked at your list, but I can not add or remove something from it. I think your list is quite complete. Success with your study.

Potential topic that can be included in the topics list: Well, none of the topics are explicitly rejected, the list is commented as *complete*. Therefore, I conclude that topics list is fine.

Candidate No: 45
Name:
Name and affiliation:
Date of feedback:

Letter: The topic list looks good from my point of view. Obviously we are still a bit of an old fashioned industry in marine construction when I read about robotics etc. which I presume has come out of the other interviews.

Potential topic that can be included in the topics list: Well, none of the topics are explicitly rejected. Therefore, I conclude that topics list is fine.

Appendix 6. Sample of online survey form

Construction logistics educational expectations

Knowledge level definition according to Bloom's taxonomy matrix

1 (Remembering) - Employees are recognizing or recalling knowledge from memory.
2 (Understanding) - Employees are constructing meaning from different types of functions be they written or activities like interpreting, exemplifying, or explaining.
3 (Applying) - Employees are carrying out or using a procedure through executing or implementing.
4 (Analyzing) - Employees are breaking materials or concepts into parts, determining how the parts relate to an overall structure or purpose.
5 (Evaluating) - Employees are making judgments based on criteria and standards through checking and critiquing.
6 (Creating) - Employees are putting elements together to form a new product or process.

Please, fill out survey form ONLY if you have professional experience in the construction logistics.

1. Please indicate your details below.

Organization:
Position:
Years of professional experience:
Geographical location:

2. In each of the following areas, please indicate, the knowledge level that is expected from potential employees with Bachelor's degree.

	1 (Remembering)	2 (Understanding)	3 (Applying)	4 (Analyzing)	5 (Evaluating)	6 (Creating)
1.1 Systems perspective/overview	○	○	○	○	○	○
1.2 Enterprise Resource Planning	○	○	○	○	○	○
1.3 BIM-based planning (e.g. 4D/5D modeling)	○	○	○	○	○	○
1.4 Demand forecasting	○	○	○	○	○	○
1.5 Return planning	○	○	○	○	○	○
1.6 Procurement	○	○	○	○	○	○
1.7 Construction site layout planning	○	○	○	○	○	○
1.8 Inner city deliveries (e.g. hubs, control tower systems)	○	○	○	○	○	○
1.9 Delivery strategies (e.g. JIT)	○	○	○	○	○	○
1.10 Routing and scheduling techniques	○	○	○	○	○	○
1.11 Circular business models	○	○	○	○	○	○
1.12 Site waste management	○	○	○	○	○	○
2.1 Total quality management	○	○	○	○	○	○
2.2 Supplier relationship management	○	○	○	○	○	○
2.3 Risk management in supply chains	○	○	○	○	○	○
2.4 Sensoring technologies	○	○	○	○	○	○
2.5 Transport regulations	○	○	○	○	○	○
2.6 Transport modes and intermodality	○	○	○	○	○	○

2.7 Robotization and automation (e.g. autonomous vehicles, 3D printers, drones)	○	○	○	○	○	○
2.8 Construction sequences	○	○	○	○	○	○
2.9 Deconstruction sequences	○	○	○	○	○	○
2.10 Site-specific safety management (e.g. fire, health, crime)	○	○	○	○	○	○
3.1 Physical distribution cost	○	○	○	○	○	○
3.2 Materials flow control methods (e.g. early involvement, 3TP)	○	○	○	○	○	○
3.3 Progress monitoring (e.g. dashboard systems, scorecard systems, supplier performance reporting, KPIs)	○	○	○	○	○	○
3.4 Tracking technologies (e.g. GIS, tagging)	○	○	○	○	○	○
3.5 Site storage space management	○	○	○	○	○	○
3.6 End-of-life-cycle scenarios (e.g. refurbishing, reusing, recycling, disposing)	○	○	○	○	○	○
3.7 Asset information models (e.g. material passports)	○	○	○	○	○	○

3. In each of the following areas, please indicate, knowledge level that is expected from potential employees with Master's degree.

	1 (Remembering)	2 (Understanding)	3 (Applying)	4 (Analyzing)	5 (Evaluating)	6 (Creating)
1.1 Systems perspective/overview	○	○	○	○	○	○
1.2 Enterprise Resource Planning	○	○	○	○	○	○
1.3 BIM-based planning (e.g. 4D/5D modeling)	○	○	○	○	○	○
1.4 Demand forecasting	○	○	○	○	○	○
1.5 Return planning	○	○	○	○	○	○
1.6 Procurement	○	○	○	○	○	○
1.7 Construction site layout planning	○	○	○	○	○	○
1.8 Inner city deliveries (e.g. hubs, control tower systems)	○	○	○	○	○	○
1.9 Delivery strategies (e.g. JIT)	○	○	○	○	○	○
1.10 Routing and scheduling techniques	○	○	○	○	○	○
1.11 Circular business models	○	○	○	○	○	○
1.12 Site waste management	○	○	○	○	○	○
2.1 Total quality management	○	○	○	○	○	○
2.2 Supplier relationship management	○	○	○	○	○	○
2.3 Risk management in supply chains	○	○	○	○	○	○
2.4 Sensoring technologies	○	○	○	○	○	○
2.5 Transport regulations	○	○	○	○	○	○
2.6 Transport modes and intermodality	○	○	○	○	○	○
2.7 Robotization and automation (e.g. autonomous vehicles, 3D printers, drones)	○	○	○	○	○	○
2.8 Construction sequences	○	○	○	○	○	○
2.9 Deconstruction sequences	○	○	○	○	○	○
2.10 Site-specific safety management (e.g. fire, health, crime)	○	○	○	○	○	○
3.1 Physical distribution cost	○	○	○	○	○	○
3.2 Materials flow control methods (e.g. early involvement, 3TP)	○	○	○	○	○	○

3.3 Progress monitoring (e.g. dashboard systems, scorecard systems, supplier performance reporting, KPIs)	○	○	○	○	○	○
3.4 Tracking technologies (e.g. GIS, tagging)	○	○	○	○	○	○
3.5 Site storage space management	○	○	○	○	○	○
3.6 End-of-life-cycle scenarios (e.g. refurbishing, reusing, recycling, disposing)	○	○	○	○	○	○
3.7 Asset information models (e.g. material passports)	○	○	○	○	○	○

4. In each of the following areas, please indicate, the knowledge level that is expected from employees with more than 10 years of professional experience.

	1 (Remembering)	2 (Understanding)	3 (Applying)	4 (Analyzing)	5 (Evaluating)	6 (Creating)
1.1 Systems perspective/overview	○	○	○	○	○	○
1.2 Enterprise Resource Planning	○	○	○	○	○	○
1.3 BIM-based planning (e.g. 4D/5D modeling)	○	○	○	○	○	○
1.4 Demand forecasting	○	○	○	○	○	○
1.5 Return planning	○	○	○	○	○	○
1.6 Procurement	○	○	○	○	○	○
1.7 Construction site layout planning	○	○	○	○	○	○
1.8 Inner city deliveries (e.g. hubs, control tower systems)	○	○	○	○	○	○
1.9 Delivery strategies (e.g. JIT)	○	○	○	○	○	○
1.10 Routing and scheduling techniques	○	○	○	○	○	○
1.11 Circular business models	○	○	○	○	○	○
1.12 Site waste management	○	○	○	○	○	○
2.1 Total quality management	○	○	○	○	○	○
2.2 Supplier relationship management	○	○	○	○	○	○
2.3 Risk management in supply chains	○	○	○	○	○	○
2.4 Sensoring technologies	○	○	○	○	○	○
2.5 Transport regulations	○	○	○	○	○	○
2.6 Transport modes and intermodality	○	○	○	○	○	○
2.7 Robotization and automation (e.g. autonomous vehicles, 3D printers, drones)	○	○	○	○	○	○
2.8 Construction sequences	○	○	○	○	○	○
2.9 Deconstruction sequences	○	○	○	○	○	○
2.10 Site-specific safety management (e.g. fire, health, crime)	○	○	○	○	○	○
3.1 Physical distribution cost	○	○	○	○	○	○
3.2 Materials flow control methods (e.g. early involvement, 3TP)	○	○	○	○	○	○
3.3 Progress monitoring (e.g. dashboard systems, scorecard systems, supplier performance reporting, KPIs)	○	○	○	○	○	○
3.4 Tracking technologies (e.g. GIS, tagging)	○	○	○	○	○	○
3.5 Site storage space management	○	○	○	○	○	○
3.6 End-of-life-cycle scenarios (e.g. refurbishing, reusing, recycling, disposing)	○	○	○	○	○	○
3.7 Asset information models (e.g. material passports)	○	○	○	○	○	○

5. Do you have any other comments related to the expected levels of knowledge on construction logistics (e.g. missing topics)?

Appendix 7. Data collected by online survey

Table 20: Data collected by online survey.

1			2			3			4			5			6		
BA	MSc	EXP	BA	MSc	EXP	BA	MSc	EXP	BA	MSc	EXP	BA	MSc	EXP	BA	MSc	EXP
2	4	6	4	4	5	3	4	5	2	2	2	4	4	6	2	3	6
1	2	5	2	6	6	2	5	5	3	3	3	2	3	5	2	3	5
3	3	5	2	6	6	3	6	5	3	3	3	3	3	5	3	4	4
2	3	5	2	4	5	2	5	5	4	5	6		3	5	1	3	4
1	3	5	2	6	5	2	5	5	4	4	6		3	5	2	2	4
1	2	4	2	6	6	2	4	5	4	4	5	2	3	5	2	2	5
2	3	4	4	6	6	3	4	5	4	4	5	3	4	5	2	3	6
2	2	4	2	6	5	3	5	5	2	3	3	2	3	4	1	2	5
3	3	6	4	4	5	3	5	5	2	2	3	2	3	4	3	3	5
3	3	6	4	6	5	3	5	5	4	2	3	3	3	4	3	3	5
2	2	5	4	5	6	2	6	5	2	2	3	2	2	4	1	1	3
2	3	5	2	6	6	3	5	5	4	4	5	2	2	4	3	3	5
2	3	5	2	6	6	2	5	5		2	2	3	4	6	2	4	6
1	2	5	2	6	6	2	5	5	2	2	2			5	2	3	6
2	3	5	4	4	6	3	5	5	2	4	4	4	5	6	2	3	5
2	2	4	2		5	2	4	5				2	3	4	1	2	4
2	3	4	4	2	5	3	4	5	2	2	2	2	2	4	2	2	4
2	3	4	4	2	6	3	4	5	3	3	2	2	2	4	1	2	4
2	2	5	2	2	5	2	5	5	1	2	2	2	3	4	1	2	3
2	3	6	2	4	5	3	5	5	4	4	5	3	3	5	4	4	6
2	3	5	2	4	5	2	5	5	4	4	5	3	3	5	3	3	5
2	3	5	2	4	6	3	5	5	3		3	2	3	5	4	4	6
2	2	5	2	4	6	2	4	5	2	4	3	2	3	5	2	2	6
2	2	5	2	4	6	2	5	5	4	5	5	3	3	5	2	2	5
2	3	5	4	6	5	2	5	5	2	5	3	2	3	5	2	3	5
2	3	5	2	4	5	2	4	5	2	5	3	2	2	4	1	2	4
2	3	5	2	4	6	3	5	5	4	3	3	2	2	5	3	3	6
2	3	5	2	4	5	2	6	5	3	2	2	2	3	5	2	2	4
3	4	6	2	4	5	3	5	5	2	2	2	3	3	6	1	2	4
Croonwolterendors			BAM Bouw en Techniek - Grote Projecten			Plegt-Vos			TU Delft - Advisor Sustainable Construction Logistics			Wagemaker			Heijmans Utiliteit		
principal systems engineer			Manager Planontwikkeling			Innovationmanager			retired professional ir. bi			Director			Projectdirector		
30			35			10			50			18			20		
Netherlands			Netherlands -Bunnik			Netherlands			Rotterdam Urban Region - Netherlands			Netherlands			Netherlands, Rotterdam		

.

7			8			9			10			11			12		
BA	MSc	EXP	BA	MSc	EXP	BA	MSc	EXP	BA	MSc	EXP	BA	MSc	EXP	BA	MSc	EXP
3	5	4	2	4	5	2	4	6	2	6	2	5	5	5	2	2	5
2	3	4	2	3	4	4	3	5	4	6	2	6	5	6	3	4	5
3	3	3	3	3	3	5	4	5	3	4	3	4	5	4	3	6	6
4	5	4	3	3	3	4	2	4	3	3	2	4	4	4	2	3	4
3	3	4	2	2	3	4	2	2	3	4	5	3	3	3	3	3	4
3	3	3	2	4	5	4	4	5	1	6	3	3	3	3	3	4	6
5	3	5	4	3	3	5	4	3	3	6	3	4	3	2	2	2	5
5	4	5	3	3	6	3	3	4	2	4	2	3	3	2	4	4	3
5	4	5	2	3	6	5	4	3	1	5	3	5	5	6	3	3	6
4	3	5	2	2	5	5	3	3	3	3	3	5	5	5	1	2	3
4	5	5	2	3	5	2	2	5	2	3	3	4	4	4			
4	6	4	3	3	5	3	4	4	3	6	3	2	3	3	2	2	3
3	5	5	2	4	5	4	5	6	2	6	3	4	5	5	3	4	5
3	5	5	2	5	6	4	4	5	2	6	5	4	5	5	2	5	6
4	5		2	4	5	3	3	4	2	4	2	4	5	5	3	3	4
5	5	3	3	2	3	1	2	3	3	5	3	3	3	3			
3	3	3	3	2	3	3	2	3	5	5	2	3	3	3	1	2	3
3	3	4	2	3	5	4	3	3	5	4	2	3	3	3			
3	3	4	2	2	3	2	2	5	3	6	3	2	3	4	1	1	2
4	4	5	3	3	5	5	5	5	3	4	6	4	4	4	4	4	5
4	4	5	3	3	5	2	5	4	3	4	6	2	3	3	4	4	5
5	5	4	2	3	4	4	2	3	1	3	2	3	4	5	3	6	6
3	4	3	3	2	4	3	2	3	2	4	4	4	5	5	2	5	5
4	3	5	3	4	5	5	3	4	2	3	3	4	5	5	2	2	5
4	5	5	2	4	5	4	4	4	1	6	6	4	5	4	1	5	6
3	5	3	2	3	4	2	2	2	3	3	3	3	4	4	1	1	2
5	3	4	3	3	4	2	3	2	6	5	3	3	3	4	3	4	3
3	5	5	2	3	4	2	2	2	3	6	4	2	3	4	2	5	6
3	5	3	2	3	4	3	2	2	1	3	3	3	4	4			
Heijmans Utility			BAM Advies en engineering			Bouwlogistiek Nederland			Rapp Technique du Bâtiment			Haitsma Beton BV			Skanska Sverige AB		
Director Building Technology			Manager Projectbeheersing			Supply Chain Engineer			BIM mdleler			Directeur			Category Maneger Site Logistics		
30			11			1			27			28			7		
Netherlands, Rosmalen			Neherlands, Utrecht			South-Holland			Switzerland, Geneve			Netherlands, Kootstertille			Stockholm, Sweden		

.

13			14			15			16			17			18		
BA	MSc	EXP	BA	MSc	EXP	BA	MSc	EXP	BA	MSc	EXP	BA	MSc	EXP	BA	MSc	EXP
1	1	5	2	2	3	5	3	4	3	6	5	4	4	4	5	4	5
1	1	4	2	2	4	4	3	3	4	6	3	3	4	4	5	4	5
1	1	3	2	3	5	5	4	3	2	5	4	3	3	4	6	5	5
1	1	4	1	3	4	4	3	2	3	5	5	4	4	5	5	5	5
1	1	4	1	3	4	5	4	3	4	5	6	4	4	5	5	5	5
1	1	3	1	4	4	5	4	3	3	3	2	5	4	5	4	5	5
2	2	4	1	2	6	5	3	2	4	6	5	6	4	4	5	5	5
1	1	3	2	2	4	5	3	2	3	6	5	5	4	5	4	5	5
1	1	3	2	3	5	5	3	3	5	5	4	4	4	4	4	5	5
1	1	3	2	3	4	5	4	2	5	4	3	3	4	4	4	5	5
1	1	3	2	4	3	4	4	3	2	6	2	4	6	5	6	5	5
1	1	4	2	5	4	5	3	3	6	2	3	4	4	3	5	5	5
1	2	4	1	3	5	4	3	3	3	6	5	4	4	5	5	5	5
1	2	4	1	3	5	4	3	3	6	2	6	5	4	6	5	6	5
1	2	4	1	3	5	4	4	2	2	5	4	4	4	6	5	6	5
1	1	4	1	4	4	5	4	2	4	6	3	3	4	4	4	6	5
1	1	4	4	5	5	4	3	2	2	2	3	3	4	3	4	5	5
1	1	4	2	5	5	4	4	2	3	5	4	3	4	3	4	5	5
1	1	3	3	5	6	4	3	2	2	6	3	4	4	5	5	5	5
2	2	5	3	3	5	5	4	3	5	4	6	3	4	4	5	5	5
2	2	5	3	3	5	5	4	3	6	5	5	4	4	4	5	5	5
2	2	5	5	4	5	4	4	3	5	3	2	3	4	4	5	5	5
1	1	3	2	4	5	5	3	3	2	6	5	3	4	5	4	5	5
1	1	5	2	3	5	5	3	3	3	5	3	3	4	4	4	5	5
1	1	5	3	3	6	4	3	3	4	6	3	4	4	4	6	5	5
1	1	4	3	4	5	5	4	3	4	4	2	4	5	4	5	5	5
2	2	5	2	3	6	5	3	3	6	2	6	4	5	4	5	5	5
1	1	4	2	3	5	4	3	3	5	6	3	2	5	5	6	5	5
1	1	4	1	3	5	5	3	3	3	6	2	3	5	4	5	5	5
BAM Construct UK			Turner International			Dansk kabel tv			Rijkswaterstaat			Skanska, UN			Roelofs Groep BV		
Construction Manager			Construction Manager			Logistisk manager			BIM programmamanager			Manager			CEO		
14			20			25			30			20			28		
UK			India			Denmark			Netherlands, Utrecht			Europe, Asia, middle East			North, East and Central Netherlands		

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19			20			21			22			23			24		
BA	MSc	EXP	BA	MSc	EXP	BA	MSc	EXP	BA	MSc	EXP	BA	MSc	EXP	BA	MSc	EXP
5	6	5	3	3	5	2	2	1	2	2	3	4	5	5	3	5	1
5	6	5	2	2	3	2	2	3	1	2	3	3	6	6	2	4	1
3	5	4	3	4	5	4	6	4	2	3	3	5	5	6	1	2	1
5	6	5	3	1	3	3	3	6	2	2	3	5	5	6	2	5	2
5	6	5	2	1	3	2	2	3	3	2	3	5	5	6	5	6	3
5	6	5	2	1	2	1	3	3	3	4	3	4	6	6	5	6	3
5	6	4	2	2	2	3	5		2	3	3	4	6	6	2	2	3
4	5	4	1	1	2	5	3	2	2	2	3	4	6	6	2	2	1
5	6	5	1	3	5	1	5	3	1	2	3	5	5	5	2	3	1
5	5	5	3	3	3	6	6	2	3	3	3	5	6	5	2	5	6
5	6	5	1	2	3	1	6	3	1	3	3	5	6	6	2	4	1
4	5	4	1	2	3	2	6	2	1	2	3	5	6	6	1	2	2
5	6	5	3	4	5	2	5	5	1	2	3	6	6	6	2	2	6
5	6	5	2	2	5	3	6	6	1	2	3	4	6	6	6	6	6
5	6	5	4	4	5	1	6	6	1	3	3	5	6	6	6	6	6
4	5	4	1	2	2	4	4	6	1	2	3	4	5	5	2	2	2
4	6	4	1	1	3	3	3	4	1	2	3	3	5	6	3	5	6
4	5	4	1	1	2	2	2	4	1	1	3	3	5	6	3	4	6
3	4	3	2	3	3	1	5	5	2	3	3	4	6	5	1	1	1
3	5	3	3	2	5	3	6	6	2	3	3	2	6	6	2	5	1
3	5	3	1	2	3		2	6	1	2	3	2	6	6	2	5	3
4	5	3	2	3	5	3	3	6	1	2	3	2	6	6	2	2	1
5	6	4	2	2	3	1	4	6	1	2	3	4	6	6	2	3	2
5	6	4	3	3	3	2	3	6	1	2	3	5	5	6	1	2	1
5	6	4	2	3	5	2	4	4	1	3	3	5	6	6	1	4	1
5	6	4	2	2	2	6	5	5	2	3	3	4	5	5	1	2	1
5	6	4	1	1	2	3	5		1	2	3	5	6	6	2	6	6
3	5	3	1	1	2	2	4	3	2	2	3	5	6	6	2	5	6
4	5	3	2	2	3	1	4	4	1	2	3	4	5	6	6	6	6
Swire Blue Ocean A/S			Ingenieursbureau Verhoeven en Leenders bv			NCC						from July 1st Independent entrepreneur (former Unilever)			Van Oord		
Logistics and Procurement Superintendent			Owner / manager			Construction Manager						mpact drive Social & Sustainable consultant (UL last role Logistics Manager)			Logistics planner		
24			25			5						40			2		
Denmark			Netherlands, Volkel (Uden)			Denmark						Current NL (UL Europe)			Netherlands and Russia		

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25			26			27			28			29			30		
BA	MSc	EXP	BA	MSc	EXP	BA	MSc	EXP	BA	MSc	EXP	BA	MSc	EXP	BA	MSc	EXP
3	4		2	4		3	6		2	3		2	2		4	5	
3	2		2	2		4	4		2	5		3	2		3	4	
3	6		1	2		3	5		3	4		2	4		3	4	
4	5		1	1		5	6		3	3		3	2		3	4	
4	2		2	4		4	4		3	4		3	1		3	4	
2	2		2	4		2	5		3	3		3	5		3	4	
2	2		1	2		3	2		3	3		2	2		3	4	
3	6		1	1		2	3		2	3		1	5		3	4	
3	2		2	4		3	3		4	5		1	1		3	3	
3	2		1	1		3	2		2	4		1	1		2	3	
3	2		1	1		4	4		2	3		1	4		2	3	
3	2		1	1		3	2		2	3		3	1		2	3	
2	2		2	3		4	5		3	4		1	5		3	4	
2	2		2	1		5	6		3	3		1	5		3	3	
2	4		2	3		5	6		2	5		1	1		3	3	
3	5		1	1		2	3		2	3		1	1		1	2	
2	2		1	1		0	4		3	4		3	4		1	2	
2	4		1	1		3	4		2	3		1	1		2	3	
2	6		1	1		2	3		1	3		1	1		2	3	
2	2		1	3		4	5		2	4		3	4		2	3	
2	2		1	3		4	5		2	3		1	2		2	3	
2	2		1	2		4	6		3	3		3	4		1	3	
2	3		1	1		3	5		2	4		2	4		2	3	
2	4		1	1		3	3		3	4		1	3		1	3	
3	5		1	1		5	6		3	5		4	3		3	4	
3	5		1	1		3	3		2	3		1	1		2	3	
2	3		1	1		3	3		3	4		2	3		2	3	
2	4		1	1		4	5		2	5		1	1		2	3	
2	4		1	1		3	5		3	4		1	1		2	3	
Volker Wessels			Rijkswaterstaat			REEF			BAM International bv								
Directur			Inkoop- en Contractmanager			Project manager			Project Engineer and Logistics Team Leader for the Antarctic Construction Partnership						Adviseur Projectbeheersing / Kwaliteitsmanager at Zuidasdok		
NL			NL			NL			NL						NL		

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31			32			33			34			35			36		
BA	MSc	EXP	BA	MSc	EXP	BA	MSc	EXP	BA	MSc	EXP	BA	MSc	EXP	BA	MSc	EXP
4	5		3	6		3	3		5			3			2	6	5
2	4		3	6		3	6		5			3			3	6	5
3	4		6	2		2	3		4			2			2	3	6
4	5		4	5		3	6		2			4			4	3	6
4	5		5	5		2	3		2						5	4	6
2	4		2	3		2	3		3			3			5	2	3
4	3		6	6		6	6		2			1			6	2	3
4	3		2	4		3	6		2			2			2	5	3
4	5		3	5		6	6		4			5			3	6	6
2	3		6	5		3	6		4			3			4	6	6
2	2		4	6		2	4		3			2			4	5	6
4	4		3	4		6	6		2			1			5	2	5
3	5		6	5		6	6		5			5			2	6	6
2	4		4	5		2	6		4			6			5	5	6
2	4		5	6		3	3		3			6			5	4	6
1	2		4	5		2	3		3			1			4	5	6
1	3		3	2		2	3		2			1			2	2	4
1	2		4	2		2	5		2			1			2	2	4
1	2		2	4		2	2		1			1			5	5	6
2	2		3	6		6	6		4			2			2	6	6
2	2		3	6		5	6		3			2			2	6	6
4	4		6	5		6	6		2			2			5	4	6
3	4		4	2		2	3		5			3			4	4	6
3	4		4	5		3	3		2			2			2	6	6
3	4		4	5		5	6		3			6			3	6	6
1	2		3	2		2	3		3			2			2	6	6
3	4		6	4		6	6		2			2			2	2	6
3	2		2	4		6	6		3			5			2	2	6
3	3		2	6		2	3		2			2			2	6	6
Koninklijke Saan			QUA - Vadis (V.o.f.)			GMI Construction Group Plc			Balfour Beatty						Ballymore Group		
logistics manager			CEO			Site Manager			Construction Manager						Senior Project Manager		
					36			5			32						35
NL			NL, Rotterdam			UK			UK, London						UK, London		

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37			38			39			40			41			42		
BA	MSc	EXP	BA	MSc	EXP	BA	MSc	EXP	BA	MSc	EXP	BA	MSc	EXP	BA	MSc	EXP
4	6	5	3	4	4	5	3	6	4	2		2	4	6	3	5	5
3	3	2	3	3	5	5	5	6	4	4		2	4	5	4	5	5
4	5	2	2	3	4	5	4	6	5	2		1	4	4	3	5	2
5	5	5	3	3	4	5	4	6	4	2		3	6	6	4	5	4
4	5	5			4	4	4	6	4	5		3	6	6	5	5	4
3	5	5	3	4	5	4	4	6	1	2		3	6	6	3	5	4
3	5	6	4	5	6	6	4	6	2	2		3	6	6	4	6	6
4	6	4	3	4	4	4	4	6	4	5		3	5	4	3	5	4
4	6	4	4	4	5	5	3	6	2	2		3	6	6	4	6	4
2	3	2	4	4	4	4	3	6	1	2		3	6	6	4	5	4
2	5	2	1	4	3	5	4	6	5	2		3	5	6	3	5	4
3	5	4	2	3	3	4	3	6	2	5		3	6	6	3	6	4
3	3	3	2	3	3	6	5	6	3	2		3	5	6	3	4	3
5	5	4	2	3	3	4	5	6	2	6		4	6	6	4	5	3
2	5	3	3	4	4	4	5	6	5	2		4	5	6	4	5	4
3	3	2	1	2	2	4	5	6	4	5		2	4	4	4	5	4
3	3	3	3	3	3	4	4	6	1	5		2	3	4	3	4	4
3	6	2	3	3	3	5	5	6	5	2		2	3	4	4	4	4
2	3	2	1	1	1	5	5	5	6	6		2	3	4	4	4	2
4	3	5	4	5	6	5	5	5	4	4		4	6	6	6	6	6
4	3	5	4	5	6	5	5	5	2	2		4	6	6	6	6	6
3	2	5	3	3	4	5	5	6	2	5		4	6	6	5	6	5
4	5	3	1	1	2	5	5	6	1	2		3	6	6	4	6	4
4	5	3	2	3	2	5	4	6	4	5		4	6	6	4	5	3
2	5	3	4	5	6	5	4	6	5	5		4	6	6	4	6	5
3	5	3	1	1	2	5	5	6	2	2		4	6	6	3	5	2
4	4	5	3	5	6	5	5	6	6	6		4	6	6	4	5	6
2	3	3	2	3	3	5	5	6	4	4		3	5	6	4	4	3
2	3	3	1	1	1	5	4	6	5	6		2	5	6	4	4	3
TNO			Sir Robert McAlpine Ltd			BOLLORE logistics			Bancon Construction			4PL managemnt			EPC contractor		
logistics consultant			Regional Planner			General manager Airfreight the Netherlands			Project manager			MD			Construction Site Manager		
27			30			21			20			18			20		
The Hague, The Netherlands			Newcastle upon Tyne, UK			NL			UK, Aberdeenshire			Europe, France			Europe		

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43			44			45			46			47			48		
BA	MSc	EXP	BA	MSc	EXP	BA	MSc	EXP	BA	MSc	EXP	BA	MSc	EXP	BA	MSc	EXP
2			1			6	4	6	2	6	5	2			2	3	3
3			3			5	5	6	2	6	5	3			2	3	4
2			2			5	4	5	2	6	5	2			2	2	3
2			4			4	6	6	3	6	5	3			2	3	3
2			5			4	5	6	3	6	5	3			2	3	4
3			3			5	5	6	6	6	5	3			3	3	5
2			2			6	6	6	4	6	5	3			4	2	5
2			4			6		5	6	6	5	2			3	4	4
3			6			5	6	6	3	6	5	4			3	4	4
2			4			5	5	6	1	6	5	3			3	4	4
2			6			4	5	6	4	6	5	6			2	4	4
3			2			6	6	6	6	6	5	6			2	4	4
4			2			6	6	6	6	6	5	3			3	4	3
3			3			4	6	6	3	6	5	6			5	2	3
2			2			5	6	6	3	6	5	6			4	4	3
2			2			4	5	5	4	6	5	6			1	3	2
2			2			4	5	5	4	6	5	3			2	2	2
2			3			4	6	6	4	6	5	6			2	4	2
2			4			2	5	5	2	6	5	6			1	2	2
2			2			6	6	6	2	6	5	3			4	3	5
2			2			6	6	6	3	6	5	6			2	3	3
4			2			5	6	6	1	6	5	3			3	2	4
2			4			4	6	6	1	6	5	6			4	2	4
2			6			5	6	6	3	6	5	6			3	4	3
3			3			6	6	6	1	6	5	6			2	4	3
3			3			3	5	6	1	6	5	6			2	2	3
3			6			6	6	6	4	6	5	3			4	2	4
2			4			3	6	6	1	6	5	4			2	4	2
2			2			5	6	6	1	6	5	3			2	3	2
			Ardmore			Track works			NCC SVERIGE AB			Slokker Bouwgroep B.V			Vanhout.pro		
			Site manager			project management			Site Manager Logistics			Bim manager			BIM Engineer		
					12			15			5			20			3
			UK			Europe			Sweden			NL, Huizen			Turnhout, Belgium		

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49			50			51			52			53			54		
BA	MSc	EXP	BA	MSc	EXP	BA	MSc	EXP	BA	MSc	EXP	BA	MSc	EXP	BA	MSc	EXP
3			5	6	6	2	6	6	3	6	6	3	4	5	3	5	
			2	3	5	3	6	6	5	5	6	4	4	5	3		
2			3	5	6	6	6	4	4	3	2	4	4	6	2		
			4	4	5	4	4	6	5	6	6	4	3	6	3		
			2	4	5	6	5	6	5	5	6	4	3	6			
			4	4	5	2	5	5	3	5	6	3	3	6	2		
			6	5	6	4	6	6	6	5	6	3	4	5			
2			3	2	5	2	5	6	4	4	5	2	3	5	2		
			3	2	6	5	4	6	3	4	5	2	3	6	3		
2			5	3	4	5	5	6	3	3	5	2	3	5	3		
			2	5	6	2	6	4	2	3	5	2	3	6	2		
			3	5	4	3	6	6	3	5	6	3	4	5	3		
			1	3	5	3	6	6	3	5	6	2	4	6	3		
			2	4	4	4	5	6	5	5	6	2	4	6	3		
			2	4	5	2	5	5	5	6	6	2	4	6	3		
2			1	3	5	5	6	4	3	4	4	2	3	5	2		
			1	3	4	6	5	6	2	3	5	3	4	5	3		
			1	3	4	4	5	6	2	3	4	3	4	5	2		
2			1	3	5	2	6	4	1	3	3	2	3	5	2		
2			3	5	6	5	5	6	5	6	6	2	3	6	3		
			1	5	5	5	5	6	5	6	6	2	3	6	3		
			1	5	6	6	6	6	5	6	6	3	4	6	3		
			1	4	5	3	6	6	4	5	5	2	4	6	3		
			1	5	6	3	5	4	4	3	5	3	4	5			
2			3	5	6	4	5	4	3	3	6	2	3	5	2		
2			1	4	5	5	5	4	2	2	3	2	4	5	2		
			3	5	5	5	6	6	3	3	6	3	3	6	3		
			2	4	6	6	6	6	2	2	5	2	3	6	3		
2			2	4	6	5	6	6	2	3	6	2	3	6	3		
Solidu			Etro Vastgoedzorg			Strukton			Besix			Sweco					
owner			Procesmanager			Site manager			Project manager			Senior Consultant Overheadline Systems					
8			10			5			15			31					
Nijmegen, The Netherlands			NL			Denmark			Middle east			NL. De Bult					

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55		
BA	MSc	EXP
2	2	2
6	2	2
2	2	4
5	4	4
4	4	4
4	4	2
2	2	3
2	2	2
4	4	4
2	2	5
4	2	2
2	3	5
1	2	4
4	5	3
5	5	3
2	2	2
3	5	2
4	2	2
2	4	2
2	2	3
5	2	3
2	5	3
5	4	3
2	4	3
4	2	3
3	6	4
5	2	4
2		4
4	2	3
Parsons Brinckerhoff International Inc		
Logistics Engineer		
		14
Qatar		

Appendix 8. Industry respondents data filtration

The table 21 shows list of construction industry respondents that filled out online survey. The representatives are categorized horizontally by organization, position, geographical location, and years of experience and level of contribution. The table 21 identifies relevant and irrelevant respondents.

Table 21: Relevant respondents identification.

#	Organization	Position	Geografical location	Years of experience	Filtering out the respondents	Contribution		
						BA	MSc	Exp
1			NL	30		x	x	x
2			NL	35		x	x	x
3			NL	10		x	x	x
4			NL	50		x	x	x
5			NL	18		x	x	x
6			NL	20		x	x	x
7			NL	30		x	x	x
8			NL	11		x	x	x
9			NL	1	Irrelevant because respondent has less than 5 years of experience.			
10			SWISS	27		x	x	x
11			NL	28		x	x	x
12			SW	7		x	x	x
13			UK	14		x	x	x
14			HIND	20	Irrelevant because respondent is located outside of Western European zone.			
15			DK	25	Irrelevant because respondent does not work for construction industry.			
16			NL	30		x	x	x
17			EU	20		x	x	x
18			NL	28		x	x	x
19			DK	24		x	x	x
20			NL	25		x	x	x

21			DK	5		x	x	x
22			.-.	.-.	Irrelevant because respondent has not provide personal information.			
23			NL (UL Europe)	40		x	x	x
24			NL, RU	2	Irrelevant because respondent has less than 5 years of experience.			
25			NL	.-.		x	x	
26			NL	.-.		x	x	
27			NL	.-.		x	x	
28			NL	.-.		x	x	
29			.-.	.-.	Irrelevant because respondent has not provide personal information.			
30			NL	.-.		x	x	
31			NL	.-.		x	x	
32			NL	36	Irrelevant because respondent does not work for construction industry.			
33			UK	5		x	x	
34			UK	32		x		
35			.-.	.-.	Irrelevant because respondent has not provide personal information.			
36			UK	35		x	x	x
37			NL	27		x	x	x
38			UK	30		x	x	x
39			NL	21		x	x	x
40			UK	20		x	x	
41			FR, EU	18		x	x	x
42			EU	20		x	x	x

43			.-.	.-.	Irrelevant because respondent has not provide personal information.			
44			UK	12		x		
45			EU	15	Irrelevant because respondent does not work for construction industry.			
46			SW	5		x	x	x
47			NL	20		x		
48			BEL	3	Irrelevant because respondent has less than 5 years of experience.			
49			NL	8		x		
50			NL	10		x	x	x
51			DK	5		x	x	x
52			Middle East	15	Irrelevant because respondent is located outside of Western European zone.			
53			NL	31		x	x	x
54			.-.	.-.	Irrelevant because respondent has not provide personal information.			
55			Qatar	14	Irrelevant because respondent is located outside of Western European zone.			
	41 (Relevant respondents)				14 (Irrelevant respondents)	41	37	29

Appendix 9. Universities webpages and syllabus

Color code:
… potential topic
… potential cognitive level according to Bloom's taxonomy

AF1723 - BUILDING LOGISTICS AND RISK MANAGEMENT 5.0 CREDITS

Intended learning outcomes:

The student shall have:

knowledge of the building supply chain, capacity, planning and schedules
Knowledge of how different delivery service solutions support efficient production
knowledge of risks, different likelihood of risks and its impact on efficient production
knowledge of its own role in the possibilities and risks of affecting the total cost
Knowledge of how different logistics tools can be used in planning, work environment and purchasing
knowledge to be able to describe and apply to the basic construction concepts, models, tools and working methods of the construction industry industry to observe, map and describe a logistics system at a general level

knowledge to be able to compile and communicate a simpler mapping of a specific logistics system in the construction industry and how this interacts with the profitability of the material supplier and in later stages profitability in operation and maintenance

Knowledge in being able to evaluate and compare several different action options with respect to the risk of changing a specific logistics system, and to motivate and recommend one or more options

Intended learning outcomes:

Course main content:

Eligibility:

Literature:

Modern logistik - för ökad lönsamhet av Björn Oskarsson, Håkan Aronsson och Bengt Ekdahl, Liber förlag, senaste utgåvan

Examination:

PRO1 - Project Assignment, 1.0, grade scale: A, B, C, D, E, FX, F

TEN1 - Examination, 4.0, grade scale: A, B, C, D, E, FX, F

AI2805 - BUILDING INFORMATICS AND LOGISTICS 7.5 CREDITS

Intended learning outcomes

The aim of the course is to extend the students knowledge about IT from a organizational and strategic business perspective.

After the course the students should:

a) Be able to describe and analyse the information handling in the design and construction process.
b) Be oriented in the field of classification, information systematics and information standards in design and construction.
c) Be familiar with common industrial IT-platforms for information sharing and delivery.
d) Be able to prepare an IT-strategy for a company and a project.
e) Be aware of different principles to organize and manage the information exchange in the design and construction process.
f) Be famliar with IT-based project management.
g) Be conscious about the relation between the implementation of information technology and the changeover of working methods, roles of different actors and the built results.

Course main content"

IT-strategies, organization and management in companies and projects. Information systems in the real estate and construction sector. Conceptual modeling and classification. Process and product modeling, building information modeling, simulation and visualization. Information standards. IT-integrated architecture, construction and facility management. Common industrial IT-platform. Computer supported cooperative work. Project communication, project networks, document management. Mobility.

Eligibility:

Eligibility to the master programme in Real Estate and Construction Management.

Literature:

Information about course literature will be announced at the beginning of the course.

Examination:

SEM1 - Seminars, 2.5, grade scale: P, F

TEN1 - Examination, 5.0, grade scale: A, B, C, D, E, FX, F

MO9409 - OPERATIONS AND INTEGRATED SUPPLY CHAIN AND MARKETING MANAGEMENT

What will I learn on this module?

This module intends to provide you with managerial and operational issues in business context. The module has a three dimensional approach towards business processes in which the operations, supply chain and marketing management principles, key strategies and issues will be underpinned with the element of considering the cross- functionality and integration of these business processes. Therefore, within this module, you will learn different topics under two clusters in your lectures and seminars. There are main topics under Operations and Supply Chain Management and also the Marketing Management as below:

Topics with the possibility of integration and interface approach between two clusters in their nature

Operations and Supply Chain management:
Introduction to Operations and Supply Chain Strategies
Operations Sustainability*
Quality Management*
Lean Management
Performance Measurement*
Operations Planning
Supply Network Management*
Supplier Development and Purchasing
Supply Chain Risk Management*
Logistics Management*
Sustainable Supply Chain management*
Capacity and Demand Management*

Marketing Management:
Marketing introduction: B2C verses B2B*
Market Environment Business-to-Business Environment: Customers, Organizations, and Markets*
Market Segmentation and segmentation strategies
Market Research
Product: Product Strategy, Product Positioning, Branding, and Product Line Strategies*
Developing the Product, Service, and Value of The Offering*
Price: Value-Based Pricing and Pricing Strategies
Place: Marketing Channels and Channel Mapping*
Promotion: Communicating with the Market
Promotion: Business-to-Business Selling*
Customer satisfaction and customer loyalty*

The module will lead you to understand and demonstrate the necessary theories, strategies and principles of operations, supply chain and marketing management in an integrated style to solve any business problem associated to these processes. The module will facilitate you with theoretical and practical understanding and knowledge to be able to demonstrate your real world problem solving skills in this module and also your experiential learning or business practice module.

On completing this module, you will be able to demonstrate knowledge and understanding of an integrated supply, demand and marketing managerial and operational issues and strategies alongside tools and techniques to solve issues in a business context with any size and in any sector.

How will I learn on this module?

This module encourages you to develop your practical integrated and cross-functional view of operations, supply chain and marketing management in order to solve business problems in the real world. Delivery consists of lectures and seminars to encourage your learning of theoretical and practical strategies, and skills, in an integrated operation, supply chain, and marketing management context. It will demonstrate how core elements of business interact and are dependent upon on each other in order to fulfil the purpose and objectives of a business.

This will be achieved through a series of linked lectures encompassing the primary functions of the business set out in three key business processes relating to the formation of a business strategy. The lectures will explore the complex interactions between these primary elements and in doing so reflect the dynamic nature of operations, supply chain and marketing. The seminars promote interactive learning relevant to these three business management elements through individual case study analysis, team-based discussion and guided seminar activities. It is intended to develop theoretical, practical and personal skills useful for your study as well as operational and leadership skills. In addition to business-related skills and strategies, you also have opportunity for personal development and problem solving skills such as team working, presentations, task delegation, academic writing and information searching skills during seminars and as part of independent study.

The design of this module will encourage your development as an independent learner, enabling you to explore issues arising and make extensive use of the available information technology. You will have opportunity to work on a case study to identify a series of relevant business issues and challenges and their interface and integration; and to utilise problem solving strategies or tools to address the issues.

How will I be supported academically on this module?

Support will be provided to you by the member of academic staff leading the module and providing the lecture input, alongside other academic staff members. The use of a teaching team allows that subject specialist staff will deliver lectures in their own area of expertise.

The seminar sessions will be delivered to groups of up to 20 students and will be facilitated by a group of academic staff who can offer support and guidance.
Your module is also supported by an e-learning portal, which accommodates lecture materials, seminar instructions, supportive learning resources, alongside assessment details and various support facilities such as electronic reading list comprising your recommended to purchase and to read book(s), academic reports, conference papers and journal articles that are relevant to principles of operations, supply chain and marketing management.

The module summative assessment consists of two major components that will be distributed at the beginning of the semester and supported throughout. You will be receiving extensive support for your assessment including the assessment brief, marking criteria, marking guide, assignment examples alongside on-line and face-to-face communication by the module leader and the teaching team.

What will I be expected to read on this module?

All modules at Northumbria include a range of reading materials that students are expected to engage with. The reading list for this module can be found at: http://readinglists.northumbria.ac.uk (Reading List service online guide for academic staff this containing contact details for the Reading List team – http://library.northumbria.ac.uk/readinglists)

What will I be expected to achieve?

Knowledge & Understanding:

1) Demonstrate knowledge and understanding of the managerial and operational issues in a business context (MLO1)

2) Demonstrate the knowledge and understanding of an integrated approach of supply and demand management and practical problem solving (MLO2)

Intellectual / Professional skills & abilities:

3) Problem solving skills in global business context associated with different operational and marketing strategies with the support of research, teamwork and presentation skills (MLO3)

Personal Values Attributes (Global / Cultural awareness, Ethics, Curiosity) (PVA):

4) Ethical and social awareness in global operations, supply chain and marketing environment (MLO4)

How will I be assessed?

Summative Assessment: 1) 80% single individual assignment referring to the theory (lecture material, books, journal articles…) and practice (a case study, which is analysed in seminars). Assignment will be in the form of academic essay answering two separate tasks. One task represents the Operations and Supply Chain Management, while the other task represents Marketing Management. You will be expected to identify the inter-relationship between two subjects.
2) 20% individual poster presentation developed prior to each seminar in the hardcopy format and delivered in both digital and hardcopy formats at the end of the semester. There are certain cells in a pre-structured format refer to each seminar task to be signed off by the seminar tutor on the actual hardcopy format to promote full attendance and participation. The non - signed cells on hardcopy formats must be left blank on digital format.
Both summative assessments assess MLO1, MLO2, MLO3 and MLO4.

Formative Assessment: It will take place through group work, discussions and reflection, discussion board activity on the e-learning platform, case study activity, group – based oral presentation, and theory/ practice related discussions.

MO0487 - STRATEGIC PROCUREMENT AND LOGISTICS

What will I learn on this module?

This module aims to provide you with an appreciation of the synergy between strategic procurement and logistics management. The focus is given to processes that add value through the production and delivery of services and products in the supply chain, and the tools needed to manage these processes effectively. Furthermore, you will be given a comprehensive understanding of modern approaches to strategic procurement and logistics management throughout the supply chain. On completion of the module you will be able to critically analyse the approaches to managing procurement and logistics management used by a variety of product and service organizations operating in a global business environment.

The content of the module comprises a number of key parts which are listed below.
Introduction to purchasing and SCM
The purchasing process
Supplier quality management
Supplier evaluation and selection
Negotiation and Contract management / incoterms
Supplier management and development - creating a world-class supply base
Worldwide sourcing
Introduction to ERP systems
Information technology benefits evaluation
Knowledge management in supply chains
Innovation management in supply chains
Outsourcing/ re-shoring management
Power in supply chains
Change management in supply chains

Scope of Materials Management and Logistics
The effects of ROI and Profits
Customer Service
Purchasing - the 5 'rights'-Partnership Sourcing (I)
Purchasing - the 5 'rights'-Partnership Sourcing (II)
Inventory Management Strategy
Inventory Management MRP
Inventory Management ERP
Channel and Network Strategy
Materials Handling and Storage (I)
Materials Handling and Storage (II)
Information Technology in Logistics

How will I learn on this module?

Critical reflection on knowledge, experience and practice underpins the learning and teaching philosophy along with the explicit development of competence. This is key to your learning on the module. To put this in place, the module will be taught by lectures and seminars covering the key issues in strategic procurement and logistics.

The module is supported by a teaching and learning plan, which outlines the formal sessions, together

with the tutor-directed study and independent reading. An interactive approach to lecture sessions will draw upon the directed learning undertaken and your own experiences. Throughout, the emphasis will be on high levels of your participation, both individually and within small groups or teams. You can therefore expect the reflective-practitioner approach to learning to be embedded in all seminar sessions through undertaking activities which facilitate you to apply theory to 'real-life' situations, critically analysing and making recommendations for appropriate ways forward for the supply chain/organization/individual.

Directed learning will centre upon a range of activities including pre-reading, preparation for interactive activities and use of the discussion board on the e-learning platform. Independent learning will centre upon you identifying and pursuing areas of interest in relation to the subject area or by providing deeper/broader knowledge and understanding of the subject through a range of learning activities that might include extended reading, reflection, research etc.

How will I be supported academically on this module?

The module is supported by a teaching and learning plan which outlines the formal sessions, together with the tutor-directed study and independent reading. An interactive approach to lecture sessions will draw upon the directed learning undertaken and your own experiences. Throughout, the emphasis will be on high levels of participation, both individually and within small groups or teams. You can therefore expect the reflective-practitioner approach to learning to be embedded in all workshop/seminar sessions through undertaking activities which facilitate you to apply theory to 'real-life' situations, critically analysing and making recommendations for appropriate ways forward for the organization/individual.

Directed learning will centre upon a range of activities including pre-reading, preparation for interactive activities and use of the discussion board on the e-learning platform.

Independent learning will centre upon you identifying and pursuing areas of interest in relation to the subject area or by providing deeper/broader knowledge and understanding of the subject through a range of learning activities that might include extended reading, reflection, research etc.

Critical reflection on knowledge, experience and practice underpins the learning and teaching philosophy along with the explicit development of competence.

Technology Enabled Learning (e.g., the use of the e-learning portal) and Research Rich Learning (e.g., you will do research as part of your seminar preparation and your assessment) will be used.

What will I be expected to read on this module?

All modules at Northumbria include a range of reading materials that students are expected to engage with. The reading list for this module can be found at: http://readinglists.northumbria.ac.uk (Reading List service online guide for academic staff this containing contact details for the Reading List team – http://library.northumbria.ac.uk/readinglists)

What will I be expected to achieve?

Knowledge & Understanding:

• Understand and critically evaluate the wider impact of individual or organisational decision making on strategic procurement and logistics management contexts. [MLO1]

• Acquire, interpret and critically apply knowledge of strategic procurement and logistics management. [MLO2]

Intellectual / Professional skills & abilities:

Personal Values Attributes (Global / Cultural awareness, Ethics, Curiosity) (PVA):

How will I be assessed?

The module will be assessed by one individual exam and by one individual assignment.

Individual Exam (25%)
You will be asked to answer a number of essay type questions, which can be case study related and are based on the lecture and seminar content of the module.

This will assess MLO1 and MLO2.

Individual Assignment (75%)
Individual assignment: (3,600 words, 75% weighting): a critical evaluation of various strategic procurement and logistics management aspects in relation to practical organisational settings.

This will assess MLO1 and MLO2.

34390 - LOGISTICS ENGINEERING

During the four-year Logistics Engineering program, you will analyze, improve, plan and (re) design logistics processes in companies and organizations. Whether it's goods, information, people or money.

In the first year you will get a general introduction in logistics. How do I produce what the customer wants? How do I distribute what the customer wants to the desired location? And how do I purchase to get what the customer wants? Areas that are concerned include:

Marketing, Distribution Logistics, Production Logistics and Purchasing Logistics. In addition, you also get Mathematics, Management Skills, ICT, English, Business and Serious Gaming.

Approximately one third of education is offered in project form. You will soon get to know the practice through practical assignments in projects and company visits. In the second year, you will deepen your knowledge in logistics. Among other things, you are involved in setting up

Warehouses, distribution of goods, tracking and tracing and sustainable logistics.

You will also go abroad for a trip abroad. In the third year you will graduate and follow a minor. For example, you can participate in the Logistics research program, focusing on Airport Seaport Logistics or City Logistics. In the fourth year you will complete the last major subjects and complete the studies with a graduation assignment within a company. For ambitious students who want extra challenge, there is an additional education program.

This program offers students 25 contact hours per week in the first year of study. A study year contains 42 lesson weeks. A contact hour is an education (50 minutes) with a teacher present.

You can get started in numerous professions that plant and monitor logistics flows and optimizes inventory management, production and transportation. As a logistics engineer, you carry out process analyzes of logistics processes, work on innovations, put together teams and send people.

Diploma havo, vwo, mbo-4 or a similar foreign diploma. Additional requirements appear in the admission schedule.

Write your appearance on May 1st via Studielink. For this you need a DigiD. The application and acquisition of a DigiD takes about 5 working days. After registration, it is compulsory to participate in a study selection check. You will be invited by the program and will receive a study selection recommendation.

The customer is becoming increasingly demanding. Not only in terms of product quality and price, but also in terms of product availability and service. Thoughtful logistics keeps the business world sharp: logistics makes true what is promised in marketing.

The training is strongly linked to research in Smart Mobility and Logistics. Within the Urban Technology research program, you can co-operate with research assignments in the field of Airport Seaport Logistics and City Logistics under the guidance of a lecturer and logistical researchers. The research is being applied within the course of education. In this way you learn to do applied research, and you can apply it later in the company where you are going to work. This experience is therefore well placed on your CV

in the first block of the first year, you will be familiar with different aspects of logistics and the market and its versatility. A lot of attention is paid to computational skills. You also get Dutch and English.

In the second block you get more insight into the various aspects of physical distribution. You will learn more about the organization and its environment and further explore Dutch and English.

In the third block, you will learn how to plan, manage, and manage logistic processes, especially enterprise-based processes. You will learn how to manage stocks and how to respond to the customer's needs as cost-effective as possible. The environment in which you work as a logistic job changes quickly and therefore you learn more about value creation and gain insight into the associated costs. At the end of this block, you know how to handle data (analysis and reporting) and give a presentation about a logistic subject.

In the fourth block you will learn how to make strategic purchasing decisions a sustainable economy. In addition, the topic of process improvement is addressed. During their internship and graduation period, many students are busy with the question of how the logistics operation can be improved. How do you reduce the number of errors as a business, shorten your lead time or improve your delivery reliability? And what else can you do as an organization to keep the customer happy? Various process improvement methods and techniques are central, you are familiar with research methods and techniques and apply this knowledge in a process improvement process.

In a rapidly changing world, organizations must constantly adapt to the environment. They need to develop new processes and products, provide the necessary information and reduce risks. Organizations, people as well as complete supply chains must therefore be both flexible and viable.

The first block of the second year gives you more insight into the various aspects of supply chain management and information provision. You will learn how to formulate a supply chain strategy with a clear link to the supply chain design and process planning and management. In addition, the supply of information of all links in the supply chain is discussed in detail.

In the second block the design of logistics processes is central. You will learn how to make interior choices that meet the requirements and wishes of different stakeholders and how to match those choices to the changing environment. You explore in quantitative models that help to make the effects of different choices insightful.

In the third block you get insight into the impact of general economic developments on international transactions and goods movements. You apply your previously acquired knowledge of quantitative methods in simulation and optimization models.

The fourth block focuses on value creation and learning innovation. How do you move yourself and others in motion? You are investigating an external client who has to contribute to the value added of this party.

In the third year you will follow a minor, a six-year elective program. You can choose a specialization within or outside your own field of study. Look at Minors for more information about minors. The second part of the third year is your internship.

In the fourth year you will learn more about the strategy in logistics. For example, do you choose a company for production in the Netherlands or China? What are the reasons you make for this?

Technical innovation plays a major role in logistics. For example, a special lorry can ensure that fruit stays longer lasting, which makes the transport more flexible. A great deal of attention is paid to this subject within the fourth year.

The second part of the fourth year, you will independently conduct an examination at a graduation company and write a thesis on this.

195810200 SUPPLY CHAIN MANAGEMENT & ICT

Background and context:

Starting point of this course are supply chain management (SCM) and purchasing concepts and methodologies supporting a controlled and predictable building process.

Course content:

The focus is on the opportunities for the application of supply chain and purchasing management concepts from other industries to construction for the improvement of construction supply chain management and materials transport and distribution between manufacturers and construction sites. Basic similarities and differences between supply chains in the construction industry and supply chains in manufacturing industries are analysed. The focus is on supply chain and purchasing management issues in the relation between construction firms and their suppliers. Attention will be devoted to the role of building information modeling in improving construction supply chain management.

Topics of the course are:

- supply chain and purchasing management in construction;

- Lean production and physical distribution in construction;

- Alliancing and construction supply chains;

- suppliers' maturity in using building information models;

- benchmarking of construction supply chains.

Learning goals:

- analysing preconditions for the application of supply chain management and purchasing concepts from other industries into the construction supply chain;

- creating, elaborating and choosing solutions for supply chain and purchasing management problems in a structured way;

- obtaining insights in the role of building information modeling (BIM) in integrating the different stages of the construction supply chain.

- evaluate existing practice of supply chain management and purchasing

Assessment:

- Individual theory test on the literature on supply chain and purchasing management and topics discussed during the four literature/theory lectures (50%)
- Research project on supply chain and purchasing management in the construction practice (group work) (50%)

To pass this course you need to obtain at least a 5,5 on both parts (requirement of the Onderwijs- en ExamenReglement (OER)).In the individual written test on September 26, the literature discussed during the four lectures will be examined by a test consisting of four questions. ONLY the subjects discussed during the four theory lectures are part of this individual the.

Appendix 10. In-depth interviews results and data triangulation

Candidates No: 2.1, 2.2 and 2.3

University: Twente

Course name: 195810200 Supply Chain Management & ICT (MSc)

Table 22: Expected educational level for (C) course and for included topics.

Country: The Netherlands						
University: University of Twente						
Master's course: 195810200 Supply Chain Management & ICT (C)						
Topics evaluation						
Comprehensive framework		Triangulation	Candidate No: 2.1	Candidate No: 2.2	Candidate No: 2.3	Data obtained from the university's web page and syllabus
(1) Planning	1.1 Systems perspective/overview	The cognitive level defined by candidate No: 2.1 was radically low and because of that it was excluded as a non-reliable data. However, data derived from university web page and candidate No: 2.3 was matching. Besides, evaluation level from candidate No: 2.2 was also standing very close to them. Therefore, as a final cognitive level for this particular topic is recognized **4 (analyzing).**	2	3	4	The systems approach is one of the four main theoretical topics of the course, it contains theories about *'lean production and physical distribution in construction (UT blackboard, 2015a)'*. Also, it teaches different combinations of lean and agile supplies; types of postponements and supply chains (Voordijk, 2015a). Course allows students to see different parts of supply chain separately and put them together. However, course do not provides practical assignments that would make students '*able to create solutions for supply chain problems in a structured way (UT blackboard, 2015b)*'. Given those, expected educational level for this particular topic is 4 (analyzing).
	1.2 Enterprise Resource Planning	This topic was not mentioned by any of interview candidates, therefore information derived from web page was recognized as most of reliable and as an expected educational level defined **4 (analyzing).**	-	-	-	The course includes *'analysis of success or failure of Enterprise Resource Planning - implementation in construction (*Voordijk, 2015b*).'* it emphasize current role of the Enterprise Resource Planning (ERP) systems for integrated management of data, cost control and workflow management. After course students will have a knowledge about weak and strong sides of ERP systems, and strategies of its implementation into organizational structure or purpose. Given those, expected educational level for this particular topic is 4 (analyzing).

	1.3 BIM-based planning	The cognitive level defined from candidate No: 2.2 and university web page are 4. However candidates No: 2.1 and 2.3 evaluated given topic at level 6, which is radically high and therefore cannot be reliable. As most of reliable evaluation for this topic was recognized **4 (analyzing)**. Because, data provided from candidate no: 2.2 and university's web page are in compliance with each other.	6	4	6	BIM is one of the important part of a benchmark approach that is provided within this course. The students *'obtaining insights in the role of building information modelling in integrating the different stages of the construction supply chain (UT blackboard, 2015b).'*After course students are getting clear understanding that BIM *'becomes important for the future strategy of construction firms (Voordijk, 2015b).*' In addition, course includes one group assignment where students are analyzing use of BIM in construction logistics and supply chain. Given those, expected educational level for this particular topic is 4 (analyzing).
	1.4 Demand forecasting	This topic was not mentioned by any of interview candidates, therefore information derived from university web page are most of reliable and as an expected educational level recognized **4 (analyzing).**	-	-	-	This course includes portfolio management that provides knowledge about *'optimal situation when characteristics of the product match with characteristics of the supply chain (Voordijk, 2015c).'* In other words it allows students to analyze and choose right supply chain design according to product type in order to catch the customers' voice. This means that students can break materials or processes into parts, determine how the parts relate to an overall processes in order to predict the future. Given those, expected educational level for this particular topic is 4 (analyzing).
	1.5 Return planning	-	-	-	-	Excluded
	1.6 Procurement	Candidates No: 2.1, 2.2 and university web page defined for this topic level 4. The candidate No: 2.3 defined for this topic level 5 that is higher but stands close to the previous evaluations. Decision of majority was recognized as a most of reliable evaluation for this topic, which is level **4 (analyzing).**	4	4	5	The governance approach is one of the four main theoretical topics of the course, it contains theories about *'innovative procurement contracts (Voordijk, 2015d).' Also, it teaches 'alliancing and construction supply chains (UT blackboard, 2015a).'* It provides students weak and strong sides of different contracts in order to *'analyze preconditions for the application of supply chain management and purchasing concepts from other industries into the construction supply chain (UT blackboard, 2015b).'* Given those, expected educational level for this particular topic is 4 (analyzing).
	1.7 Construction site layout planning	-	-	-	-	Excluded

	1.8 Inner city deliveries	Candidate No: 2.1 evaluated this topic at level 6, which is a highest level in cognitive dimensions. However, university web page defined for this topic level 2, which is quite low level. Those two source of information are very radical and therefore they can be excluded. Candidates No: 2.2 and 2.3 are standing quite close with theirs evaluation by levels 3 and 4. Because of that they were recognized as most of reliable evaluation for this topic and final level was accepted as **4 (analyzing).**	6	3	4	The physical distribution of materials are part of the systems approach. Course gives knowledge about *'lean production and physical distribution in construction (UT blackboard, 2015a).'* It provides knowledge about *'Elements of the logistical system […] and trade-offs between the elements (Voordijk, 2015a).'* In addition, course provides two main of distribution strategies, however it gives student only theoretical understanding of main concept of deliveries. Therefore, expected educational level for this particular topic is 2 (understanding).
	1.9 Delivery strategies	Candidate No: 2.1 gave radical high evaluation for this topic, which is 6 and because of that is was excluded. However, evaluation levels from candidate No: 2.2, and university web page matched, with level 3. Besides candidate No: 2.3 evaluation was also quite close to them by level 4. Final decision was made based on majority and given topic was evaluated at level **3(applying).**	6	3	4	Delivery strategies are provided as one of the elements of SPITS model such as: Sourcing, Production, Inventory, Transportation, and Service (Voordijk, 2015a). Given information was part of board game and therefore students are able to carry out or use a procedure through execution or implementation. Given those, expected educational level for this particular topic is 3 (applying).
	1.10 Routing and scheduling techniques	-	-	-	-	Excluded
	1.11 Circular business models	-	-	-	-	Excluded
	1.12 Site waste management	-	-	-	-	Excluded
(2) Implementation	2.1 Total quality management	This topic was not mentioned by any of interview candidates, therefore, information derived from web page are most of reliable and as an expected educational level recognized **5 (evaluating).**	-	-	-	The course includes systems approach, which considers also long-term benefits from continues improvement to supply chain strategy, products and relations with customers (Voordijk, 2015a). This allows students to make judgments based on criteria and standards through critiquing and *'evaluating existing practice of supply chain management in construction (UT blackboard, 2015a).'* Given those, expected educational level for this particular topic is 5 (evaluating).
	2.2 Supplier relationship management	Candidates No: 2.1, 2.2 and 2.3 evaluated this topic at level 2. However, university web page defined for this topic level **6 (creating)**, which is radically high but it is recognized as a final level for this topic, because given course covers all	2	2	2	Supplier relationship management is one of the key aspects of supply chain management course it is mentioned in governance approach as well as in an introduction part (Voordijk, 2015c, d). Students are getting detailed knowledge about different models of relationship and forms of governance. *'The focus is on supply chain and purchasing*

		aspects of supplier relationship management.				*management issues in the relation between construction firms and their suppliers (UT blackboard, 2015a).'* The course allows students to create solutions for purchasing management problems in a structured way (UT blackboard, 2015b). Given those, expected educational level for particular topic is 6 (creating).
	2.3 Risk management in supply chains	-	-	-	-	Excluded
	2.4 Sensoring technologies	-	-	-	-	Excluded
	2.5 Transport regulations	-	-	-	-	Excluded
	2.6 Transport modes and intermodality	-	-	-	-	Excluded
	2.7 Robotization and automation	-	-	-	-	Excluded
	2.8 Construction sequences	This topic was not mentioned by any of interview candidates, therefore information derived from web page are most of reliable and as an expected educational level recognized **1 (remembering).**	-	-	-	This course included simulation, board game where students came across with construction sequences. However, it was far away from reality and therefore expected educational level acquired by the students can be scaled as 1 (remembering).
	2.9 Deconstruction sequences	-	-	-	-	Excluded
	2.10 Site-specific safety management	-	-	-	-	Excluded
(3) Control	3.1 Physical distribution cost	Candidate No: 2.1 and university web page defined for this topic level 6 and level 2, which are radicaly different and therefore they were excluded, as non reliable data. The candidates No: 2.2 and 2.3 defined levels 3 and 4, which are standing quite close to each other and because of that final evaluation level was recognized **4 (analyzing).**	6	3	4	The physical distribution cost is part of the systems approach. Course provides information about physical distribution cost modeling, model inputs with examples. However, given information is not part of practical assignment and therefore, students know about given functions by interpretation or explanation. Given those, expected educational level for this particular topic is 2 (understanding).
	3.2 Materials flow control methods	This topic was not mentioned by any of interview candidates, therefore information derived from web page are most of reliable and as an expected educational level recognized **4 (analyzing).**	-	-	-	The materials flow control methods are discussed in a governance approach and in a benchmark approach. The control over innovative procurement contract and knowledge of different clock speed can effect coordination of supply chain (Voordijk, 2015 b, d). Course allows students to break procurement processes into parts, and determine how the parts relate to an overall process. Given those, expected educational level for this particular topic is 4 (analyzing).
	3.3 Progress monitoring	-	-	-	-	Excluded
	3.4 Tracking technologies	-	-	-	-	Excluded
	3.5 Site storage space management	-	-	-	-	Excluded

	3.6 End-of-life-cycle scenarios	-	-	-	-	Excluded
	3.7 Asset information models	-	-	-	-	Excluded
Course evaluation						
Percentage amount of included topics: 42 %						

Candidate No:2.4

University: Royal Institute of Technology (SW)

Course name: AF1723 - Building Logistics and Risk Management (BA)

Table 23: Expected educational level for (E) course and for included topics.

Country: Sweden				
University: Royal Institute of Technology (KTH)				
Bachelor's course: AF1723 Building Logistics and Risk Management (E)				
Topics evaluation				
Comprehensive framework		Triangulation	Candidate No: 2.4	Data obtained from the university's web page and syllabus
(1) Planning	1.1 Systems perspective / overview	The both sources of information Candidate No: 2.4 and university web page defines for this topic level **3 (applying)**.	3	This course provides knowledge about basic concepts for describing logistics systems. Students will '*be able to describe and apply to the basic construction concepts, models, and tools and working methods of the construction industry to observe, map and describe a logistics system at a general level (Syllabus BA, 2017).'* Given those, expected educational level for this particular topic is 3 (applying).
	1.2 Enterprise Resource Planning	-	-	Excluded
	1.3 BIM-based planning	-	-	Excluded
	1.4 Demand forecasting	A candidate No: 2.4 defines for this topic level 2, which is radically low and therefore cannot be recognized as reliable. However, university web page defines level **4 (analyzing)**, which seems more realistic and therefore it was recognized as final evaluation level for this topic.	2	This course provides knowledge to formulate the conditions for efficient logistics through mapping and analysis of production projects. Students will *'be able to compile and communicate a simpler mapping of a specific logistics system in the construction industry and how this interacts with the profitability of the material supplier and in later stages profitability in operation and maintenance (Syllabus BA, 2017).'* Given those, expected educational level for this particular topic is 4 (analyzing).
	1.5 Return planning	-	-	Excluded
	1.6 Procurement	-	-	Excluded
	1.7 Construction site layout planning	-	-	Excluded
	1.8 Inner city deliveries	-	-	Excluded
	1.9 Delivery strategies	-	-	Excluded

	1.10 Routing and scheduling techniques	-	-	Excluded
	1.11 Circular business models	-	-	Excluded
	1.12 Site waste management	-	-	Excluded
(2) Implementation	2.1 Total quality management	-	-	Excluded
	2.2 Supplier relationship management	-	-	Excluded
	2.3 Risk management in supply chains	A candidate No: 2.4 evaluated topic at level 3. However, university webpage defined for this topic level 5. Both evaluation seems reliable and therefore as a final level was recognized average value **4 (analyzing)**.	3	This course provides knowledge to formulate and evaluate profitability and risks with different logistical action options. Students will *'be able to evaluate and compare several different action options with respect to the risk of changing a specific logistics system, and to motivate and recommend one or more options (Syllabus BA, 2017).'*Given those, expected educational level for this particular topic is 5 (evaluating).
	2.4 Sensoring technologies	-	-	Excluded
	2.5 Transport regulations	-	-	Excluded
	2.6 Transport modes and intermodality	-	-	Excluded
	2.7 Robotization and automation	-	-	Excluded
	2.8 Construction sequences	-	-	Excluded
	2.9 Deconstruction sequences	-	-	Excluded
	2.10 Site-specific safety management	-	-	Excluded
(3) Control	3.1 Physical distribution cost	The both sources of information Candidate No: 2.4 and university web page defines for this topic level **3 (applying)**.	3	This course provides knowledge about total costs. After graduation students will *'have a knowledge of its own role in the possibilities and risks of affecting the total cost […] how different logistics tools can be used in planning, work environment and purchasing (Syllabus BA, 2017).'* Given those, expected educational level for this particular topic is 3 (applying).
	3.2 Materials flow control methods	The both sources of information Candidate No: 2.4 and university web page stands very close with evaluation of this topic and therefore as a final value for this topic was recognized information derived from web page by level **3 (applying)**.	4	This course provides knowledge about building supply chain. After graduation students will '*have a knowledge of the building supply chain, capacity, planning and schedules […] how different delivery service solutions support efficient production (Syllabus BA, 2017).'* Given those, expected educational level for this particular topic is 3 (applying).
	3.3 Progress monitoring	-	-	Excluded
	3.4 Tracking technologies	-	-	Excluded
	3.5 Site storage space management	-	-	Excluded

	3.6 End-of-life-cycle scenarios	-	-	Excluded
	3.7 Asset information models	-	-	Excluded
Course evaluation				
Percentage amount of included topics: 17 %				

Candidates No: 2.5, 2.6, and 2.7

University: Amsterdam University applied science (NL)

Course name: 34390 - Logistics Engineering (BA)

Table 24: Expected educational level for (F) course and for included topics.

Country: The Netherlands						
University: Amsterdam University of Applied Sciences (AUAS)						
Bachelor's course: 34390 Logistics Engineering (F)						
Topics evaluation						
Comprehensive framework		Triangulation	Candidate No: 2.5	Candidate No: 2.6	Candidate No: 2.7	Data obtained from the university's web page and syllabus
(1) Planning	1.1 Systems perspective/overview	Candidate No: 2.7 evaluated this topic at level 4. However, other candidates No: 2.5, 2.6 and university web page did not provide any information about that. Due to fact that AUAS has a good reputation in the researches of city logistics the data provided by candidate No: 2.7 is recognized reliable, and the final evaluation level for this topic was decided to be **4 (analyzing).**	-	-	4	-
	1.2 Enterprise Resource Planning	Candidate No: 2.7 evaluated this topic at level 4. However, other candidates No: 2.5, 2.6 and university web page did not provide any information about that. Due to fact that AUAS has a good reputation in the researches of city logistics the data provided by candidate No: 2.7 is recognized reliable, and the final evaluation level for this topic was decided to be **4 (analyzing).**	-	-	4	-
	1.3 BIM-based planning	-	-	-	-	Excluded
	1.4 Demand forecasting	Candidate No: 2.5 and 2.7 gave a radically different evaluation for this topic 1 and 6, which cannot be reliable. However, evaluation from candidate No: 2.6 and university web page are standing quite close with each other 3 and 4, therefore it was recognized as a reliable data, and final evaluation level was decided to be **4 (analyzing)**.	1	4	6	In this course demand forecasting is presented as a marketing concept. Generally it teaches how to find out customers' needs, and how logistics should be organized in order to meet customers' requirements (Introduction, 2017). In the first block students becoming familiar with different aspects of logistics and markets' versatility (Year I, 2017). Students are involved in the applied research under guidance of a lecturer and logistical

						researchers, which means that students can carry out a procedures through execution or implementation. Given those, expected educational level for this particular topic is 3 (applying).
	1.5 Return planning	Candidate No: 2.7 evaluated this topic at level 4. However, other candidates No: 2.5, 2.6 and university web page did not provide any information about that. Due to fact that AUAS has a good reputation in the researches of city logistics the data provided by candidate No: 2.7 is recognized reliable, and the final evaluation level for this topic was decided to be **4 (analyzing).**	-	-	4	-
	1.6 Procurement	Due to fact that evaluation levels provided by all sources are standing very close to each other as a final level for this topic was decided to be **4 (analyzing).**	3	4	3	In this course procurement is presented as a Production Logistics and Purchasing Logistics. In the fourth block students will learn how to make strategic purchasing decisions a sustainable economy (Year I, 2017). Approximately one third of education is offered in project form, students are doing practical assignments where analyzing logistics processes in companies and organizations (Introduction, 2017). Given those, expected educational level for this particular topic is 4 (analyzing).
	1.7 Construction site layout planning	-	-	-	-	Excluded
	1.8 Inner city deliveries	Candidates No: 2.6 and 2.7 gave for this topic quite high evaluation 5 and 6. However candidate no: 2.5 and university web page provided lower evaluation that is 3 and 4. But, due to fact that evaluation levels are higher than average and gradualy rising, a final level was recognized **5 (evaluating).**	3	5	6	This course provides knowledge about distribution logistics and warehouses. In the second year the students are involved *in 'practice through practical assignments in projects and company visits (Introduction, 2017).'* In the third year they follow a minor. For example students *'participate in the logistics research program, focusing on […] city logistics (Introduction, 2017).'* After graduation students will be able to carry out process analyzes of logistics processes. Given those, expected educational level for this particular topic is 4 (analyzing).
	1.9 Delivery strategies	Candidate No: 2.7 evaluated this topic at level 4. However, other candidates No: 2.5, 2.6 and university web page did not provide any information about that. Due to fact that AUAS has a good reputation in the researches of city logistics the data provided by candidate No: 2.7 is recognized reliable, and the final evaluation level for this topic was decided to be **4 (analyzing).**	-	-	4	-

	1.10 Routing and scheduling techniques	Candidate No: 2.7 evaluated this topic at level 4. However, other candidates No: 2.5, 2.6 and university web page did not provide any information about that. Due to fact that AUAS has a good reputation in the researches of city logistics the data provided by candidate No: 2.7 is recognized reliable, and the final evaluation level for this topic was decided to be **4 (analyzing).**	-	-	4	-
	1.11 Circular business models	Candidate No: 2.7 evaluated this topic at level 6. However, other candidates No: 2.5, 2.6 and university web page did not provide any information about that. Due to fact that AUAS has a good reputation in the researches of city logistics the data provided by candidate No: 2.7 is recognized reliable, and the final evaluation level for this topic was decided to be **6 (creating).**	-	-	6	-
	1.12 Site waste management	-	-	-	-	Excluded
(2) Implementation	2.1 Total quality management	Candidate No: 2.7 evaluated this topic at level 3. However, other candidates No: 2.5, 2.6 and university web page did not provide any information about that. Due to fact that AUAS has a good reputation in the researches of city logistics the data provided by candidate No: 2.7 is recognized reliable, and the final evaluation level for this topic was decided to be **3 (applying).**	-	-	3	-
	2.2 Supplier relationship management	Candidate No: 2.7 evaluated this topic at level 5. However, other candidates No: 2.5, 2.6 and university web page did not provide any information about that. Due to fact that AUAS has a good reputation in the researches of city logistics the data provided by candidate No: 2.7 is recognized reliable, and the final evaluation level for this topic was decided to be **5 (evaluating).**	-	-	5	-
	2.3 Risk management in supply chains	The data provided by the candidate No: 2.7 and university web page are standing quite close, 2 and 3. The web page information was recognized most of reliable and as a final level decided to be **3 (applying)**.	-	-	2	This course provides knowledge about risk management in supply chains. Students are learning about *'interior choices that meet the requirements and wishes of different stakeholders and how to match those choices to the changing environment (Year II, 2017).'* They apply quantitative models

						that help to make the effects of different choices insightfully. Given those, expected educational level for this particular topic is **3 (applying).**
	2.4 Sensoring technologies	Candidate No: 2.7 evaluated this topic at level 2. However, other candidates No: 2.5, 2.6 and university web page did not provide any information about that. Due to fact that AUAS has a good reputation in the researches of city logistics the data provided by candidate No: 2.7 is recognized reliable, and the final evaluation level for this topic was decided to be **2 (understanding).**	-	-	2	-
	2.5 Transport regulations	Candidate No: 2.7 evaluated this topic at level 2. However, other candidates No: 2.5, 2.6 and university web page did not provide any information about that. Due to fact that AUAS has a good reputation in the researches of city logistics the data provided by candidate No: 2.7 is recognized reliable, and the final evaluation level for this topic was decided to be **2 (understanding).**	-	-	2	-
	2.6 Transport modes and intermodality	Candidate No: 2.7 evaluated this topic at level 3. However, other candidates No: 2.5, 2.6 and university web page did not provide any information about that. Due to fact that AUAS has a good reputation in the researches of city logistics the data provided by candidate No: 2.7 is recognized reliable, and the final evaluation level for this topic was decided to be **3 (applying).**	-	-	3	-
	2.7 Robotization and automation	Candidate No: 2.7 evaluated this topic at level 3. However, other candidates No: 2.5, 2.6 and university web page did not provide any information about that. Due to fact that AUAS has a good reputation in the researches of city logistics the data provided by candidate No: 2.7 is recognized reliable, and the final evaluation level for this topic was decided to be **3 (applying).**	-	-	3	-
	2.8 Construction sequences	-	-	-	-	Excluded
	2.9 Deconstruction sequences	-	-	-	-	Excluded

	2.10 Site-specific safety management	-	-	-	-	Excluded
(3) Control	3.1 Physical distribution cost	Candidate No: 2.7 evaluated this topic at level 4. However, other candidates No: 2.5, 2.6 and university web page did not provide any information about that. Due to fact that AUAS has a good reputation in the researches of city logistics the data provided by candidate No: 2.7 is recognized reliable, and the final evaluation level for this topic was decided to be **4 (analyzing).**	-	-	4	-
	3.2 Materials flow control methods	Candidate No: 2.7 evaluated this topic at level 5. However, other candidates No: 2.5, 2.6 and university web page did not provide any information about that. Due to fact that AUAS has a good reputation in the researches of city logistics the data provided by candidate No: 2.7 is recognized reliable, and the final evaluation level for this topic was decided to be **5 (evaluating).**	-	-	5	-
	3.3 Progress monitoring	Candidate No: 2.7 evaluated this topic at level 5. However, other candidates No: 2.5, 2.6 and university web page did not provide any information about that. Due to fact that AUAS has a good reputation in the researches of city logistics the data provided by candidate No: 2.7 is recognized reliable, and the final evaluation level for this topic was decided to be **5 (evaluating).**	-	-	5	-
	3.4 Tracking technologies	The data provided by the candidates No: 2.5, 2.6 and university web page are evaluating this topic at level 5. The major source of information is recognized reliable and the final decision was to evaluate this topic at level **5 (evaluating).**	5	5	3	This course provides knowledge about tracking and tracing and sustainable logistics. Students learn how to plant and monitor logistics flows and optimizes inventory management, production and transportation (Introduction, 2017). Which means that students can make judgments based on criteria and standards through checking and critiquing. Given those, expected educational level for this particular topic is **5 (evaluating).**
	3.5 Site storage space management	Candidate No: 2.7 evaluated this topic at level 4. However, other candidates No: 2.5, 2.6 and university web page did not provide any information about that. Due to fact that AUAS has a good reputation in the researches of city logistics the data provided	-	-	4	-

		by candidate No: 2.7 is recognized reliable, and the final evaluation level for this topic was decided to be **4 (analyzing).**				
	3.6 End-of-life-cycle scenarios	Candidate No: 2.7 evaluated this topic at level 3. However, other candidates No: 2.5, 2.6 and university web page did not provide any information about that. Due to fact that AUAS has a good reputation in the researches of city logistics the data provided by candidate No: 2.7 is recognized reliable, and the final evaluation level for this topic was decided to be **3 (applying).**	-	-	3	-
	3.7 Asset information models	Candidate No: 2.7 evaluated this topic at level 3. However, other candidates No: 2.5, 2.6 and university web page did not provide any information about that. Due to fact that AUAS has a good reputation in the researches of city logistics the data provided by candidate No: 2.7 is recognized reliable, and the final evaluation level for this topic was decided to be **3 (applying).**	-	-	3	-
Course evaluation						
Percentage amount of included topics: 80.5 %						

Candidate No: 2.8
University: Royal Institute of technology (SW)
Course name: AI2805 - Building Informatics and Logistics (MSc)

Table 25: Expected educational level for (B) course and for included topics.

Country: Sweden				
University: Royal Technical University (KTH)				
Master's course: AI2805 Building Informatics and Logistics (B)				
Topics evaluation				
Comprehensive framework		Triangulation	Candidate No: 2.8	Data obtained from the university's web page and syllabus
(1) Planning	1.1 Systems perspective/overview	Candidate No: 2.8 evaluated this topic at level 3. However, university webpage did not provide any information about that. Which seems that the topic is provided at average level and therefore it was not mentioned on the university's web page. As a final evaluation level for this topic was recognized data obtained during the interview, which is level **3 (applying)**.	3	-
	1.2 Enterprise Resource Planning	Candidate No: 2.8 evaluated this topic at level 2. However, university webpage did not provide any information about that. Which seems that the topic is provided at low level and therefore it was not mentioned on the university's web page. As a final evaluation level for this topic was recognized data obtained during the interview, which is level **2 (understanding)**.	2	-
	1.3 BIM-based planning	This is perfect match. When both sources of information university web page and candidate No: 2.8 recognized expected educational level for this topic at **4 (analyzing)**.	4	This course provides knowledge about building information modeling. Students will learn about *'IT from an organizational and strategic business perspective […]. They will be able to describe and analyze the information handling in the design and construction process […] Be aware of different principles to organize and manage the information exchange in the design and construction process, be familiar with IT-based project management (Syllabus MSc, 2017).'* Given those, expected educational level for this particular topic is 4 (analyzing).
	1.4 Demand forecasting	Candidate No: 2.8 evaluated this topic at level 2. However, university webpage	2	-

		did not provide any information about that. Which seems that the topic is provided at low level and therefore it was not mentioned on the university's web page. As a final evaluation level for this topic was recognized data obtained during the interview, which is level **2 (understanding)**.		
	1.5 Return planning	-	-	Excluded
	1.6 Procurement	Candidate No: 2.8 evaluated this topic at level 3. However, university webpage did not provide any information about that. Which seems that the topic is provided at average level and therefore it was not mentioned on the university's web page. As a final evaluation level for this topic was recognized data obtained during the interview, which is level **3 (applying)**.	3	-
	1.7 Construction site layout planning	This is perfect match. When both sources of information university web page and candidate No: 2.8 recognized expected educational level for this topic at **2 (understanding)**.	2	This course provides knowledge about simulation and visualization. Students will become conscious about the *'relation between the implementation of information technology and the changeover of working methods, roles of different actors and the built results (Syllabus MSc, 2017)'*. Which means that they will be able to construct meaning from different types of functions by interpretation or explanation. Given those, expected education level for this particular topic is 2 (understanding).
	1.8 Inner city deliveries	Candidate No: 2.8 evaluated this topic at level 2. However, university webpage did not provide any information about that. Which seems that the topic is provided at low level and therefore it was not mentioned on the university's web page. As a final evaluation level for this topic was recognized data obtained during the interview, which is level **2 (understanding)**.	2	-
	1.9 Delivery strategies	Candidate No: 2.8 evaluated this topic at level 2. However, university webpage did not provide any information about that. Which seems that the topic is provided at low level and therefore it was not mentioned on the university's web page. As a final evaluation level for this topic was recognized data obtained during the interview, which is level **2 (understanding)**.	2	-
	1.10 Routing and scheduling techniques	Candidate No: 2.8 evaluated this topic at level 2. However, university webpage did not provide any information about that. Which seems that the topic is	2	-

		provided at low level and therefore it was not mentioned on the university's web page. As a final evaluation level for this topic was recognized data obtained during the interview, which is level **2 (understanding)**.		
	1.11 Circular business models	Candidate No: 2.8 evaluated this topic at level 2. However, university webpage did not provide any information about that. Which seems that the topic is provided at low level and therefore it was not mentioned on the university's web page. As a final evaluation level for this topic was recognized data obtained during the interview, which is level **2 (understanding)**.	2	-
	1.12 Site waste management	Candidate No: 2.8 evaluated this topic at level 1. However, university webpage did not provide any information about that. Which seems that the topic is provided at low level and therefore it was not mentioned on the university's web page. As a final evaluation level for this topic was recognized data obtained during the interview, which is level **1 (remembering)**.	1	-
(2) Implementation	2.1 Total quality management	Candidate No: 2.8 evaluated this topic at level 1. However, university webpage did not provide any information about that. Which seems that the topic is provided at low level and therefore it was not mentioned on the university's web page. As a final evaluation level for this topic was recognized data obtained during the interview, which is level **1 (remembering)**.	1	-
	2.2 Supplier relationship management	Candidate No: 2.8 evaluated this topic at level 1. However, university webpage did not provide any information about that. Which seems that the topic is provided at low level and therefore it was not mentioned on the university's web page. As a final evaluation level for this topic was recognized data obtained during the interview, which is level **1 (remembering)**.	1	-
	2.3 Risk management in supply chains	Candidate No: 2.8 evaluated this topic at level 2. However, university webpage did not provide any information about that. Which seems that the topic is provided at low level and therefore it was not mentioned on the university's web page. As a final evaluation level for this topic was recognized data obtained during the interview, which is level **2 (understanding)**.	2	-

	2.4 Sensoring technologies	Candidate No: 2.8 evaluated this topic at level 2. However, university webpage did not provide any information about that. Which seems that the topic is provided at low level and therefore it was not mentioned on the university's web page. As a final evaluation level for this topic was recognized data obtained during the interview, which is level **2 (understanding)**.	2	-
	2.5 Transport regulations	-	-	Excluded
	2.6 Transport modes and intermodality	-	-	Excluded
	2.7 Robotization and automation	Candidate No: 2.8 evaluated this topic at level 2. However, university webpage did not provide any information about that. Which seems that the topic is provided at low level and therefore it was not mentioned on the university's web page. As a final evaluation level for this topic was recognized data obtained during the interview, which is level **2 (understanding)**.	2	-
	2.8 Construction sequences	Candidate No: 2.8 evaluated this topic at level 3. Besides, university web page defined for this topic level 4. Both evaluations are standing quite close with each other, therefore as a final expected educational level was recognized data derived from the university's leading lecturer, by candidate No: 2.8, which is level **3 (applying)**.	3	This course provides knowledge about process and product modeling, which can be used for identification of construction sequences. Students will *'be able to describe and analyze the information handling in the design and construction process (Syllabus MSc, 2017).'* Given those expected educational level for this particular topic is 4 (analyzing).
	2.9 Deconstruction sequences	Candidate No: 2.8 evaluated this topic at level 3. Besides, university web page defined for this topic level 4. Both evaluations are standing quite close with each other. However, as a final expected educational level was recognized data derived from the university's web page, which is level **4 (analyzing)**.	3	This course provides knowledge about process and product modeling, which can be used for identification of deconstruction sequences. Students will *'be able to describe and analyze the information handling in the design and construction process (Syllabus MSc, 2017).'* Given those expected educational level for this particular topic is 4 (analyzing).
	2.10 Site-specific safety management	Candidate No: 2.8 evaluated this topic at level 3. However, university webpage did not provide any information about that. Which seems that the topic is provided at average level and therefore it was not mentioned on the university's web page. As a final evaluation level for this topic was recognized data obtained during the interview, which is level **3 (applying)**.	3	-
(3) Control	3.1 Physical distribution cost	Candidate No: 2.8 evaluated this topic at level 1. However, university webpage did not provide any information about that. Which seems that the topic is provided at low level and therefore it	1	-

		was not mentioned on the university's web page. As a final evaluation level for this topic was recognized data obtained during the interview, which is level **1 (remembering)**.		
	3.2 Materials flow control methods	-	-	Excluded
	3.3 Progress monitoring	Candidate No: 2.8 evaluated this topic at level 3. However, university webpage did not provide any information about that. Which seems that the topic is provided at average level and therefore it was not mentioned on the university's web page. As a final evaluation level for this topic was recognized data obtained during the interview, which is level **3 (applying)**.	3	-
	3.4 Tracking technologies	This is perfect match. When both sources of information university web page and candidate No: 2.8 recognized expected educational level for this topic at **2 (understanding)**.	2	This course provides knowledge about common industrial IT-platform and computer supported cooperative work. Students will *'be familiar with common industrial IT-platforms for information sharing and delivery […] be aware of different principles to organize and manage the information exchange in the design and construction process (Syllabus MSc, 2017).'* Given those, expected educational level for this particular topic is 2 (understanding).
	3.5 Site storage space management	-	-	Excluded
	3.6 End-of-life-cycle scenarios	Candidate No: 2.8 evaluated this topic at level 2. However, university webpage did not provide any information about that. Which seems that the topic is provided at low level and therefore it was not mentioned on the university's web page. As a final evaluation level for this topic was recognized data obtained during the interview, which is level **2 (understanding)**.	2	-
	3.7 Asset information models	Candidate No: 2.8 evaluated this topic at level 2. Besides, university web page defined for this topic level 3. Both evaluations are standing quite close with each other. However, as a final expected educational level was recognized data derived from the university's web page **3 (applying)** as it teaches *preparation* in other words *application* of IT knowledge in document management.	2	This course provides knowledge about document management. Students will *'be oriented in the field of classification, information systematics and information standards in design and construction […] be able to prepare an IT-strategy for a company and a project (Syllabus MSc, 2017).'* Given those, expected educational level for this particular topic is 3 (applying).
Course evaluation				
Percentage amount of included topics: 84 %				

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Table 26: Expected educational level for (D) course and for included topics.

Country: United Kingdom				
University: Northumbria University				
Bachelor's course: MO9409 Operationd and Integrated Supply Chain and Marketing Management (D)				
Topics evaluation				
Comprehensive framework		Triangulation	None candidates	Data obtained from the university's web page and syllabus
(1) Planning	1.1 Systems perspective/overview	-		Excluded
	1.2 Enterprise Resource Planning	-		Excluded
	1.3 BIM-based planning	-		Excluded
	1.4 Demand forecasting	Due to fact that none of the candidates express interest to participate in an in-depth interviews, as final expected educational level for this topic was recognized data derived from the university's web page, which is level **2 (understanding).**		This course provides knowledge about capacity and demand management, marketing management, marketing introduction *(B2C verses B2B)*, market environment business-to-business environment *(customers, organizations, and markets)*, and market research. Students will learn demonstration of knowledge and understanding of the managerial and operational issues in a business context. Also, they learn integrated approach of supply and demand management and practical problem solving (Module information, 2017b). Given those, expected educational level for this particular topic is 2 (understanding).
	1.5 Return planning	-		Excluded
	1.6 Procurement	Due to fact that none of the candidates express interest to participate in an in-depth interviews, as final expected educational level for this topic was recognized data derived from the university's web page, which is level **2 (understanding).**		This course provides knowledge about supplier development and purchasing. Students will learn demonstration of knowledge and understanding of the managerial and operational issues in a business context. Also, they learn integrated approach of supply and demand management and practical problem solving (Module information, 2017b). Given those, expected educational level for this particular topic is 2 (understanding).
	1.7 Construction site layout planning	-		Excluded
	1.8 Inner city deliveries	-		Excluded
	1.9 Delivery strategies	-		Excluded

	1.10 Routing and scheduling techniques	-		Excluded
	1.11 Circular business models	-		Excluded
	1.12 Site waste management	-		Excluded
(2) Implementation	2.1 Total quality management	Due to fact that none of the candidates express interest to participate in an in-depth interviews, as final expected educational level for this topic was recognized data derived from the university's web page, which is level **2 (understanding).**		This course provides knowledge about quality management and lean management. Students will learn demonstration of knowledge and understanding of the managerial and operational issues in a business context. Also, they learn integrated approach of supply and demand management and practical problem solving (Module information, 2017b). Given those, expected educational level for this particular topic is 2 (understanding).
	2.2 Supplier relationship management	Due to fact that none of the candidates express interest to participate in an in-depth interviews, as final expected educational level for this topic was recognized data derived from the university's web page, which is level **2 (understanding).**		This course provides knowledge about market segmentation and segmentation strategies, and supply network management. Students will learn demonstration of knowledge and understanding of the managerial and operational issues in a business context. Also, they learn integrated approach of supply and demand management and practical problem solving (Module information, 2017b). Given those, expected educational level for this particular topic is 2 (understanding).
	2.3 Risk management in supply chains	Due to fact that none of the candidates express interest to participate in an in-depth interviews, as final expected educational level for this topic was recognized data derived from the university's web page, which is level **2 (understanding).**		This course provides knowledge about supply chain risk management. Students will learn demonstration of knowledge and understanding of the managerial and operational issues in a business context. Also, they learn integrated approach of supply and demand management and practical problem solving (Module information, 2017b). Given those, expected educational level for this particular topic is 2 (understanding).
	2.4 Sensoring technologies	-		Excluded
	2.5 Transport regulations	-		Excluded
	2.6 Transport modes and intermodality	-		Excluded
	2.7 Robotization and automation	-		Excluded
	2.8 Construction sequences	-		Excluded
	2.9 Deconstruction sequences	-		Excluded
	2.10 Site-specific safety management	-		Excluded
(3) Control	3.1 Physical distribution cost	-		Excluded
	3.2 Materials flow control methods	-		Excluded

	3.3 Progress monitoring	Due to fact that none of the candidates express interest to participate in an in-depth interviews, as final expected educational level for this topic was recognized data derived from the university's web page, which is level **2 (understanding).**		This course provides knowledge about performance measurement. Students will learn demonstration of knowledge and understanding of the managerial and operational issues in a business context. (Module information, 2017b). Given those, expected educational level for this particular topic is 2 (understanding).
	3.4 Tracking technologies	-		Excluded
	3.5 Site storage space management	-		Excluded
	3.6 End-of-life-cycle scenarios	-		Excluded
	3.7 Asset information models	-		Excluded
Course evaluation				
Percentage amount of included topics: 21 %				

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Table 27: Expected educational level for (A) course and for included topics.

Country: United Kingdom				
University: Northumbria University				
Master's course: MO0487 Strategic Procurement and Logistics (A)				
Topics evaluation				
Comprehensive framework		Triangulation	None candidates	Data obtained from the university's web page and syllabus
(1) Planning	1.1 Systems perspective/overview	-	-	Excluded
	1.2 Enterprise Resource Planning	Due to fact that none of the candidates express interest to participate in an in-depth interviews, as final expected educational level for this topic was recognized data derived from the university's web page, which is level **5 (evaluating).**	-	This course provides knowledge about Enterprise Resource Planning systems and inventory management (*ERP*). Students are learning how to understand and critically evaluate the wider impact of individual or organizational decision making on strategic procurement and logistics management contexts (Module information, 2017a). Given those, expected educational level for this particular topic is 5 (evaluating).
	1.3 BIM-based planning	-	-	Excluded
	1.4 Demand forecasting	-	-	Excluded
	1.5 Return planning	-	-	Excluded
	1.6 Procurement	Due to fact that none of the candidates express interest to participate in an in-depth interviews, as final expected educational level for this topic was recognized data derived from the university's web page, which is level **5 (evaluating).**	-	This course provides knowledge about purchasing and supply chains management, purchasing process, negotiation and contract management / incoterms, and purchasing - the 5 'rights'-Partnership Sourcing (I) and (II). Students are learning how to understand and critically evaluate the wider impact of individual or organizational decision making on strategic procurement and logistics management contexts (Module information, 2017a). Given those, expected educational level for this particular topic is 5 (evaluating).
	1.7 Construction site layout planning	-	-	Excluded
	1.8 Inner city deliveries	-	-	Excluded
	1.9 Delivery strategies	-	-	Excluded

	1.10 Routing and scheduling techniques	-	-	Excluded
	1.11 Circular business models	-	-	Excluded
	1.12 Site waste management	-	-	Excluded
(2) Implementation	2.1 Total quality management	-	-	Excluded
	2.2 Supplier relationship management	Due to fact that none of the candidates express interest to participate in an in-depth interviews, as final expected educational level for this topic was recognized data derived from the university's web page, which is level **5 (evaluating).**	-	This course provides knowledge about Supplier evaluation and selection, Supplier management and development - creating a world-class supply base, and Outsourcing/ re-shoring management. Students are learning how to understand and critically evaluate the wider impact of individual or organizational decision making on strategic procurement and logistics management contexts (Module information, 2017a). Given those, expected educational level for this particular topic is 5 (evaluating).
	2.3 Risk management in supply chains	Due to fact that none of the candidates express interest to participate in an in-depth interviews, as final expected educational level for this topic was recognized data derived from the university's web page, which is level **5 (evaluating).**	-	This course provides knowledge about Change management in supply chains. Students are learning how to understand and critically evaluate the wider impact of individual or organizational decision making on strategic procurement and logistics management contexts (Module information, 2017a). Given those, expected educational level for this particular topic is 5 (evaluating).
	2.4 Sensoring technologies	-	-	Excluded
	2.5 Transport regulations	-	-	Excluded
	2.6 Transport modes and intermodality	-	-	Excluded
	2.7 Robotization and automation	-	-	Excluded
	2.8 Construction sequences	-	-	Excluded
	2.9 Deconstruction sequences	-	-	Excluded
	2.10 Site-specific safety management	-	-	Excluded
(3) Control	3.1 Physical distribution cost	-	-	Excluded
	3.2 Materials flow control methods	Due to fact that none of the candidates express interest to participate in an in-depth interviews, as final expected educational level for this topic was recognized data derived from the university's web page, which is level **5 (evaluating).**	-	This course provides knowledge about scope of materials management and logistics, inventory management (*Material Resource Planning*). Students are learning how to understand and critically evaluate the wider impact of individual or organizational decision making on strategic procurement and logistics management contexts (Module information, 2017a). Given those, expected educational level for this particular topic is **5 (evaluating).**

	3.3 Progress monitoring	-	-	Excluded
	3.4 Tracking technologies	-	-	Excluded
	3.5 Site storage space management	Due to fact that none of the candidates express interest to participate in an in-depth interviews, as final expected educational level for this topic was recognized data derived from the university's web page, which is level **5 (evaluating).**	-	This course provides knowledge about materials handling and storage (I, II). Students are learning how to understand and critically evaluate the wider impact of individual or organizational decision making on strategic procurement and logistics management contexts (Module information, 2017a). Given those, expected educational level for this particular topic is **5 (evaluating).**
	3.6 End-of-life-cycle scenarios	-	-	Excluded
	3.7 Asset information models	-	-	Excluded
Course evaluation				
Percentage amount of included topics: 21 %				

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3. Voordijk, H. (2015a) *Supply Chain Management. A systems approach.* Course Supply Chain Management & ICT. University of Twente, September.
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