DEVELOPING A MODEL OF NON-TECHNICAL COMPETENCES FOR ENGINEERS

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About the authors

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Abstract

Current paper focuses on the question *"What are the non-technical competences (NTC) needed for engineering professional work?"* Based on theoretical study we draw a heuristic model of NTC for engineers and test it empirically. There are six domains of NTC for engineers: a) Professional ethics competences; b) Personal competences; c) Interpersonal competences; d) Leadership, management, and administrative competences; e) Innovation and entrepreneurial competences; and f) Law and legal system competences. Analysing the correspondence between NTC use in everyday professional work, and NTC competences developed in university study indicated several gaps. Supporting engineers' Personal competences up to the highest level is especially important as these are used on a daily basis. Young engineers entering the workforce also need extra training to develop their Interpersonal competences.

Introduction

Engineering is a key factor in innovation and is vital in addressing the global issues and challenges that societies currently face. The profession of engineering and the roles of engineers have changed rapidly over the past few decades. Engineers are expected to have an understanding of relevant environmental, social, economic, and cultural contexts in addition to strong technical knowledge and skills (OECD, 2011). Engineers themselves acknowledge the need for a new kind of engineer, one who can think broadly across disciplines (Chan & Fishbein, 2009; Grasso & Burkins 2010; Grimson, 2002; Ravenstein, De Graaff, & Kroesen, 2006; Sheppard, Macatangay, Colby, & Sullivan, 2009).

Preparing future engineers is prioritised in several European Union (EU) countries, including Estonia. At the same time, there is lot of discussion about the graduate competence gap in Europe and elsewhere; i.e., a mismatch between the competencies engineering graduates acquire during their studies and the competences employers expect from graduates. Numerous studies demonstrate that the employability gap originates from both deficiencies in technical/subject specific skills and, more importantly, from deficiencies in general and social skills (Bakar & Ting, 2012; Barte & Yeap, 2011; Beard, Schwieg-

er, & Surendran, 2007; Brown, Lee, & Alejandre, 2009; Carter, 2011; Conlon, 2008; Markes, 2006; Saravanan, 2009; Spinks, Silburn, & Birchall, 2007).

The relation between education and world of work is now conceptualised through competence-based education. Tertiary education degree programmes in vocationally focused disciplines like engineering have always aimed to produce graduates equipped with competences appropriate for employment (Coll & Zegwaard, 2006). For now, there exists considerable consensus that the modern engineering profession requires not only technical excellence, but also some additional, non-technical competences (NTC). In recent years engineers' educators and professional bodies have accepted the challenge of teaching NTC. Unfortunately, no agreement has been reached regarding what exactly the non-technical skills and/or competences are in their deeper content. On-going debate clearly shows that different researchers and educators understand this issue differently and are offering different "packages" of engineers' non-technical skills and/or competences.

The problem facing many of the approaches to engineering NTCs is that the competence models used in the engineering literature follow different theoretical approaches to competence and the exact content of each engineering NTC is vague and undefined. The current challenge engineers, employers, and engineers' educators are facing is getting a thorough understanding about "What exactly are the NTCs needed for engineering professional work?" This was the main research question leading the studies conducted in the department of Industrial Psychology at TUT.

First, this article introduces the results of these studies, on the basis of which the model of NTCs for engineers was developed. Second, as the aim of competence based education is to prepare students with competences appropriate for employment we focus on correspondence between the NTC engineers use in their everyday professional work, and the NTC competences developed in university by teaching special NT subjects. Altogether we aim to map the NTCs needed in engineering work and the preparation of future engineers in Estonia.

Concept of competence

Competence is about mastery in relation to specified goals, outcomes or standards. The concept of competence was originally developed in psychology to refer to an individual's ability to respond to certain demands placed on them by their environment (Sampson, 2009). Whereas R.H. White is credited with the introduction of the term competence in 1959, David McClelland (1973) proposed competence testing instead of intelligence testing as the critical differentiator of performance.
A clear and coherent definition of competence is needed when one wants to develop a competence model. Unfortunately, this is not as straightforward as it may seem, as the lack of a generally accepted operational definition of competence/competency is widely acknowledged (e.g., Garavan & McGuire, 2001; Winterton, 2009). The lack of consensus originates in the diversity of disciplines in which the concept is developed and applied: law, clinical psychology, vocational

counselling, education, training, and management (Voskuijl & Evers, 2012; p.149). The confusion and inconsistent usage of the term competence derives from differences in systems, structures and cultures of Human Resource development and vocational-educational training in different countries (e.g., USA, UK, France, Germany and Austria) (Delamare-Le Deist & Winterton, 2005).

Theoretically, there are several competing approaches in the literature; for example in Work and Organisational Psychology (WOP) two main approaches are distinguished: the competency or the person-based approach; and the competence or job/work based approach (Voskuijl & Evers, 2012; p.150).

The competency approach finds its origin in the USA where competency is mainly defined as any characteristics relating to superior performance. In this approach competency equals the basic features of a person that are associated with excellent or superior performance in a situation. This worker-oriented perspective is based on the seminal work of McClelland (1973) who found that academic aptitude and knowledge content tests, as well as school grades and credentials; did not predict job performance or success in life, and were often biased against minorities. This approach is concerned with the input of individuals in terms of behaviour, skills, or other underlying personal characteristics of job holders that are causally related to superior performance in a job or situation (Boyatzis, 1982; Spencer & Spencer, 1993). Person-based competency frameworks are widely adopted in business organizations where consultants have developed a variety of 'unique' competence systems which have found their way into use with larger client organizations.

The competence or the job/work-based approach is widely used in the EU. This approach is task centred and focuses on the purpose of the job or occupation (i.e. on output), rather than the job holder (Voskuijl & Evers, 2012; p. 150). The origin of the model is the foundation of scientific management, and subsequent development of the National Vocational Qualifications. Competences in terms of the occupational standards models used in many EU countries are described as being the minimum standards of performance (known as threshold performance) and the characteristics required by job holders that are assumed to exist when standards are met (ibid).

Roe (2002) defines competence as a "learned ability to adequately perform a task, duty or role", relating to a specific type of work. Competence integrates several types of knowledge, skills, and attitudes in a dynamic way, and should be distinguished from abilities, personality traits, and other more stable characteristics of the individual (ibid.). The latter can be seen as the basis for what the individual learns and how well they perform. There's enough research evidence that learning process and performance also depend on personal and situational factors and on time. Thus, dispositions cannot be equated with knowledge, skills, and attitudes that are learned qualities. Competence is a "proximal antecedent" of performance but whether a competent person performs well also depends on other factors, including motivation, current state (e.g., being in good health or not, energetic

state, level of vitality) and the opportunity to perform (ibid.). While the presence of a high level of competence is a prerequisite for good performance, it does not guarantee adequate performance.

While the terms competence and skills are often used simultaneously, they should be treated as distinctive terms. Skill concerns the execution of a single task, while competence deals more with the execution of a whole series of different tasks in a certain domain, all of them performed well and in an integrated manner (Coll & Zegwaard, 2006). People demonstrate competence by applying their competencies in a goal-directed manner within a work setting (Kurz & Bartram, 2002; p.226). Therefore, competencies relate to the behaviours that underpin successful performance; they are the "behavioural repertoires" that people use in order to meet their objectives. The questions we want to ask are: how do people go about achieving the required outcomes; and what enables competent performance?

Engineering competence

Engineering competence is defined as the application of relevant skills and knowledge in solving problems of interest to an engineer. Engineering competences can be divided into technical competences and non-technical competences. The first are based on technical knowledge, understanding, and skills (i.e., made up of competences in basic and engineering sciences), and therefore are called "technical competences" (TC). "Non-technical engineering competences" (NTC) describe the broad field of competences relevant to professional work in the engineering domain. They are different from transferable competences as they are context-specific, that is they are applicable in the context of the engineering profession (although in a rather general way; they are not specific to a concrete occupation). Non-technical engineering competences are defined in the current work as "a specific range of non-technical knowledge, skills, and attitudes/value system needed to adequately perform the professional work and professional roles of an engineer."

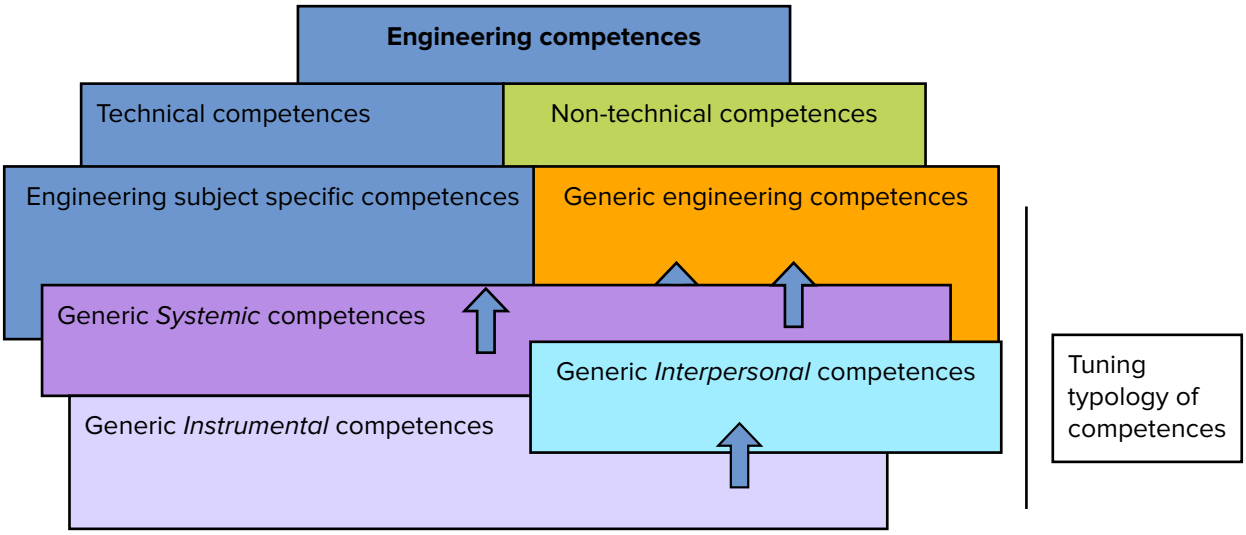
According to Tuning-AHELO model engineering competences are divided into subject-specific competences and generic competences (OECD, 2009; 2011). Subject-specific engineering competences are made up of competences in basic and engineering sciences as well as competence in engineering processes. Generic (or general academic) competences are divided into *generic engineering competences* (competences important to graduates across all different engineering fields) and *generic competences* (also named transferable competences/skills or general competences/skills). To elaborate: there are three types of generic competences:

- *Instrumental competences* refers to cognitive abilities, methodological abilities, technological abilities and linguistic abilities;
- *Interpersonal competences* refers to individual abilities relating to the capacity to express one's own feelings, critical and self-critical abilities, and social skills relating to interpersonal skills (e.g., used in team working) or the expression of social or ethical commitment that facilitates processes of social interaction and co-operation;

- *Systemic competences* refer to abilities and skills concerning whole systems. For example, the combination of understanding, sensibility and knowledge that allows one to see how the parts of a whole relate and come together; capacities that include the ability to plan changes to make improvements in whole systems and to design new systems. Systemic competences require as a base the prior acquisition of both instrumental and interpersonal competences; and are used for the attainment of both TCs and NTCs.

We choose to position our research to the Tuning-AHELO model (hereafter "the model") as it is the most recent attempt to define engineering competences and compiles prior work on learning outcomes/competences in the field of engineering. In the model, TCs are engineering subject specific competences, and NTCs are generic engineering competences, and include generic interpersonal and generic systemic competences. The relationships between the aforementioned competences are depicted below in Figure 1.

Figure 1: Positioning of Non-Technical Competences in relation to engineering subject specific and generic competences as suggested by the Tuning-AHELO model



Developing model of non-technical competences for engineers

Creating a competence model for an occupational group is of value if it's useful and applicable for a broad audience (i.e., all the relevant groups that hope to benefit from it). First, the model should be capable of being utilised by and provide benefit to specialists that address the competences of engineers in their everyday work; such as WO Psychologists and human resource management (HRM) specialists, as well as the educators of engineers. In curricula development, learning objectives are essentially competences, and engineering organizations can specify or update professional qualifications, to include those: a) concrete competences

(and sub-competences) already required of their engineers; and b) areas of competence and professional requirements that reflect both the current and future needs in the working world,

Second, the model should cover/include competences for engineers in various career levels: such as: a) competences that entry-level professional engineers use in their everyday work; b) competences used by engineers with longer work experience; and c) competences used by engineers with management responsibilities at various management levels within an organization.

Third, the model of NTC for engineers should be of help to analyse and design engineering curricula in Higher Education Institutions (HEIs) for entry-level engineers and for developing supplementary training programmes for engineers at different career stages.

We conducted two studies to develop and test the model of NTCs for engineers. First, we identified the ideal NTCs for engineers on the basis of a comprehensive review of research literature, visions of the engineers of the future, analysis of qualification criteria for engineers prescribed by professional bodies, and expected outcomes of engineering graduate programmes (see Figure 2 below). The next step was empirically testing this model.

Figure 2. The Model of Non-Technical Competences for Engineers

There are six NTC domains in this model for engineers. Each domain, in turn, is divided into several competences and each competence consists of various competencies. The six domains of NTC are:

Professional ethics (E): competences that are an essential part of the education and everyday working of engineers. Providing knowledge of the relationship between science, technology, and the ethical prob-

lems of engineers in industry, helps engineers to deal with ethical issues within their professional practice. Three important components in this domain are:

- *Ethics of personality* (E1): honesty and other ethical values, tolerance of differences, including cultural differences, following principles of ethical behaviour in general;
- *Professional ethics* (E2): adhering to engineering ethical standards, such as knowing where assignments extend beyond an engineer's competence;
- *Social responsibility of engineers* (E3): an engineer's responsibility to society (socially responsible behaviour) such as providing clearly understood information to the public that allows others to consider the impact of decisions related to science and technology on nature and the environment.

Personal (P): competences are the basis that allows individuals to act autonomously, manage their own lives, and situate their lives in a broader social context. Personal competences promote expected professional behaviour and productivity in engineers. Because they affect goal adoption, pursuit, and disengagement, they are critical for productivity in multiple life domains. The common thread among these attributes is self-regulation. Mastering self-regulation allows one to counteract undesired influences that may arise from within the person or from the environment and support volitional behaviour. The four competences in this domain are:

- *Flexibility* (P1):adaptability, coming to terms with new or rapidly changing situations, objectively evaluating a situation and changing plans if necessary;
- *Stress tolerance and coping with stress* (P2): coping with working in stressful situations (techno-stress), coming to terms with work stress and burnout;
- *Self-management* (P3): setting personal goals and priorities, effective use of time, realistic evaluation of resources, adapting activities according to feedback, learning from mistakes, self-motivation and a positive, optimistic outlook on life, the ability to control one's emotions (self-control), calmness and balance, persistence in completing a task that has been started;
- *Learning skills and motivation* (P4): understanding the importance of lifelong learning, participating in supplementary training, curiosity forms the basis of continuous learning.

Interpersonal (IP): competences are the bases individuals use when engaging with others, and since they encounter people from a range of backgrounds, it is important that they are able to interact in heterogeneous groups. Skills of co-operation and collaboration, creating and maintaining relationships, influence, conflict resolution, and negotiation are needed for effective professional conduct in engineering. The competences in this domain are:

- *Communication* (IP1): effective communication (face-to-face and in a virtual environment) that involves listening, providing feedback, using language that is appropriate to the situation, ability to speak before an audience, clear oral and written expression, and creating an atmosphere that is conducive to good communication;
- *Cooperation and creating relationships* (IP2): the ability to create and maintain good relationships, empathy,

the ability to listen to others and take the needs of all parties into account, creating and participating in co-operation networks;

- *Negotiation and conflict management* (IP3): the ability to rephrase a problem, achieving solutions that are helpful to all parties, construction resolution of arguments, and achieve a consensus;
- *Influencing* (IP4): consciously creating a certain impression, inspiring, convincing, implementing, motivating, including, delegating, and display of mentorship and leadership behaviours.

Leadership, management and administrative (LMA): competences that provide a foundation for successfully handling work situations related to team, project, and division management, and other tasks and duties in the professional work of engineers. Competences in this domain include:

- *Project management* (LMA1): planning and implementing activities to achieve desired results while remaining within the limits of the given schedule, budget and other resources;
- *Leadership of an organization or unit/division* (LMA2): planning, organising, controlling, directing resources, coming to terms with crises, directing processes, administering, directing and encouraging results, delegating, knowing and influencing the culture of the organization, initiating and directing changes, including leading meetings;
- *Team leadership* (LMA3): creating and developing a team, initiating work, projects, being familiar with and influencing group processes, leading an interdisciplinary and multicultural team.

Innovation and entrepreneurial (IE): competences that guarantee the success of engineers, depending on their ability to identify unconventional, emerging opportunities using entrepreneurial skills. Two competences in this domain are:

- *Creativity and innovativeness* (IE1): creating a vision and strategy for the development of new products/services, finding a solution to problems, generating new ideas and approaches, finding/seeing innovative solutions, striving towards innovation;
- *Entrepreneurship* (IE2): defining and recognising a market niche for new products and services, developing an idea into an actual product or service, being oriented to the needs of the client, developing products or services that suit the given market and product development, willingness to take risks, working in a focused and goal-oriented way, and finding resources to carry out ideas.

Law and the legal system (L): these competences are important in engineering as engineers should be aware of their rights and responsibilities, legal and social aspects of technology and its usage and possible legal consequences related to their productions. The primary value-added knowledge is related to understanding intellectual property and patent law. Engineers should also understand the legal landscape that they are bound to. Competences in this domain include:

- *Intellectual property law* (L1): copyright, patent law, brand law, trade secrets;
- *Commercial law* (L2): rights and re-

sponsibilities associated with leading a business;

- *Knowledge of legal issues in engineer's work* (L3): knowing legislation that pertains to one's work, work environment, and work safety.

These six domains of NTC are separate and yet have a shared component with their neighbouring and other competences. For example, knowledge and understanding about ethical principles is needed and engineers are expected to have professional ethics in situations when the requirements prescribed by law are open to interpretation. Also, for effective leadership and management good communication skills are essential, which fall under interpersonal competences.

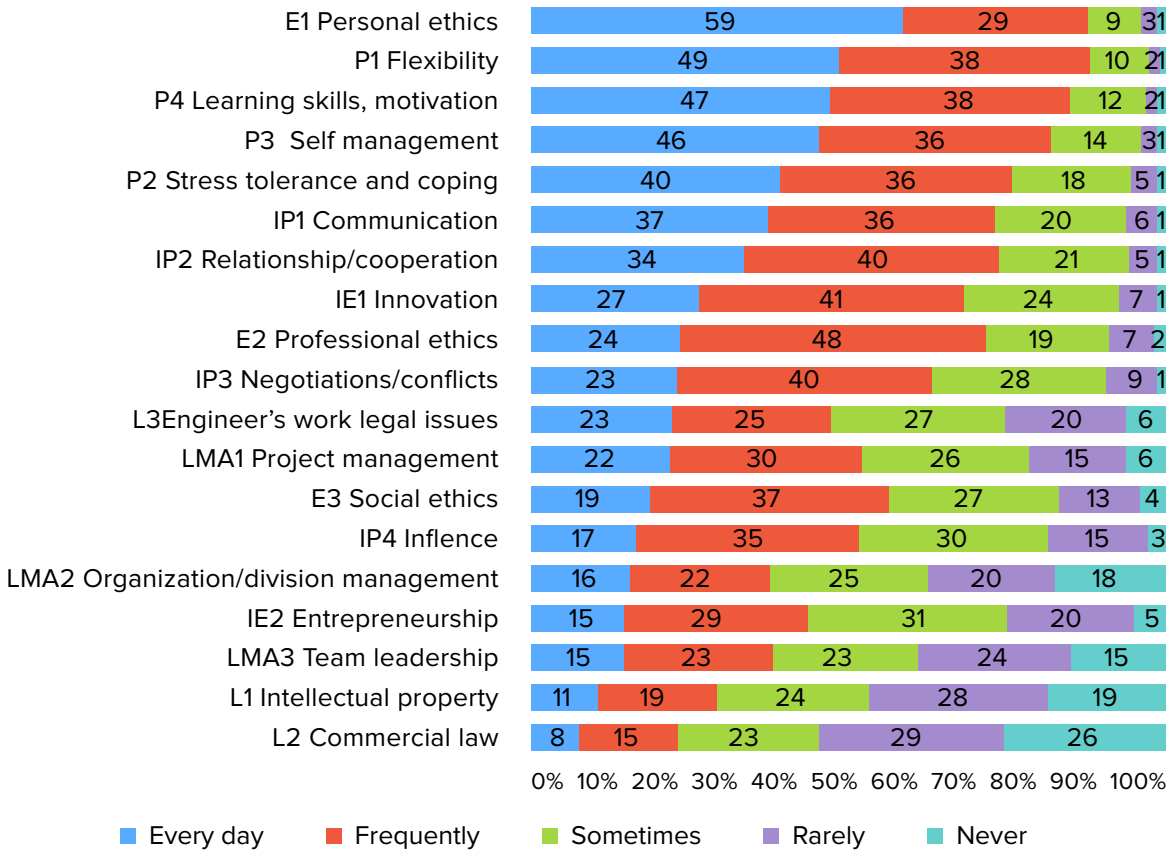
Empirical Study

A web-based survey was conducted to empirically test the model of NTC for engineers. Altogether 1,011 engineers (681 males, 322 females and eight non disclosures) with an average age of 28.11 years (SD=7.60), and average professional engineering work experience 6.45 (SD=0.25) years participated in the survey. Of the respondents 44% had a Bachelor's degree, 34% a Master's degree, and 18% had graduated from high school. In addition, four respondents had completed their doctoral studies.

The questionnaire consisted of 19 items; each of them was an NTC name followed by a brief description (i.e., an explanation of the content-opening list of keywords). For example: Stress tolerance (tolerance of pressure, working in stressful situations, techno-stress, coping with occupational stress, and burnout).

Respondents had to estimate how often they used the19 NTCs in professional engineering work. Figure 3 below shows the results with the most frequently used competences listed first.

Figure 3. Frequency of use Non-technical competences in engineering practice



It appears that approximately nine engineers out of ten use Personal ethics competences on a daily basis or frequently. In addition, more than 75% of engineers use all four Personal competences on a daily basis or frequently. Further, 40-49% of engineers report they are expected to be flexible, ready and motivated to learn new things, as well as cope with techno-stress, and come to terms with work stress on a daily basis.
Approximately 2/3rds of engineers use Interpersonal competences, Innovation and Creativity competences as well as Professional ethics competences on a daily basis or frequently. It appears that most engineers are daily or frequently required to think about honesty and other ethical values and follow principles of ethical behaviour in general. Good self-management skills are also required in the everyday work of an engineer.

Communication competencies, relationships and cooperation competences were reported by 70% of engineers on a daily basis or frequently. Further, half of the engineers use project management, influencing, and entrepreneurship competences as well as competences related to legal issues on a daily basis, or frequently. However, Leadership, Management and Administrative domain competences (LMA) were used by 41-51% of the engineers; while Intellectual property and business law competences were sometimes or rarely (with a small percent of engineers never having used them).

Innovation competences based on creativity and insightful thinking were reported by 41% of respondents frequently and by 27% of respondents on a daily basis.

The length of professional engineering work experience was positively and significantly correlated with using competences in all domains. The strongest correlations were found with Innovation/Entrepreneurial competences and LMA competences. It appeared that ratings of engineers without work experience (no work experience or work limited to a few months) were significantly lower in all six domains compared to ratings of engineers with work experience of more than five years. The ratings of engineers with one to five years of work experience were closer to the ratings of the more experienced engineers in the Personal competences domain. In IE and LMA competences domains the ratings of engineers with some work experience (1-5 yrs.) were similar to the ratings of inexperienced engineers but significantly lower than ratings obtained from more experienced engineers.

Competences developed by teaching Non-technical subjects in Engineering Curricula in TUT

In engineering education the traditional “knowledge-oriented” approach has moved towards developing degree programmes which focus on competence development. The aim is to make students as competent as is feasible in a given timeframe for their future role in society, by making optimum use of the interests and capabilities of the students (OECD, 2011).

The aim of competence-based education is to prepare students with competences appropriate for employment, work life, and professional career. It is argued that the development of generic competences or transferable skills is becoming more relevant for preparing students for their fu-

ture role in society in terms of employability and citizenship (Tuning, 2006). Thus, it is relevant to know whether NT subjects taught in the engineering curricula foster the generic competences needed for successful employment.

As previously stated, the model of NTC for engineers could be helpful to analyse engineering curricula in HEIs; exploring how many topics develop the NTCs that engineers need for their professional careers. Our empirical study of the NTCs engineers use in their everyday professional work can serve as starting point to estimate how well engineering curricula are in accordance with employment demands. An analysis of engineering curricula of the engineering faculties of TTU from the vantage point of NTCs indicated that:

- Although there is a large number of NT subjects, the content of those subjects and especially students' learning outcomes are not in accordance with general understanding of non-technical engineering competences;
- None of the curricula offer the possibility of the full development of non-technical engineering competences. Subjects were mainly electives for students, and for example, there is no one subject for developing leadership and managerial competences on either the undergraduate or postgraduate programmes.

In order to understand this further we undertook an in-depth content analysis of the aims, content and learning outcomes of NT subjects taught as compulsory subjects or electives to undergraduate and postgraduate engineering students. The research question guiding our study was *"Which NTCs are systematically developed by teaching NT subjects for engineering undergraduate and postgraduate students?"* Answering this question will allows us to find the main gaps and suggest what NTCs are needed in professional engineering work in order to prepare engineering students in Estonia.

All engineering curricula in TUT include modules on: General Studies; Economics and Entrepreneurship; and Free electives. The purpose of teaching the General Studies module is to raise the overall educational level and to satisfy common educational needs of the students. Compulsory subjects in this module are Philosophy, Law and Sustainable Development, Science of Risk and Safety, and foreign language. First four subjects are aimed to develop students' general systemic competences; the latter aims to develop students' general instrumental competences (i.e., their language skills). There are few additional compulsory general subjects such as those that develop students' writing skills and ethical competences.

The purpose of teaching free electives is to allow students to choose courses according to their individual interests, planned career needs and trends in new technology. For example, some curricula offer Sociology, Psychology and Logic as optional general subjects.

The purpose of teaching the Economics and Entrepreneurship module is to provide students with knowledge of the basics of economics and business and to improve their knowledge and skills of entrepreneurship. In addition, Micro- and Macro-economics is a compulsory subject

for undergraduate students (developing their generic systemic and instrumental competences). On average, postgraduate engineering curricula contain two or three subjects from the Innovation-Entrepreneurship (IE) competences or Leadership, Managerial and Administrative (LMA) competences domain (these are presented in Table 1).

Table 1. Law, IE, LMA competences and corresponding NT subjects taught in TUT

NTC		NT subject
Law competences	Commercial law	Contract Law
	Intellectual property	Intellectual property
	Engineer's work legal issues	Grounds of Law
Innovation and Entrepreneurship competences	Innovation	Innovation and creative problem solving
		Product Development, Innovation and Product Development, Product Development and Design
		Innovation management
		Technological Innovation
		Research work and Innovation
		Research & Development and Innovation
	Entrepreneurship	Technology-based Entrepreneurship and Innovation
		Introduction to Entrepreneurship
		Entrepreneurship and Small Business Management
		Entrepreneurship and Business Planning
		Business Administration
Leadership, Managerial, Administrative competences	Team leadership	Team Management in Developing Information Systems; Teamwork – project
	Organization/division management	Quality management, Project and Quality Management
		Organisational Behavior, Managerial Psychology
	Project management	Project management

Leadership, Managerial and Administrative (LMA) competences

Most engineering curricula include Project Management courses to develop these respective competences. The Quality Management course, in part, focuses on developing students' Organization/Division management competences. Only Faculty of Information Technology offers specific subjects aimed to develop students' teamwork and team leadership competences. However, there are just a few curricula in different engineering faculties that offer Organizational Behaviour or Managerial Psychology courses. Thus, whereas Project Management competences are systematically developed, there are few engineering specialities where postgraduate

students are offered the opportunity to develop Team leadership and Organization/Division management competences.

Innovation / Entrepreneurship (IE) competences

Although creativeness and innovative solutions are seen as core in the engineering profession; only a few subjects specifically deal with developing students' creativity and innovative thinking (e.g., Faculty of Information Technology teaches innovation and creative problem solving, Technological Innovation). Product Development courses focus on basic knowledge about product development processes in enterprises and aim to educate students about principles and methodologies of modern product development. While the aims and content of Innovation Management are similar to Product Development courses (i.e., the subject aims to develop students' understanding of the process of innovation and product development in companies); the role of the state and wider socioeconomic context in innovation are given more attention. These courses also aim to prepare students for participation in product development team activities (such as Research and Development, R&D), and the development of elementary team leadership skills. Further, Research Work and Innovation, Research & Development and Innovation aim to develop students' skills for planning and realising independent research, R&D or innovation projects.

Subjects offered in TUT to develop engineering students' entrepreneurship competences aim to provide the knowledge and skills one needs to start new business venture (such as, understanding business environment, evaluation of business opportunities, developing business ideas into business plan, financial planning, and solving problems related to starting one's own business). Creating an understanding about the essence of entrepreneurship, and providing knowledge that enables students to evaluate their potential for becoming entrepreneurs and to appreciate team working are valuable competences these courses aim to develop.

Law domain competences

These competences are developed by teaching Grounds of Law as compulsory subject to all engineering students. However, it would appear that the majority of engineering curricula do not contain subjects that would enable the development of commercial law and intellectual property competences. Only a couple of curricula in Faculty of Chemical and Materials Technology and in Faculty of Civil Engineering offer courses on Intellectual property and Contract Law respectively.

Table 2 overleaf describes the Interpersonal, Personal, Ethics competences and corresponding NT subjects taught at TUT. These are described below.

Interpersonal competences

Engineering curricula contain many subjects aimed seemingly to develop students' Communication competences; but the focus of those subjects is in fact on developing instrumental competences (such as language skills). Only a couple of curricula include optional subjects that aim to develop students' Interpersonal communication competence (Communication Psychology, Business Communication and Negotiations). The Faculty of

Social Sciences offers Communicational Psychology as a free elective that aims to develop a wider range of communication competences (e.g., listening, self-presentation, cooperation, team building, and conflict management). Interpersonal competences related to effective communication skills and building and maintaining cooperative relationships as well as negotiation and conflict management and influence competences are not systematically developed in engineering curricula.

Table 2. Interpersonal, Personal, Ethics competences and corresponding NT subjects taught in TUT

NTC		NT subject
Interpersonal competences	Influence	
	Negotiations / conflicts	
	Relationships / cooperation	
	Communication	Communicational psychology Business Communication and Negotiations
		Human communication
		Estonian Language and Culture
		Giving Presentations in English
		Revision of Productive Skills in the Estonian Language
		Scientific Communication/Science communication
		Scientific writing
		Visual Communication I, II
Personal competences	Flexibility	Self-management (Free elective)
	Stress tolerance	
	Self management	
	Learning skills and motivation	
Ethics competences	Social ethics	Business ethics
	Professional ethics	Ethics of engineering profession
	Personal ethics	Social Skills and Ethics

Personal competences

Only one subject, Self-management, is taught in TUT to systematically develop students' Personal competences. This subject is free elective (i.e., not included in any engineering curricula as compulsory or optional). The Self-Management course was specifically designed to diminish the student dropout rate, and many first-year students attend it.

Professional Ethics competences

Several engineering curricula include Ethics of the Engineering Profession as a subject which aims to develop students' Ethics of personality, Professional ethics, and Social ethics competences. Some curricula contain a Business ethics course focusing on ethical problems and dilemmas in the business context and issues of Corporate Social Responsibility. However,

these courses tend not to address specific engineering professional ethics questions and issues that engineers may encounter regarding their social responsibility. It appears, although many engineering curricula give students an opportunity to develop Ethical competences, the choice has to be made by students themselves which are the specific concerns requiring the development of Ethical domain competences.

In summary, it appears that the NTCs systematically developed by teaching (compulsory or optional) NT subjects for engineering students in TUT are: a) engineers' work legal issues; b) entrepreneurship competences; c) project management competences; and d) ethical competences.
Engineering curricula partially develop students' innovation competences, and team leadership competences. The latter is achieved mainly by using teamwork in achieving course's aims and therefore does not include thorough preparation for team leadership (e.g., influencing group processes, leading interdisciplinary and multicultural teams).
Supporting the development of following NTC of engineering students cannot be considered systematic in TUT: a) interpersonal and personal competences; b) organization / division management; and c) intellectual property and business law competences.

Discussion
On the whole, there appears to be an imbalance in the NTCs that engineers report using most in their professional work and the NT subjects offered to under- and post-graduate students during their studies. General subjects in engineering curricula are aimed to develop students' general understanding of the world including understanding of safety, and legal rights and responsibilities. Principles of project management, understanding the processes of product development, and principles of ethical conduct in engineering profession have been taught to engineers over the last 50 years.

However, the need to develop engineers' soft skills and their business focus to better serve the learners and their eventual employers (in business and/or industry) has been voiced for several decades. Engineers of the 21st century are expected to possess cross-functional inter-disciplinary knowledge, skills, and attitudes which extend well beyond the traditional scope of technological training. For some time, surveys have suggested that employers find engineering graduates weak in communication and associated professional skills; particularly creative thinking and innovativeness (e.g., Markes, 2006). Understanding the very nature of the organization and their contribution to its performance is also expected from engineers (Meier, Williams, & Humphreys, 2000, Ravenstein et al., 2006, Spinks et al., 2007). But, not possessing those qualities after under- and post-graduate training is not the fault of the student; but rather the question of adequacy of the professional skills requirements in the engineering curricula.

It is argued that knowledge, skills, and attitudes of the 21st century worker must be universally recognised, understood, and taught (e.g., Meier et al., 2000). To be successful, engineers of today can no longer be the isolated innovator; they

must consider also what personal skills are involved in the position, from working with others to successfully communicating ideas with environmental and social sensitivity (Grasso & Burkings, 2010; Wissey, 2000). Thus, developing NTCs adds value to the performance of engineers as well as supports their employability. The results of our studies suggest that the development of the competences in the Personal, Interpersonal, and Professional Ethics domains is highly recommended for competence-based engineering education. As engineering graduates estimate the level of their existing NTCs as lower than those needed in their current professional work; organizations should not expect high levels of these competences from newly recruited engineers.

Analyses of the responses of TUT alumni 18 months after their graduation demonstrated concerns with such competences as: social ones (e.g., teamwork, negotiations, self-assertion), self-expression, presentation, and foreign language. A considerable gap was found between the real competences of engineers and those competencies required for the job. Also, it appears that graduates do not fully perceive or underestimate the influence of NTCs on their employability. This may be that an understanding of the necessity for NTCs only develops after a graduate has already been hired and is working in that job. Of course, perhaps employers do not consider NTCs during their recruiting processes; but they certainly are required in everyday work. Therefore, sadly, when graduates start their professional careers they discover that the level of NTCs required and that they possess are unfortunately, different.

Most NT subjects in TUT are electives; so if the student does not choose the subject the development of specific NTCs is not supported. The gap in graduates' NTCs might be related to the fact that development of the Interpersonal and Personal competences of engineering students is not systematic during their studies and/or is missing. For example, there is no one subject designed for developing leadership and managerial competences at graduate or post-graduate levels. Certain teaching methods (such as project work and problem-based learning) used in technical subjects, are also supposed to support the development of students' personal, interpersonal and leadership competences. However, the attainment of these competencies seems doubtful when we look at the results of alumni surveys. Further, Intellectual Property Law competences were used by approximately half of the engineers we studied. As only a few curricula contain this subject, developing this competence is left on the shoulders of students and/or future employers.

Activities supporting the development of Personal competences up to the highest level are especially important as engineers reported using them practically every day. Young engineers entering the workforce require extra training to develop the Interpersonal competences. In, addition, innovation and creative problem solving is core to engineering. Therefore, we suggest, there should be special courses in engineering curricula to develop students' innovative thinking, creativity, and problem solving skills. At the moment, the aims, learning outcomes and content of subjects supposed to de-

velop students' innovation competences are focused on developing innovation process management competencies and not creativeness. We were pleased to see that developing students' entrepreneurship competences was regarded important in engineering studies with subjects such as Economics and Entrepreneurship emphasising the development of students' entrepreneurial skills.

The finding that inexperienced engineers use all competences less compared to engineers with five or more years' work experience indicates that undergraduate students have a somewhat vague picture concerning the everyday work of engineers. Not all NTCs are equally required during the initial period of an engineer's career; for example the development of managerial competences as well as those of business law will only be required as the engineer's career progresses. Additional training in developing organization/division management and team leadership competences, as well as knowledge of business law will be needed when an engineer is assigned managerial responsibilities as these competences are not systematically developed during graduate and post-graduate studies.

Conclusion

In everyday work, engineers use a broad range of competences simultaneously, and distinguishing one type of competence from another is quite abstract, even on the analytical level. However, the findings of this research are applicable to many areas of WOP; such as work analysis, recruitment, selection, training, development and the appraisal of engineers in companies.

There are many questions left for future research: How are different engineering competences integrated and used in practice? How do different competences or combinations of competences support each other and lead to successful performance? Which competences are the most crucial for success? Which competencies can compensate for the lack of one specific skill? However, these studies have established the need for continuous collaboration between universities and enterprises in order to develop the competences necessary for today's engineering work; and this need is becoming more and more urgent.

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