Információs Társadalom

TÁRSADALOMTUDOMÁNYI FOLYÓIRAT

alapítva: 2001-ben

Főszerkesztő: Héder Mihály

Kiadja az INFONIA (Információs Társadalomért, Információs Kultúráért) Alapítvány

A folyóirat fő támogatója a BME Gazdasági és Társadalomtudományi Kara

Technikai partnerünk a SZTAKI

ISSN 1578-8694

Készült a Server Line Print & Design műhelyében

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A folyóirat a 2008/1. számtól kezdve megtalálható a Thomson Reuters indexen (Social Scientes Citation Index®, Social Scisearch®, Journal Citation Reports/Social/Sciences Edition)

Tartalom

sonal competencies and attitudinal factors. Furthermore, according to graduates' ratings, some competencies have developed more than appears to be necessary at the beginning of their career. These competencies were the most valued in degree programmes. Similarly, some competencies that were least valued in degree programmes were part of the least developed competencies in studies, but also part of the most important competencies for graduates.

ELLEN SJOER, PETRA BIEMANS

A design-based (pre)recruitment approach for new professions: defining futureproof job profiles

In a rapidly developing labor market, in which some parts of jobs disappear and new parts appear due to technological developments, companies are struggling with defining future-proof job qualifications and describing job profiles that fit the organization's needs. This is even more applicable to smaller companies with new types of work because they often grow rapidly and cannot hire graduates from existing study programs. In this research project, we undertook in-depth, qualitative research into the five roles of a new profession: social media architect. It has become clear which 21st century skills and motivations are important per role and, above all, how they differ in subcategory and are interpreted by a full-service team in their working methods, in a labor market context, and in the talents of the professional themselves. In a workshop, these "skills" were supplemented through a design-based approach and visualized per team role in flexibly applicable recruitment cards. This research project serves as an example of how to co-create innovative job profiles for the changing labor market.

EUGENIA STAMBOLIEV

On Care Robots and the Ethics of Tracking

This paper establishes a transdisciplinary exploration of care robots and their tracking capacity as an ethical performance. It does this to highlight the concerns around the ubiquity and availability of data in care contexts. In my attempt to scrutinise care robots beyond being humanoid and sociable actors, but instead as data tracking technologies, I link robot ethics, media and surveillance studies with posthuman and performative ethics to redefine tracking as an ethical microcosm within care robots. I do this, first, by challenging how to look at care robots and robot interactivity, particularly in reference to tracking as an ethical, not necessarily moral, question of interactivity and relationality. This angle will challenge the ethical timing and evaluation around tracking as an inherently ethical relation. Second, by arguing that the common ethical views on tracking are about concerns of privacy intrusion and data infringement while overlooking that a main ethical issue might not be a robotic intention to spy but the availability of data because of robots. Consequently, what deserves more attention in the ethics of robots is the

GREET LANGIE AND SOFIE CRAPS

Professional competencies in engineering education: the PREFERed-way 142

Professional competencies vary across engineering job characteristics. The design of the educational environment should take into account this diversity and enable students to develop career awareness. The European project PREFER (Professional Roles and Employability for Future EngineeRs) has developed instruments to make engineering students aware of the existence of professional roles and their associated competency profiles. These are designed and validated in strong interaction with industry, guaranteeing a discipline-independent, future-proof framework that is ready to implement in the engineering curriculum. In this paper, we describe the integration of this framework in the Faculty of Engineering Technology of KU Leuven, Belgium. The selection of professional competencies based on professional roles, the adaptive level of the professional competencies thanks to electives and the collaborative assessment of the students by experts in professional competencies and experts in technological competencies, are key elements of the new engineering curriculum. All of them are developed thanks to a university-business collaboration. The reformed curriculum will start from the academic year 2020-2021.

LECTORI SALUTEM!

Az Információs Társadalom 2020/2-es száma angol nyelven jelenik meg. Technikafilozófiai és mérnöki oktatáselméleti cikkek érdekes kombinációját prezentáljuk az olvasónak.

Gonçalves (Ecole polytechnique fédérale de Lausanne, Svájc) és társai svájci, kínai, orosz és kolumbiai példákat vizsgálnak arra vonatkozóan, hogy nemzetközi és interdiszciplináris gyakornoki projektek és feladatok hogyan, és milyen eredménnyel mozdítják ki a hallgatókat a komfortzónájukból.

Kálmán Anikó (BME) és Linda Citterio (European Distance and E-learning Network) áttekintő cikket készített a SEFI (European Society for Engineering Education) 2019 konferenciáról bemutatva annak legfontosabb témáit és fókuszait, többek között a növekvő hangsúlyt a mérnökhallgatók „soft" skilljein és az egyre növekvő komplexitáson.

Greet Langie és Sofie Craps anyaintézményük, a belga KU Leuven egyetemén alkalmazott, komlpex kompetenciaelemző és párosító módszertant mutatják be, amellyel új tantervet készítettek a mérnökhallgatók számára.

Nádasi Eszter (BME) a kultivációs elmélet felhasználásával a sebészábrázolások potenciális hatásait elemzi, amelyek a médiareprezentációtól a társadalom szélesebb rétegei felé mutatnak.

Jesse de Pagter (TU Wien, Ausztria) esettanulmányában a robotokra mint emergens technológiákra tekint azt vizsgálva, hogy a társadalmi elvárások hogyan alakítják a technológiát, valamint hogy a technológiával kapcsolatos narratívák sokaságának milyen hatása van az adott technológiába vetett bizalom alakításában.

Veli-Pekka Pyrhönen, Sonja Niiranen és Eila Pajarre (Tampere University, Finnország) kvantitatív alapon elemezték azt, hogy milyen szórás mérhető a mérnökhallgatók önértékelésében a különféle kompetenciáik fontosságát illetően az egyetem elvégzésekor, majd ezt a tanterv elemeivel vetették össze így azonosítva a tantervek megújításának lehetőségeit.

Ellen Sjoer (The Hague University of Applied Sciences, Hollandia) és Petra Biemans (Inholland University of Applied Sciences, Hollandia) a régi munkakörök eltűnésének és az újak megjelenésének hatását vizsgálják az oktatási rendszerre vetítve. Természetes, hogy ez a folyamat óriási kihívások elé állítja mind az oktatási intézményeket, mind a cégeket, amikor mukakörprofilokat hoznak létre. A szerzők egy kísérleti megoldást mutatnak be az új munkakörök pozícionálásához.

Eugenia Stamboliev (University of Plymouth, Nagy Britannia) a „gondoskodó" (egészségügyi) robotokhoz kapcsolódó adatetikai kérdésekkel foglalkozik. Az ilyen megoldások egyik fontos eleme a pontos és állandó monitorozás, ráadásul minél antropomorfabb az adott megoldás, annál több és személyesebb adatot képes gyűjteni. A cikk ennek lehetséges negatív következményeit mutatja be.

Brad Tabas és Klara Kövesi (ENSTA Bretagne, Franciaország) az európai mérnöki tantervek és a fenntartható fejlődés közötti kapcsolatot vizsgálják. A fenntartható fejlődés elősegítésére a képességdiverzitás növelését tartják alkalmasnak a mérnökök köreiben, amelynek felvázolják elméleti hátterét, és bemutatják a gyakorlati problémamegoldó erejét is.

Gareth Thomson (Aston University, Nagy Britannia) 32 alany bevonásával pályakövetéses vizsgálatot végzett gépészmérnökök körében. Vizsgálatának középpontjában a projektalapú tanulás, a disszertációírás, a gyakornoki időszakok hatása volt a későbbi munkahelyi boldogulásukra és előmenetelükre.

Kellemes olvasást kíván

a szerkesztőség!

JOHANNA GONÇALVES MARTIN,
FLORENCE GRAEZER BIDEAU, ERIC HOESLI,
MARC LAPERROUZA AND ROLAND TORMEY

Developing interdisciplinary and intercultural skills in engineers through short-term field experiences

Short-term field study experiences are increasingly popular in engineering education. Where they include an international dimension, they can also develop skills and knowledge needed for working across cultures and in interdisciplinary teams. Such programs can take students out of their 'comfort zone', thereby enabling them to question their previously taken-for-granted assumptions. Here we analyze four different case studies of organizing short-term international field study programs in engineering education which share a methodology of mixing student disciplines and skills, of interaction with people from other cultures or contexts, and using reflection tools drawn from social and human sciences. While such programs appear to directly address skills desired in engineering students, it was extremely challenging to fit them within the constraints of a traditional university program and to have their modes of reflection accepted as valid by more traditional engineering education practitioners.

Keywords: *Field-studies, engineering education, project learning, intercultural education, reflection, interdisciplinary education*

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How to cite this article:
Gonçalves Martin, Johanna, Florence Graezer Bideau, Eric Hoesli, Marc Laperrouza and Roland Tormey. "Developing interdisciplinary and intercultural skills in engineers through short-term field experiences." *Információs Társadalom* XX, no. 2 (2020): 9–18.
https://dx.doi.org/10.22503/inftars.XX.2020.2.1

1. Introduction

Engineers may in the past have been perceived as tool-makers who solve technical problems by applying mathematics and scientific knowledge, however, in a world which is increasingly globalized and complex, the boundaries for engineering knowledge becomes ever more difficult to define (Lehmann et.al. 2008). This has led to shift in emphasis in the formal requirements for the education of engineering students. The American Accreditation Board for Engineering and Technology (ABET), for example, requires that, in addition to knowledge of and ability to apply scientific knowledge and skills, students are also educated to solve problems in ways that take into account global, cultural, social, environmental, and economic factors; to recognize ethical and professional responsibilities; and to function effectively on a team that creates a collaborative and inclusive environment (ABET 2019). One way of trying to meet some of these goals is through the use of international placements. While there is growing interest in international experiences in engineering education, there appears to be relatively few studies that look at how such international experiences are organized in engineering education.

This paper looks at the experience of organizing field-based experiences for engineering and science students. It draws on four different case studies of international field-based experiences in China, Colombia, Russia and Switzerland. The goal of the study was to document the opportunities, challenges and some of the good practices which had been experienced within these cases. The paper identifies that, while such programs appear to directly address the goals of developing what are sometimes called twenty-first century skills with engineering students, the challenge of fitting them within the constraints of a traditional university program are considerable. It also highlights the ways in which the experiences of liminality and alterity can be scaffolded drawing on reflective tools from social sciences to maximize the possible learning of the engineering students.

2. Context

The growth in technological knowledge in the latter part of the twentieth century led to increasing specialisation and diversification in engineering education but also to an increased need for engineers to interact with other professionals and to understand the needs, wants and constraints of the users of the products of engineering design (Crawley et. al. 2014). Economic, social and cultural globalization also changed the context in which engineers work and meant that the development of intercultural skills have also become a priority for engineers (Handford et. al. 2019). These wider set of skills and knowledge are referred to in various ways, including transversal skills and professional skills. One commonly cited framework for making sense of these

skills is the idea of twenty-first century skills (Binkley et. al. 2012). They identify four groups of skills which include:

- Ways of thinking, including (1) innovating and creating, (2) problem solving, decision making and critical thinking, and (3) metacognition and self-regulation in learning.
- Ways of working, including (1) communication skills and (2) collaboration skills in the contexts of heterogeneous and diverse groups.
- Using tools for working, including (1) information tools and (2) technological tools.
- Living in the world, which focuses on skills of (1) global and local citizenship, (2) managing life and career and (3) cultural awareness and social responsibility.

One of the ways in which engineering educators have sought to address at least some of these skills is through the inclusion of international placements or field study. Field studies are commonly used in social scientific disciplines like Sociology or Anthropology and indeed in professional training in disciplines like social work or teaching which draw on such social scientific disciplines (e.g., Wayne, Bogo and Raskin 2010). However, while such placements are becoming more common internationally, not all countries have normalized the practice: in the US, for example, it has been estimated that as few as 3% of engineering students study abroad (as compared to some 20% of social science and business/management students) (Maldonado et. al. 2014).

Students who have participated in international experiences have been found to have experienced a number of benefits, including a measureable increase in participants' intercultural sensitivity (Olsen and Lalley 2012; Davis and Knight 2017), and an increase in ethical sensitivity or in 'global citizenship' (Tarrant, Rubin and Stoner 2013). The idea that contact with those from other social groups can lead to a reduction in prejudice and a development of intercultural competence is not new, indeed the so-called intergroup contact hypothesis is commonly associated with the post-World War II work of Gordon Allport (1954), who hypothesized that intergroup contact will improve intercultural competence when (a) the different groups are afforded equal status in the relationship, (b) both groups work together towards a common goal ('superordinate task') that requires the pooling of their resources, (c) the superordinate task is structured to ensure there is not competition between the groups, and (d) the contact between the group is supported by an institution or authority that is meaningful to both groups (Allport 1954). Allport's conditions are perhaps all the more important to bear in mind in the context of international contact, where post-colonial implicit cultural beliefs may mean that (well-educated) western students may easily slip into post-colonial mindsets when faced with an experience of 'the other' (e.g. Loomba 2005; Sin 2009). A meta-analysis of 515 studies on intergroup contact has found support both for the general hypothesis that contact, on average, reduces prejudice and for the added value which arises when Allport's four conditions are met (Pettigrew and Tropp 2006).

One important dimension of being confronted with alterity in the form of different social and cultural systems is that it can allow the 'decentering' experience which is often identified as being central to the epistemology of sociology and anthropology but can be unsettling for students who can struggle with the idea that much of their 'taken for granted' knowledge, beliefs and practices are in fact culturally specific and situationally contingent. Some engineering educators have recently adopted the anthropological concept of 'liminality' to explain these opportunities (Rose et. al. 2018): the term 'liminal' indicates a sense of disorientation, typically during a rite of passage, when a person's socially ascribed status, identity or role is changing. Liminal experiences are sometimes uncomfortable and emotionally challenging for learners as well as being potentially rewarding in terms of new learning; as such, the concept of liminality draws attention to the 'whole body' nature of the learning experience which encompasses physical and emotional experiences as well as intellectual ones.

3. Methodology

This paper looks at the experience of introducing short-term field studies which include an explicit focus on cultural difference and alterity into engineering programmes. As with other studies in this domain (Maldonado et al. 2014), a case study approach is used. A case study is defined as an empirical enquiry that investigates a contemporary phenomenon in its real life context using multiple sources of evidence, and in which there are generally more variables of interest than data points (Yin 1994). As with multiple experiments, multiple case studies allow for cross case comparison which can help to make clear what it distinctive to a single case and what is a feature of the wider phenomenon (Hakim 1987).

This paper is based on an analysis of four different case studies of international experiences offered to engineering students. Initial interviews were conducted with three of the four field study coordinators to explore if there was something meaningful to be gained from a comparative case study approach. Written notes of the meeting were collected and transcribed. Following this, data was collected from each of the four coordinators using a series of open-ended questions which were responded to either in writing (2 coordinators) or in a one-to-one interview setting (2 coordinators). A thematic analysis of this data was followed by a group interview/discussion with three of the coordinators (also transcribed by hand) which provided a further opportunities to tease out themes and comparisons, as well as an analysis of documentation and written reflections by the coordinators. The emergent themes were reflected back to and clarified with the coordinators.

The key themes which emerged from this data collection were:

- the development of interdisciplinary and intercultural competence in engineers was achieved through using the concepts and methodologies

of social sciences to structure their reflection. Key concepts linked to this theme were interdisciplinary work, reflection, and liminality.
- the challenges of 'fitting' interdisciplinary international experiences into the curriculum of the school. Key concepts linked to this theme were academic discipline, institutional culture, and power.

4. The Case Studies

Field study location	Lausanne, Switzerland; Bengaluru, India; Shanghai, China	Greater China – Shenzhen and Hong Kong	Russian Arctic and Yamal peninsula	Amazon basin, Leticia City, Colombia
Nature of project/ activity in field study location	International summer schools (academic courses and applied field visits)	Applied engineering design project with prototyping activity in China	Academic courses & Field research (e.g. oceanographic research, or civil engineering historical reconstruction)	Scientific & social research or a design project
Typical number of students per group	15–30	24	23	14
Balance between technical university students and those from other schools	75% STEM. Others from Social and Human Sciences, & Asian studies.	50% STEM. Others from Business, Industrial Design & Media Interaction Design.	50% STEM. Others from Social and Human Sciences, Environmental Sciences, Global health, & Law.	40% STEM. Others from Health, & Social and Human Sciences
Length of field study component	6 weeks	2 weeks	3-4 weeks	3 weeks
Years active	2009–2016	2015-present	2015-present	2018-present

Table 1. Overview of the Case study field studies programs

All four case studies are based on field study opportunities offered to students in scientific and engineering programmes in a European technical university. The four field study coordinators are all social scientists, and are all university teachers in the institution responsible. They each provide academic leadership and direction for the field study that they coordinate. The field studies in question are offered across a number of universities so that engineering students are mixed in groups with social science students.

The four case studies are:

- An international summer school programme in which students participated in summer schools in Europe, India and China, studying the history, political science, anthropology, cultural studies and economics of each location, including field visits and language learning
- A hardware innovation programme, in which students design a connected device in their 'home' location, then travel to China to work to produce a prototype
- A Russian Arctic research program, in which students work on oceanographic, climate, historical, and geographical research and documentation projects in the Arctic and Siberia
- An Amazon basin field study, in which students research the effect of urbanisation on indigenous people's lives focusing on the eco-epidemiology of health or on the development of on-line tools to aid indigenous language learning.

There are a number of similarities between the four programmes:

- the field study is either an option for students within their programme or offered outside the programme
- the students engage with a different culture and language
- students work on a project which involves some combination skills from social and natural sciences
- reflective activities while in the field study location provide an important part of the learning in the field study.

A number of issues and challenges have been experienced by those responsible for the programmes. These are described below.

4.1. Reflection based on social science epistemologies

One of the challenges faced by engineering students in learning from field studies is that learning will require some reflection. The field study is a manifestation of liminal space – a space away in which a person is separated from their 'normal life' and in which the taken for granted becomes uncertain and a change in beliefs but also identity becomes possible. The journey through this liminal space is scaffolded by teachers who engage students in a process of reflection. But students may well be unclear as to what it means to 'reflect'. Indeed, this issue is not restricted to engineering education: McGarr and McCormack (2014) note that, although 'reflective practice' is the dominant paradigm in teacher education, student teacher's engagement with reflection is typically quite superficial, in part because students are being trained within a system which is essentially conservative and focused on conformity to established practices (see Kazeronian and Foley [2007] on the similar dominant paradigm in engineering education).

A strategy shared across the case studies is to use the conceptual frameworks and methodologies drawn from social sciences in order to make clear to students what it means to engage in 'deep' reflection on their experiences. Students on the China field trip, for example, draw on practices from management studies to draw up customer profiles, value propositions and business models for both Chinese and Swiss markets. Students who participate in the Amazon field study are required to have a fieldwork notebook and to document their own experiences in anthropological field notes on the practices, concepts, and emotions they experience or observe (Wagner 1981). Students on the Siberia field trip are also involved in documenting their experiences drawing on methods and conceptual tools from investigative journalism. As such, 'reflection' moves from being something fuzzy and unclear to being clearly framed as 'thinking like a social scientist'. Interdisciplinarity is, then, not just a function of having students from different disciplines present in the team, but also as a result of having students engage with the methods and concept of disciplines other than their own. Such (inter)disciplinary tools are perhaps all the more important since both 'cultural shock' and post-colonial images of 'the other' can get in the way of student learning. The interdisciplinary use of social scientific concepts and methods by engineering students in this setting can enable a 'slowing down of reasoning', which in turn allows students to avoid jumping to post-colonial conclusions.

Not all students engage positively in this task. Some remain resistant to the use of social scientific methods and concepts while others seek to divide the tasks in their group in such a way that it allows them to focus on their pre-existing skillset rather than on developing the new thinking skills which are intended to underpin their reflections. This provides a difficult challenge which needs to be mediated by the fieldwork academic co-ordinators in interaction with the students.

4.2. The 'value' and 'costs' of field study experiences

All of the field study experiences described here involve substantial investment from students, including investment of time during the summer to travel to the field study location, and paying a portion of the associated travel and accommodation costs. While some students are 'rewarded' by academic credit for participation in the field study, in other cases the field study seems to be regarded as being, in itself, a reward for this investment: as one of the co-ordinators put it, "…the trip itself was viewed as the reward. The idea of the school was very much [to say to the student] 'you get a free trip to China, so you should do the work required [by the project] for free [i.e., without getting academic credit]'".

Indeed, at various times, the field study has struggled for acceptance and legitimacy within the technical university. There was initially a resistance on

the part of the school to assign credits to the field study in the same way as they would be assigned to traditional courses. First, the field study needed to establish a track record which justified its inclusion. This meant that newer field studies (such as the Amazon basin program) had to establish their value by running for a number of years without significant academic credit before being accepted as 'creditworthy'. It is notable that this is a higher bar than is set for traditional courses offered (which received academic approval on the basis of a short written description rather than having to be first offered without credit).

One of the features of a field study is that the students are engaged in a realistic professional activity; either a design activity, a scientific research activity, or in some mix of the two. This development has probably made it easier to 'legitimate' the field study in that this superordinate activity (to use the language of Allport) is clearly an engineering or scientific activity. At the same time, it also poses potential difficulties in that the superordinate activity itself becomes central to the experience and reflection on that practice runs the risk of being marginalised. Where credits are now assigned to the field study, the majority are assigned for the product of the work undertaken. The 'voluntary' or underweighted nature of the social scientific reflection places significant additional pressure on coordinators who are left in the role of having to negotiate with students their commitment to group project activities.

The challenges of embedding in the curriculum are increased when multiple universities are involved. Within those field studies that are currently embedded in a curriculum (the China and Russian Arctic field studies) in the technical university, two different models of doing this emerged. In the case of the China program, each university managed the process differently, with, for example, different weights being assigned to the field study in different institutions. As a result, students were sometimes doing similar work for different credit. As noted above, this puts additional pressure on coordinators who are left in the role of having to negotiate learning activities with students. In the Russian field study, a single model for the program was developed and offered to different partner universities who either chose to 'buy-in' or not. Perhaps because the program was perceived as prestigious, this did not have a negative impact on student uptake.

5. Summary and Conclusions

Field studies can play an important role in enabling engineering students to learn through experiencing engineering and scientific practices in different social and cultural settings, and through reflecting on those experiences. Based on the case studies discussed here, there is reason to think that there are a number of characteristics that should be considered in designing such experiences. These include (a) working on a project which requires inputs

from multiple disciplines and building teams drawn from multiple disciplines (and perhaps multiple universities), (b) physically moving the project group to a fieldwork location radically different from a classroom setting, (c) interacting with people from other cultures or contexts in a way that ensures that both students and those from the 'host' culture are equally necessary to the success of the project, (d) using concepts and methodologies from social sciences (e.g., methods like customer profiles and value propositions from management studies or fieldwork notes from anthropology) to structure 'reflection' in the liminal space that students enter, and (e) valuing the field study experience and the reflection by providing it with appropriate academic credit.

At the same time, embedding these experiences in an already crowded curriculum however, is not without its challenges. First, the field studies discussed here differ from traditional courses. They do not follow the traditional timetable or semester structure, and their experiential nature means that what and how students learn may be hard to describe in advance within the limitations of a taxonomy of cognitive outcomes. All of this meant that the bar to be accepted within the academic program seems higher for field studies than is the case for more traditional courses. Embedding within the formal program does, however, appear to be worthwhile, given the challenges for coordinators raised by more ad hoc solutions.

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Complexity as new normality: What is going on?

A response collected at SEFI 2019

In this paper we aim at presenting SEFI Annual Conference 2019 from the thematic point of view. Authors have creatively reacted to the main theme 'Complexity as the new normality' by targeting different areas of education where complexity arises: project work, curricular changes and connection to the job market are just few examples. The importance of soft skills alongside the core engineering background has motivated an intense discussion on the role of teaching in developing students' skills. We identified the most represented topics at SEFI 2019 and we reflected on the importance of less represented topics such as Lifelong learning, Talent management, Sustainability and 4th Industrial Revolution. We based our decision on the relevance of such topics for shaping the future engineering education practices. We hope to spark the readers' interest and motivate to explore the articles in this thematic issue as well as the Proceedings of SEFI 2019 Conference.

Keywords: *SEFI conferences, teaching engineering, learning models, lifelong learning*

Acknowledgement

We wish to thank all contributors to SEFI Annual Conference 2019. We apologize to the authors we did not cite, especially if they are involved in the practices we have mentioned in this article. We thank Alessandro Tarchini (MathWorks) for generating the word cloud in Figure 3.

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How to cite this article:

Kálmán, Anikó, Linda Citterio. "Complexity as new normality: What is going on?" *Információs Társadalom* XX, no. 2 (2020): 19–32.
https://dx.doi.org/10.22503/inftars.XX.2020.2.2

1. Introduction

1.1. What is SEFI

SEFI (European Society for Engineering Education) is a non-profit international organization and the largest network of engineering education professionals in Europe. Established in 1973, SEFI aims at improving engineering education and strengthening the image of the engineering education professionals.

The network comprises academics, teachers, students and engineering experts from institutions, associations and corporate partners.

SEFI organizes a scientific annual conference, activities for the deans of Engineering Education, ad hoc seminars/workshops led by SEFI Special Interest Groups. SEFI society is involved in scientific publications such as the European Journal of Engineering Education and participates in ERASMUS+ and Horizon2020 projects. In addition, SEFI cooperates with partner and sister engineering organizations in Europe as well as worldwide.

Several SEFI sister organizations were indeed represented at SEFI 2019: ASEE (American Society for Engineering Education), IGIP (International Society for Engineering Pedagogy), BEST (Board of European Students of Technology), CSEE (Chinese Society for Engineering Education) and ASIBEI (Asociación Iberoamericana de Instituciones de Enseñanza de la Ingeniería).

The SEFI annual conferences focus on how to teach, educate, motivate and help the engineers of the future to succeed. SEFI is strongly committed to keep up with the ever-changing trends in the society and culture by adapting the targets of the conferences according to the new roles and expectations set up by the universities.

1.2. SEFI 2019

At SEFI 2019 there were 393 participants from 41 countries, where Hungary and The Netherlands were the most represented. The conference programme consisted of four keynote lectures, 1 plenary session focused on the relation between industry and academia, 47 paper sessions, 32 workshops, 11 Special Interest Group meetings with plenary pitches and 1 poster session with plenary pitches. The paper, poster and workshop sessions were organized to accommodate a high number of accepted contributions: 128 Concept Papers, 61 Research papers and 32 Workshops. These publications were accepted at the end of a strict evaluation process, based on a double blind peer review process.

While submitting their contribution, authors were asked to characterize it by choosing a maximum of two topics.

At the 2019 conference, the following topics were suggested:

- Diversity in Engineering Education?
- Fundaments of engineering education: mathematics and physics
- Gender, inclusion and ethics
- How to detect and attract talents with new generations of learning technologies and networks?
- Impacts of demographics in tertiary education
- Integrated learning environments for the digital native learners
- Lifelong learning
- Network Capital (in the production of knowledge and the popularization of science)
- New Complexity quest in engineering sciences
- New notions of interdisciplinarity in engineering education
- Open and online teaching and learning
- Strong demand for democratic involvement in educational processes
- Sustainability reflecting the complexity of modern society
- Talent management
- 4th Industrial Revolution

One of the ideas behind these topics was to show that through the utilization of data derived from simulations and the production of resources for work-based practical learning as well as the integration of the human-machine intelligence model for the purpose of continuous knowledge enhancement, the development of industrial automation and info communication technologies opens up opportunities for lifelong learning. For the improvement of efficiency and access to the most varied new sources, and in order to provide such sustainable services that reflect the complexity of modern societies, high expectations and pressure are posed on education. In our 'fragmented age', the operational environment is characterized by turbulence, interdependence and complexity. For the transforming world of engineering education, more recent challenges increasingly come from the complex sociocultural, economic, structural and political sectors. It is an expectation towards university science and technology to develop excellence, explore and attract talents and collect the inputs of practicing experts, resulting in cooperation surplus. In the meantime, we also witness the specialization of education and the emergence of new skill sets. Our pragmatic and creative education experts are capable of efficiently promoting the diversity profiles of the education of scholars with new insights and intelligence, combining the entrepreneurial mindset with mental agility, mobility, flexibility and curiosity.

László Ábrahám, CEO of National Instruments Debrecen, intervened at SEFI 2019 with a workshop specifically devoted to present successful cases of cooperation between academia and industry. At this session representatives of LEGO, Knorr-Bremse, Continental, Ericsson and Schaeffler were also invit-

ed to present the outstanding Hungarian industrial practices and promote a panel discussion on how to support higher education innovation in Hungary.

SEFI 2019 Annual Conference has explored a wide range of the current available methods for teaching engineering subjects in our increasingly digitalized world.

Figure 1 shows the topics proposed at SEFI 2019 and how many times authors have chosen them. As the conference motto was 'Varietas delectat', authors were encouraged to submit contributions also pertaining to other topics than the ones suggested. As a result, 'Another topic' was the most frequently chosen topic. 'New notions of Interdisciplinarity', and 'Diversity in Engineering Education?' were also widely picked. The choice of the first topic reflects the understanding that today's engineering problems can only be solved by a multi-disciplinary approach, the second that institutions are focusing on different equally important priorities. 'Lifelong learning' was also a popular topic, reflecting the importance of continuous professional development after studies, hence the necessity to build a culture of lifelong learning during studies.

On the other hand, none of the authors chose the topic 'Network capital' in the sense of social capital. This may be explained in different ways. It is possible that the authors have not found any correlation with their current research. It is also possible that it is somehow given for granted and already present in the discussion, but not explicitly addressed.

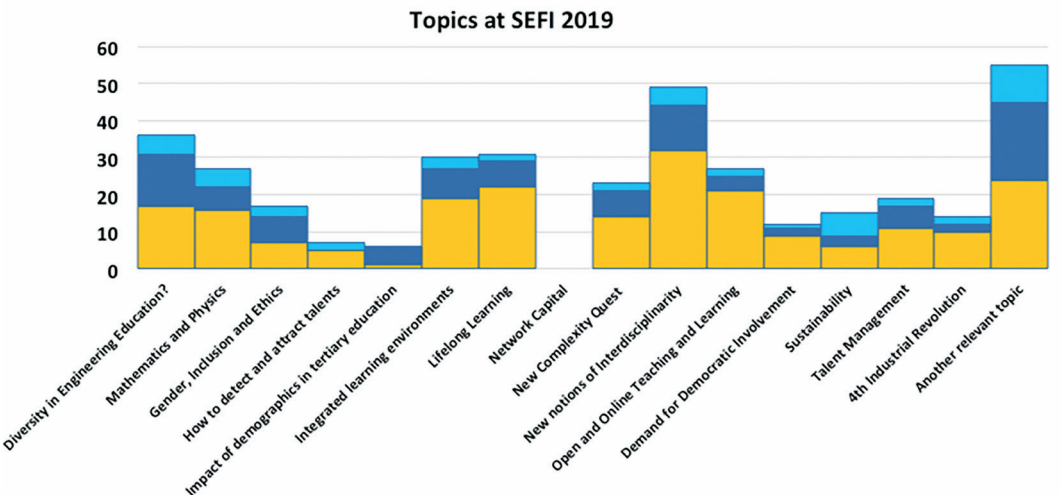

Figure 1. Number of times each topic was picked at SEFI 2019 in concept papers (yellow bars), research papers (dark blue bars) and workshops (light blue bars). Authors could choose maximum two topics per contribution.

All articles - except for the ones presented as posters - were grouped according to their topic into sessions of 60 or 100 min each. Workshops (100 min each) were not classified into topics in the conference programme and were running in parallel to the paper sessions.

Figure 2 shows how many sessions we offered in the different topics. 'Mixed topics', 'Interdisciplinarity' and 'Diversity' sessions were the most represented topics, in accordance to the topics assigned by the authors to their contribution. Note that Figure 1 reflects the topics assigned to all contributions, while Figure 2 does not include workshops and papers presented as posters.

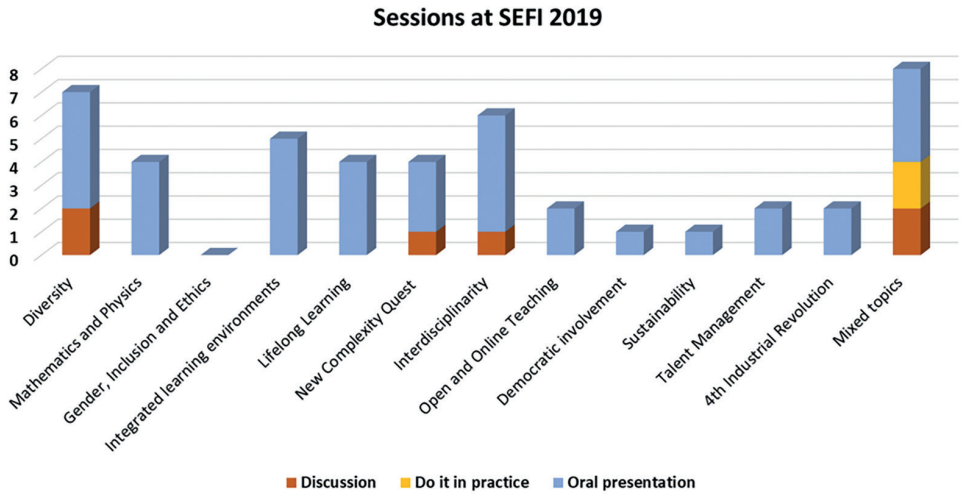

Figure 2. Number of sessions at SEFI 2019 per topic. In each session papers were presented in one of the following formats: discussion, do-it-in-practice, oral presentation.

We recognize that each paper touches upon a larger number of topics and we miss from the analysis a deeper classification of all papers that fell into the categories 'Another topic' or 'Interdisciplinarity'.

In order to infer which are highly discussed topics we chose to address directly the full text of the SEFI 2019 Conference Proceedings. We present the most mentioned terms in the text based on a word cloud analysis (Figure 3). The cloud shows that the authors' interests revolved primarily on engineering skills, curriculum/course design, project-based (group) work and learning process and methods, which is expected from a conference in engineering pedagogy.

Based on these initials considerations we reflect upon what is the State of the Art in Engineering Education and what is needed to achieve in the next 10 years in Engineering Education. Graham's report (2018) contains a comprehensive overview of both challenges and constraints of the sector, along with selected case studies from the top-rated engineering programmes. Important barriers identified by the study were the difficulty of alignment between government and higher education goals and the little reward attributed to teaching achievements in university career development. These topics were not strongly developed during SEFI 2019.

Figure 3. Word cloud containing the most mentioned words in the SEFI 2019 Conference Proceedings after excluding the following words: 'engineering', 'engineer', 'education', 'university', 'student', 'Budapest', 'Hungary', '47th', 'annual', 'conference', '20th', '16th', 'September', '2019'.

The Nordic Engineering Hub – as mentioned by Gumaelius and Kolmos (2019) – pointed at sustainability, employability and digitalization as the three major challenges to meet in the years to come. In agreement with these reflections, we selected the following SEFI 2019 topics: Lifelong learning, Talent management, Sustainability reflecting the complexity of the modern society, 4th Industrial Revolution, that are closest to challenges mentioned by Gumaelius and Kolmos.

The first two selected topics – Lifelong learning and Talent Management – were widely discussed by the contributors to SEFI 2019 (even when not explicitly chosen). Addressing these topics may represent one response to the challenge of employability. Within Talent Management, we identified a subtopic that we call 'Engineering skill set'. Despite the topic itself was not explicit at SEFI 2019, the word 'skills' is dominating the cloud in Figure 3, denoting the intense discussion around competences needed by the future engineers. The findings in Graham's report confirm the importance of employability (measured as time needed for students to find a job after studies) as a key indicator of high performing institutions.

Educators are well aware that a multidisciplinary approach is needed to shape the professional figure of the future engineer, who can deal with multidimensional problems such as sustainable development and the changes brought by the 4th Industrial revolution. This is reflected in the frequent choice of the topic 'Interdisciplinarity'. Despite authors frequently mention

the necessity of multidisciplinary curricula, we perceive the presence of contradictions and barriers in actually facing them with concrete actions. As shown by Gumaelius and Kolmos (2019) – the educators have reservations concerning changing the curricula in favor of a more generalist approach, where core skills may risk to be learnt more superficially. Another typical barrier is the need for harmonizing theory and practice, in order to support a proficient dialogue between academia and industrial partners.

We then perceive these two topics - Sustainability reflecting the complexity of the modern society, 4th Industrial Revolution - as quite vulnerable, despite their importance. Hence, in the following sections we aim at survey some of the papers presented at SEFI 2019 in order to detect the response of the authors to these crucial themes.

2. Overview of selected topics

2.1. Lifelong learning

„Without continual growth and progress, such words as improvement, achievement and success have no meaning”. (Benjamin Franklin)

Tun Zaw and Kálmán (2019) collected a number of definitions of lifelong learning present in literature, one of which is: ‘the accumulation of skills and qualifications as a means of coping with changes and uncertainty in professional practice’.

Indeed many papers that were classified under the topic ‘Lifelong learning’ focused on how to build and support a culture of continuous learning, that may enable students to cope with future challenges, for instance employability. Authors have discussed methods of teaching as well as ways of developing students’ soft skills.

In addition, authors presented how specific software can support teaching and learning.

Among the discussed methods, PBL (problem- and project- based learning) is an evergreen model. Through PBL, students are able to personalize their learning and memorize deeply for a longer time.

Self-directed learning is an important method, mentioned by a number of authors. By self-managing, self-monitoring and self-reflecting, not only students, but also educators can get a deeper vision of what needs to be done and corrected in their practices and behavior. The method builds on the idea that reflective practices are essential to the lifelong learner. Tun Zaw and Kálmán (2019) present a concise literature review on this topic.

Another frequently mentioned method at SEFI 2019 has been Agile learning. This learning concept is widely used in companies for transferring the

required competencies to employees. Through this method, skills are learnt directly while dealing with real-life problems, with coaching from more experienced employees.

Several authors at SEFI 2019 (Longmuss and Hoehne; Sten et al.; Velichová and Gabchová) applied and discussed methods based on the principles of Agile learning, customizing it to their own view and experiences. Longmuss and Hoehne (2019) suggest two successful methods to support agile learning: Learning cards and Kanban board. Learning cards are designed by the teachers in order to guide the learning process and save time used to search the literature. The well-known Kanban principles of dividing the work into smaller tasks and visualize them into four groups (To Do, In Progress, Check, Done) is used to sort and keep track of the learning cards, that are then integrated and sorted as tasks. In this way the students' learning path is facilitated and monitored.

Velichová and Gabchová (2019) investigated the level of knowledge acquisition and ability to solve problems of students who were taught Mathematics with eduScrum method. In parallel, Mendonca, Pinto and Nicola (2019) obtained a strong positive feedback from Mathematics students who were taught with this method.

Sten et al. (2019) focused on Scrum - widely used in Agile learning - and proposed a combined approach between Agile Scrum and Lean Kanban (Scrumban). The authors received very positive feedback especially on the formative evaluation in the Scrumban process: students appreciated assessment during the course rather than just at the end.

Formative assessment is typical in online learning where virtual coaches and tutors can also regulate learning and certainly support students' continuous assessment, while relieving some of the teachers' workload.

The use of peer assessment is also quite popular in order to relieve teachers' workload and engage students more. IPAC (Individual Peer Assessed Contribution) by Grammenos at al. (2019) serves as a pedagogical tool to train graduates to give professional feedback to each other within group projects. Seatwo (2019) showed that the use of this tool increased engagement and motivation of students to learn.

All these methods should guide students to become self-motivated individuals, constantly seeking for personal development.

Concerning development of the teachers, the Chinese Academy of Sciences observed that knowledge is updated at high speed and researchers of its network needed a platform for learning the required skills in short time. Zhao et al. (2019) described in detail how the Chinese Academy of Sciences developed a special learning environment - CASmooc - with the purpose of connecting the scientists of the CAS and allowing them to learn new skills, for instance through micro courses.

The content of this platform was built on the basis of other worldwide successful platforms and by surveying the needs of 872 researchers of different title

level. These researchers identified in particular the following needs: to learn in a short time about interdisciplinary content, to gain knowledge beyond their own field of expertise, and to acquire skills in scientific management and literacy.

Online platforms such as the one created by the CAS are being developed and updated continuously as a response to support and nurture the lifelong learning mentality both in students and educators.

2.2. Talent management

At SEFI 2019 the concept of 'talent' has been present in two topics, containing the questions:

- **How to attract talent?**
- **How to manage talent?**

In today's increasingly growing world, recruiting and nurturing talent is challenging. There are already steps taken to help individuals along their ways from elementary school all the way until the end of university. First, these primary institutions need to find enough dedicated and passionate people for the given science. Second and most importantly, secondary schools, workshops and workplaces need to make sure that whenever students are ready to join them, they feel welcome and are offered up-to-date opportunities.

For maintaining the quality of both recruitment and development, lower ranking universities should highly focus on building a reputation of excellence. Engineering universities are building the right environment for the students by creating professional education system in engineering specialization, extracurricular and networking activities, offering exceptional employability perspectives with access to highly recognized positions. In order to achieve such target, engineering schools shall learn from other highly ranked attractive environments (Moulignier et al. 2019).

Recruiting talent may start at a very young age. In order to foster the interest in STEM studies in future generations, there are several universities in the world that organize the so-called „Children's University Programmes". These programmes are mostly summer camps, even if sometimes they last for a whole academic year. The objectives are to offer insights and to broaden the kids' interest in scientific fields at a very young age (8-14). Through these camps kids are often advised and guided by actual university students around campus. In addition, the kids need to fulfill some teamwork projects' requirements that help them develop cooperative skills (Dallos et al. 2019).

The quality of higher education has been developing but still it is not developing fast enough to keep track of the scientific advancements in research. This gap requires both the students and the teaching environment to expand the curriculum with workshops, camps, internships and insights into the profes-

sion, research involvements. These are key assets to become a true professional in the field of studies with quality and up-to-date knowledge. Indeed newly graduated students may get lost when their acquired skills are not in line with those required by the job market. This issue has created discussion and constant attention to study programme building. In the view presented at SEFI 2019, the choice of subjects and field work should both support the role and job but most importantly the skills that students will later on use in their future career.

2.2.1. Engineering skill set

Inclusion of soft skills into degree programmes has become increasingly important during the past 20 years all over Europe since employers started putting more emphasis on graduates' soft competencies such as team working, leadership and communication (Pyrhönen et al. 2019).

Hence, some engineering curricula are adapting and hosting multi-disciplinary as well as cross-cultural projects in response to these needs. Even though the importance of such competencies (next to the knowledge of core engineering subjects) has been largely recognized, there are differences in how universities have incorporated them into their curricula and how competencies are valued in degree programmes (Pyrhönen et al. 2020, p. 71). Leandro Cruz et al. (2019) - that was awarded the Best Student Paper at SEFI 2019 - have addressed this topic with a special focus on communication skills. Engineers are prompted to refine their communication skills in order to manage the human resources and handle more successfully the relations with customers and suppliers.

Today's students can learn by themselves a lot easier with all the data available online for them. More individuality is being involved everyday into self-development, just because there is decreasing need to transfer the information from teacher to student. This makes a huge difference in higher education systems as well as in post-studies learning. Nevertheless, students need to be guided through an increased amount of available material and deep research is needed to prove whether the data sources are valid. Critical mind set is therefore an essential skill for future engineers.

Craps et al. (2019) explored congruency between career choices compared to students' competencies and interests. The authors found that circa 20% of the students do not have a clear self-perception and only half of the students that are aware of their capabilities can align themselves with the job roles. A deeper self-insight and awareness of the professional role are therefore clearly envisioned.

Introducing and practicing entrepreneurial skills is a powerful strategy to train future engineers. The Swiss DTI (Department of Innovative Technologies) Startup Garage created an opportunity for young students to develop, try and take advantage of their entrepreneurial skills (Citraro et al. 2019). The ideas are collected through an innovative App (PingeIApp) that matches students' ideas

with potential mentors. A dedicated committee evaluates the ideas and chooses the students who will have the opportunity to develop their idea into a Start-up. After each academic year, a supervising crew decides whether students can maintain their status as 'Idea Startupper'. The main objective is to create an innovative and ever-developing teacher education and teaching practice. The programme's number one advantage is to help young students to experiment themselves as entrepreneurs without any risk and learn to become one.

2.3. Sustainability reflecting the complexity of modern society

We support the idea that achievement of the Sustainable Development Goals requires a complex, multidisciplinary approach, where experts representing different fields are able to collaborate and negotiate.

Zilahy and Zsoka (2019) - that was awarded the Best Concept Paper at SEFI 2019 - believe that the focus of future trends in engineering education should shift from the content of teaching to methodology. The authors presented and advocated the use of three major methods: 1) role plays; 2) social innovation labs; 3) consultation projects with the participation of civil sector organizations.

Role plays are simulations where students can assume fictitious roles and learn to discuss and negotiate solutions to real life problems. The advantage of applying this method is that students are challenged to understand the complexity of issues such as climate change and draw input from different disciplines.

Social innovation labs are learning practices that aim at connecting innovation to the real needs of society and are especially well suited for STEM universities.

Consultation projects are based on interaction between students and civil organizations such as NGOs with the purpose of involving students into real life problems. Such projects are run with the participation of a consultancy agent.

Integration of such practices into engineering curricula definitely enriches the learning process.

The software CES EduPack (Granta Design) presented by Fredriksson and Dwek (2019) and Fredriksson and Fung (2019) represents a unique tool to teach sustainability concepts to students as well as professionals. This package may support Materials Education across Engineering, Design, Science and Sustainable Development. The targeted example at SEFI 2019 has been the issue of plastic waste: as plastic's durability is threatening our planet, it is very important to encourage future material engineers to reduce and later avoid the use of plastic materials and achieve a sustainable product life cycle. Such initiatives certainly increase critical thinking and awareness in product design and development.

Both experts and students can benefit from the above-mentioned practices by getting deeply engaged and more motivated to act. The complexity of our

society requires more and more people to look at the sustainability goals as their own personal objective to unite as one and behave regarding to that.

2.4. 4th Industrial Revolution

Sustainability and Industry 4.0 have been dominating debates as the most pressing challenges for society in general and for engineering in particular. Industry 4.0 is a vision on how new technologies will play a key role in the future. As climate change is such an urgent issue, it is expected that the vision of Industry 4.0 includes and addresses sustainable development goals by integrating targeted strategies throughout the entire production and supply chain.

Some research shows that Industry 4.0 will fundamentally change the content and complexity of jobs, because of the different interaction between technological developments, especially in automation, optics, and big data.

Peters et al. (2019) - that was awarded the Best Research Paper at SEFI 2019 - investigated how Industry 4.0 is affecting academia and which competencies CEOs and HR directors are actually looking for. As addressed by the authors, it is crucial to nurture the dialogue with industries and understand which competencies are required. Engineering education shall adopt the new concepts and prepare students to acquire such competencies.

According to employers, future tech workers need 1) a good understanding of the business and business processes, 2) the motivation to develop themselves continuously in order to stay up to speed with new technologies, 3) the ability to collaborate with tech workers of other disciplines.

Adjusting to the newest technologies and cooperating with the opportunities Industry 4.0 is offering people can highly affect efficiency and will lead, in the long term, into knowledge diversification. The progress in industrial automation and ICT opens new possibilities for lifelong learning, utilizing data from simulations, work-based practical learning and integration of human-machine intelligence models for continuous knowledge enhancement.

Education must be visionary to reach efficiency gains, new sources and to offer sustainable services that reflect the complexity of modern societies.

The societal implications of topics such as Industry 4.0 and Sustainability are huge and indeed the public opinion is often pointing at engineers as the problem-solvers. Therefore we expect that popularity and relevance of these topics increase also in Engineering Education.

3. Conclusion

Once again SEFI has provided an up-to-date networking forum for international engineering experts. Furthermore, SEFI has been succeeding in acting as a bridge over the gap being created between students and professionals.

The variety of topics at SEFI conferences shows the wideness of the current interest and the diversified engagement in the field of engineering education.

The increasing instability of the working environment requires engineering education to continue creating and strengthening students' skills for dealing with long-term uncertainties.

In parallel, there is need for acknowledging the efforts of teachers by adding value to their profession.

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Surgeons, surgeries, and operating rooms in television medical series

The longest-running American prime-time television medical series, *Grey's Anatomy* represents a society in which gender is not a potential career barrier in surgery. Focusing on an iconic scene of the series, this article brings media studies together with the history- and philosophy of surgery to provide a qualitative analysis of this portrayal on three levels: surgical procedure, protagonist, and place. Following previous studies on medical drama series, the theoretical framework of the article is cultivation theory. Some elements of the genre – like the realistic hospital setting and the authentic usage of medical jargon – might strengthen the likelihood of content cultivation. Finally, I discuss the potential positive and negative effects of the way how this popular series depict female surgical careers.

Keywords: *television, medical drama series, popular culture, medicine, cultivation theory*

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How to cite this article:

Nádasi Eszter. "Surgeons, surgeries, and operating rooms in television medical series." *Információs Társadalom* XX, no. 2 (2020): 33–54.
https://dx.doi.org/10.22503/inftars.XX.2020.2.3

1. Introduction

Successfully finishing a life-saving abdominal surgery, Meredith Grey (Ellen Pompeo), attending general surgeon, stands in the operating room and watches the broadcast of the Harper Avery Award Gala. As one of the candidates for this distinguished surgical prize, Grey should be at the ceremony; however, she decided to operate instead. She is a nominee because of the game-changing abdominal wall transplantation technique she developed. Grey wins, which means her innovation is the most remarkable surgical achievement of the year. Her colleagues celebrate Grey in the OR, and its gallery: in the crowd, there are outstanding female surgeons from different racial backgrounds. The representative of the prestigious Harper Avery Foundation is a black female surgeon. Surgery is an open field for talented, hardworking people, regardless of their gender and race. At least, this is what the long-running, award-winning television medical drama series, *Grey's Anatomy*, represents about surgical careers.

Television medical drama series are *"pre-scripted, fictional entertainment television shows in which the main events occur in hospitals and the main topics are the diagnosis and treatment of disease or injury"* (Lee and Taylor 2014, 14). The first medical drama premiered in 1952 (*City Hospital*), and despite some downturns, the genre is still popular. Surgeons are core characters of the genre from its early days: the two highly successful medical series of the ,60s (*Dr. Kildare* and *Ben Casey*) both had surgeon protagonists (Turow 2010).

Academic receptions of medical drama series highlighted that these productions serve as an information source for the audience (Murphy et al. 2008; Rideout et al. 2008; Jan and Slater 2013; Lee and Taylor 2014; Jessica Bodoh-Creed 2017). Previous empirical studies and content analyses investigated how medical drama series affect the knowledge, attitude, and behavior of the audience towards specific themes that appeared in these productions. By applying a survey method, Brian L. Quick (2009) examined the cultivation effects of *Grey's Anatomy*'s doctor representation – the concept of cultivation theory will be explained later in this chapter. According to the results, the more someone watches this show, the more someone tends to believe that the content is credible and accurate. Those who believe in the show's accuracy tends to think that real-world doctors are brave, just as the characters of the show. Doctors representation and the role of medical dramas in shaping the viewers' predisposition of doctors were examined by other researchers (Pfau et al. 1995; Chory-Assad and Tamborini 2001; Chory-Assad and Tamborini 2003; Jain and Slater 2013; Mickel, McGuire and Gross-Gray 2013; Pokhrel and Lok 2015). Cultivation effects of the genre were discussed regarding transplantation (Harbaugh et al. 2011; Kupi 2011; Kahil et al. 2014; Quick et al. 2013), bioethics (Czarny et al. 2010), death (Houben et al. 2016; Freytag and Ramasubramanian 2018), and medical malpractice (Foss 2011). Another group of studies examined whether medical drama series can be used as entertainment education source for the lay audience (Cooper, Roter and Langlieb 2000, Brodie et al. 2001; Valente et al. 2007; Hether et al. 2015; Kato et al. 2017). Many studies

focus on learning CPR from the screen (Diem et al. 1996; Gordon et al. 1998; Van den Bulck 2002; Eisenman and Stolero 2005; Bridley 2009; Harris and Willoughby 2009; Hinkelbein et al. 2014; Portanova et al. 2015). Others examine how products of this genre provide role models for future healthcare professionals and investigate whether medical series can be elements of their bioethics and communication curriculum or not (Czarny et al. 2008; Spike 2008; White 2008; Wicclair 2008; Arawi 2010; Weaver and Wilson 2011; Hirt et al. 2013; Weaver et al. 2014; Hoffman et al. 2017; Kendal and Diug 2017).

Created by Shonda Rhimes, *Grey's Anatomy* premiered in 2005, and currently, it has 16 complete seasons, 356 episodes – this is the longest-running American prime-time medical drama series in the history of television. Progress of medicine is a core plot element in this popular series; most of the surgeon characters are innovating their field of work. The series represents innovations in a technological and a social sense as well. As Linsay M. Cramer writes, creators of the series *"rhetorically construct a narrative of progress – medical, technological, and social, and therefore, racial. The merge between two of the show's major focal points, medical advancements (and thus medical technologies) and interracial relationships, functions to situate the show as an authority on >>social progress<<"* (Cramer 2016, 476). The center of the show, the Grey-Sloan Memorial Hospital as a metropolitan research hospital, signifies the show as a future-oriented and progressive one. Cramer critically analyses the postracial society depicted in the series in which race creates no professional or personal boundaries for the non-white characters.

This article uses the approach of Cramer and extends it to gender because *Grey's Anatomy* represents a society in which gender is not a potential career barrier anymore in the field of surgery. Is it an authentic representation of the domain? What are the possible effects of this representation? These questions are relevant because, since its beginnings, *Grey's Anatomy* gives inspiration[1] and courage for females from all over the world to build a career in medicine, even in surgery.

By using the above-described scene as a starting point, this study explores how *Grey's Anatomy* represents the role of surgery, surgeons, and surgical units; furthermore, it discusses the messages and social importance of these representations. Following previous studies on medical drama series, cultivation theory as a theoretical framework is applied. As Morgan and Shanahan (2010, 337) write, *„cultivation analysis investigates television's contribution to viewers' conceptions of social reality*" Furthermore, *„a meta-analysis of over two decades of cultivation research showed that television viewing makes a small but consistent contribution to viewers' beliefs and perspectives*" (Morgan and Shanahan 2010, 340). The con-

[1] *Grey's Anatomy*' star Ellen Pompeo reacts to the women she inspired to pursue medical careers: https://abcnews.go.com/Entertainment/greys-anatomy-star-ellen-pompeo-reacts-women-inspired/story?id=51035189 (03rd June, 2020)

cept of cultivation was developed by George Gerbner in the 1960s: today, it is one of the three most cited theories of mass communication research published in prestigious scholarly journals from 1956 to 2000. Despite the changing media environment, cultivation is still popular: beyond the analysis of the overall television content, scholars also examine the cultivation effects of certain genres or even single programs (Morgan and Shanahan 2010). As Hawkins and Pingree reported, „c*ultivation effect is genre specific and concluded that the formulas and conventions unique to different TV genres are responsible for cultivating subtly different views of the world*" (Grabe and Drew 2007,151). Following this trend, this article focuses on *Grey's Anatomy*, but discussing those elements of the medical drama genre that have an impact on the reception of this production. As Grabe and Drew states, perceived realism of content influences the cultivation process. For this, they bring the example of crime dramas: a high level of perceived realism leads to a higher fear of crime. I argue that some aspects of the medical drama genre – like the hospital setting and the usage of medical jargon – affects the audience's perception of realism, thus strengthen the likelihood of cultivation.

This article brings media studies together with the history and philosophy of surgery to provide an elaborate analysis of the selected scene. The investigation of the series' content builds on qualitative research methods, narrative-, and character analysis. The analysis of the selected scene has three main segments *procedure, protagonist, and place*. All segments have two levels: reality and representation. The *procedure* part starts with a historical contextualization of abdominal wall transplantation and its cultural meanings; then, it explores the positioning and ethical considerations of the procedure as it is represented in the series. By focusing on the show's *protagonist*, the second segment describes the status of American female surgeons in the past and present, and the evolution of the character type in the American medical drama series. Finally, operating rooms are the locations where technical and social innovations come into existence according to the series. Thus, the last part regards the *place* by interpreting the core principles of the real operating room setting and the way how these locations are represented in the medical series. The discussion section examines the potential cultivation effects of *Grey's Anatomy* surgeon representation by highlighting the benefits and harms. Finally, the article provides an overview of other medical dramas that might reinforce and contradict the message of the analyzed series.

2. Procedure: abdominal wall transplantation

2.1. Reality

This part of the study examines the surgical field in which Meredith Grey gain great successes and contextualize her award-winner procedure.

As the study of Sally Frampton (2018) clarifies, abdominal operations have a significant role in the history of surgery. Before the 19. century surgical procedures tend to focus on the surface of the body; diseases of inner organs were treated with non-invasive medical approaches. The abdomen used to be regarded as a mysterious and dangerous area, and it was opened only in exceptional cases, for instance, in the case of Cesarean sections and life-threatening traumatic injuries. However, by the end of the century, after the introduction of antiseptic practices, abdominal surgery started a rapid development, and organs of the abdomen become the primary scope of operations. Based on a reductionist approach, surgeons aimed to localize the reparable areas of the human body and used different manual techniques and equipment to fix these. In the beginning, most of the abdominal surgical procedures were applied to female reproductive organs. Ovariectomy, for instance, became a common intervention that was practiced for medical and psychological reasons, for example, to treat hysteria. According to the Victorian viewpoints, females are defenseless; thus, they need to be rescued by the paternalist male doctors. The digestive system also provided challenges for the surgeons, as this area of the human body was regarded as the core of ill-health, and this concept reinforced the developing surgical field that provided treatments for more and more conditions. For the beginning of the 20th century, surgeons consolidated their elite position in the medical society; they were respected by professionals and laypeople as well.

However, by the middle of the century, surgery became an umbrella term that covered respectable surgical sub-fields, and the original field of abdominal surgery got the name “general surgery” (Kernahan 2018). It was a stable and stagnated area, other surgical fields, just as the cardiothoracic specialization provided more innovative procedures. In the ,80-as, minimally invasive, laparoscopic surgical procedures were invented and became successful nearly instantly. Despite this, invasive, exploratory abdominal surgeries still have an essential role, for instance, in traumatology and transplantation.

According to Sibylle Obrecht (2018), experimentations with transplantation have already existed in the 19. century when surgeons tried to prove their place in the prestigious medical society. Early trials tend to focus on the functional reparation of organs; thus, the surgeons did not necessarily exchange the anatomically identical body parts, or they did not implant the new organs to their anatomical place in the body. With these approaches, they gained short term successes, because of the lack of knowledge on immune reactions. The two world wars slowed down the development of transplantation since the surgeons were busy with the treatment of wounds. After the ,40s, the differences of the donor-recipient body became a field of theoretical interest, and clinical trials became more widespread again in parallel with the scientific explosion of the period. For the ,60s, transplantation was an established surgical area and symbols of modern surgery. The practice of transplantation points out how medicine is capable of destabilizing and rewrite societal and

cultural values such as the demarcation lines between the living and dead bodies or between the self and others. Transplantation entails a series of biological, legal, and ethical questions. It transmits a view according to which the elements of the living body can be replaced that is a mechanical and reductionist understanding of human existence.

Abdominal wall transplantation is an existing, challenging, and not yet a routine procedure. There are patients whose condition cannot be solved with the traditional reconstructive surgical techniques, and for them, complex abdominal wall transplantation is a potential solution (Light et al. 2017). An indication behind the procedure is the common complication of intestinal organ transplantation and the difficulty of surgical wound closure (Quigley et al. 2013). According to a review article, „*several centers have already proved the technical and immunologic feasibility of partial or full-thickness abdominal wall transplantation*" (Giele et al. 2016). In the examined cases, the researchers identified different surgical techniques for abdominal wall transplantation – *Grey's Anatomy* reflects on this variety.

2.2. Representation

As Obrecht (2018) states, the exchange of body parts and organs between different people is a popular topic among writers and journalists from the beginning of the 20th century. The arts, the entertainment industry, and the media displayed the development of transplantation and its ethical dilemmas. Transplantation in a recurring plot element of medical drama series; however, these productions are often criticized because of the way how the organ donation system, organ harvesting, and transplantation surgeries represented.

The portrayal of these processes is a sensitive issue in America: there is a growing need for donor organs, but the number of donors does not grow. The transplantation system builds on voluntary registration: those who wish to be organ donors need to make a direct confess in their life. After death, if someone made no confess, the adherents make the decision. Negative transplantation representation is capable of compromising viewers' beliefs, attitudes, and actions towards the procedure. As Harbaugh et al. (2011) and Quick (2014) state, the lay audience tends to regard the media as an information source, especially in those topics that are not familiar for them: limited or no personal experience with transplantation makes them relay on the media and the entertainment industry. Prime-time infotainment programs and medical series usually have emotionally engaging storylines that eventuate a more significant potential effect on the audience.

Harbaugh et al. content analyzed nine medical series (235 episodes in sum) and identified five potentially harmful representation pattern:

1. doctors, led by their interest, play the transplantation system
2. surgeons wait like „vultures" to harvest organs
3. in some cases, doctors let the donors die, or even murder them
4. doctors do not see the human being in the donor
5. the healthcare system is a part of the black market for organs.

Kupi's (2010) narrative analysis focuses on the first five seasons of *Grey's Anatomy* (102 episodes), and she identified seven harmful narratives. Some of these are similar to Harbaugh's findings: the transplantation system is corrupt; the recipient is more important than the donor – thus, doctors do not do everything for the donor. Furthermore, donors get no empathy or mercy; doctors control the life or death of brain death patients by the usage of technology in an anti-humanistic manner. Additionally, through transplantation, the integrity of the body is harmed, personal characteristics of the donor can be transferred with the organs. Medical series tend to represent the waiting list as a death list, and donor organs are sometimes wasted. The more positive narratives celebrated the advancements of transplantation. Kupi differentiates the visually naturalistic representation of organ harvesting and the elated scenes of implantation. According to her, in many cases, it seems that the surgeon does not treat humans; instead, they operate on bodies that built up from mechanical components.

On the contrary, medical series *Three Rivers* provide a more positive representation: as Khalil et al. (2014) concluded, the series contradicted four harmful myths about transplantation. In this series, doctors do not make decisions about organ distribution, and they do everything for registered donors. The series reinforces that famous people do not have advantages in the system, and family members do not need to pay for the organs. The researchers made a content analysis first and then a survey (1325 respondents): according to the results of the empirical research, the positive representation had a positive effect on the audience.

2.3. Plot analysis: procedure

Following the conceptualization above, this section analyses the depiction of the abdominal wall transplantation in *Grey's Anatomy*.

After ten years of captivity in Iraq, an American female soldier is rescued. Megan Hunt served as a traumatologist in the army when the enemy kidnapped her and took advantage of her knowledge. She got a massive, threatening abdominal wound in a bombing. Her doctor Meredith Grey applies an established, reparation based surgical procedure, but it is not working. Grey tries to come up with a solution at her home, where she realizes that her wallpaper ruined again. She states that it must be replaced not fixed – and at this

point, she finds an analogy between the case of the abdomen and the wallpaper. From this sudden discovery, Grey develops an abdominal wall-transplantation method, which is an improvement of an already existing procedure. The difference is that Grey does not do organ transplantation as a part of the process, just closes the wounded abdominal wall. Hunt trusts in the new procedure an encourages the surgeon to do it. The residents compete to find a suitable donor, and the hospital provides financial funding for the operation. The surgery has an excellent outcome: it saves Hunt, and the procedure will help many people in the future; furthermore, Grey gets a prestigious award for it.

This storyline points to some aspects of the history of surgery. War injuries are traditionally seen as starting points for surgical developments (Bergen 2018). Surgeons tend to engage in trials not only to establish brand new procedures but to develop and alter the already existing ones. Surgical trials are different than pharmaceutical ones since the randomized, double-blind method is not always applicable in surgery. Furthermore, the amount of theoretical research and laboratory work is smaller than in other fields of medicine and, more broadly, science (Jones 2018). The storyline reinforces the social acceptance of transplantation as a healing procedure – it mirrors the hopes and optimism towards it (Obrecht 2018). There are cases in the history of surgery when the patients' support, encouragement, and bravery were needed for the trials of new procedures (Snow 2018). Moreover, this storyline displays the traditional ideal of a surgeon who is capable of dividing their emotions from the profession: Grey and Hunt have the same love interest, but despite this, Grey saves her competitor (Brown 2018).

In summary, the protagonist succeeds in a historically significant field of surgery, which unique prestige started to be shadowed by for instance operations on the brain and the cardiothoracic area. However, abdominal surgery and general surgeons played a vital role in the history of medicine, and this storyline reconfirms this heritage and suggests that there is still a considerable innovative potential is this surgical field. At the age of minimally invasive surgeries, Grey treated a traumatic injury and succeeded with an invasive procedure that creates a big wound in the body that is sensitive to infections. However, she practiced one of the most prestigious, complicated, and risky procedures of modern surgery: transplantation. Abdominal wall transplantation is an existing but challenging procedure, and *Grey's Anatomy* provides an ethically problematic representation of it. The competition of the residents to find a donor is a negative representation of transplantation since it reinforces the fear that donors are not valuable for surgeons; they are new body parts, sources of replacement for the indeed significant recipient. Also, the hospital provides money for the surgery, supposedly because Megan Hunt is herself a surgeon, and her brother works at the Grey-Sloan Memorial as a traumatologist – the latter suggests that relatives of the doctors get advantages in the transplantation system. Despite these plot elements, the general framing of the procedure is quite techno-optimist.

3. Protagonist: female surgeon

After a historical overview, this section discusses the contemporary situation of female surgeons first; then, it examines the evolution of the female surgeon character type in television medical dramas.

3.1. Reality

In America, the participation of women in medical education was prohibited until the middle of the 19th century. Even later, they were held back from the surgical specialty since surgery was traditionally seen as a masculine field of medicine. As Wirtzfeld (2009) writes, Elizabeth Blackwell (1821-1910) was the first American female doctor. Her friend died in cancer that motivated Blackwell to become a doctor and focus on the female reproductive system and to provide a "gentler hand" for female patients. She graduated in 1849 in the Geneva Medical College, but she could not start her surgical residency in the USA. She worked as a midwife in France, and because of an infection, she lost her left eyesight; thus, she had to give up her surgical ambitions. In 1862 she opened the Women's Medical College in New York, but she argued for integrated medical education. Graduated in 1855 at the Syracuse Medical College in NY, Mary Edwards Walker (1832-1919) became the first American female surgeon. For a couple of years, she worked with her surgeon husband, but her practice failed. She became the first female surgeon of the army; however, she served there as a nurse for years (Wirtzfeld, 2009). In 1941 the first Black woman got her medical degree: Dorothy Lavinia Brown (1919-2004), and she became the first Black woman who became a member of the American College of Surgeons (McLemone et al. 2012).

What is the reason behind this gender-related discrimination among doctors? As Brock states, the potential entrance of women to surgery was criticized, it was often called unimaginable, unacceptable, and undesirable (Brock 2013). However, female surgeons practiced in Europe even before they could legally enter the specialty: from the Victorian era, they served as a pro-argument for female surgeons. Another significant argument was that female patients might be more comfortable with women doctors. At the same time, before the age of anesthesia, operations required physical and mental strength, and women were not associated with either. Thus, even the male supporters of female participation in medicine tried to hold back women from this specialty. But with the technological advances, surgery, and the ideal of the surgeon had changed. World War I. also brought change: male surgeons served on the fields; females replaced them in civil hospitals (Brock 2018). Interestingly, Elizabeth Blackwell criticized female surgeons because they behaved like their male colleagues – as a reason for this, she named the education system in which women learn from men and the atmosphere in the surgical department created by men (Brock 2013).

3.1.1. Contemporary status of female surgeons in the US

Nowadays, direct discrimination of female surgeons is prohibited; however, they still need to face several challenges. In 2018 Brock stated that the amount of female surgeons is lower in surgery than generally in medicine – this is the case in the United States, Australia, New-Zealand, Great-Britain, and the Scandinavian countries (Brock 2018). According to the statistics of Wirtzfeld: until the ,70s, the amount of female medical students in America and Canada was 6% maximum.

- In 1970 only 5% of doctors were female in the USA; for 2001, this rate was 24%, and in 2009 the gender division of medical school applicants was nearly balanced (47,3% female applicants).
- In 1913 the American College of Surgeons accepted the first female member, Florance Duckering, and until 1975 the number of female members was 0-5 annually; in surgical specialties, their rate was under 2%. In 1980 the amount of female surgical residents was 2% (but this number includes gynecologists and obstetricians); for 2001, this rate was 14% (Wirtzfeld 2009).

McLemore et al. published similar numbers; according to them, a considerable number of female surgeons appeared in the late ,80s and ,90s. In 2010, 35% of the applicants for general surgery resident programs were female. But the number of women is under 15% in cardiothoracic-, neuro-, orthopedic- and urologic surgery. McLemore et al. also highlight the problem of the glass ceiling effect in case of academic positions: 41% of assistant professors are female, this number is 29% among associate professors, 17% professors, 19% tenured professor. The rate of female heads of departments is only 12% (McLemore et al. 2012).

A new study of Pories et al. reinforces that the number of female leaders in medicine has remained low until recently. But nowadays, *„more women are now rising to leadership positions in surgery, both in academics and within surgical organizations (...). However, increasing the number of underrepresented minority women in leadership positions remains an opportunity for improvement."* On its website, the Association of Women Surgeons (AWS) lists the female chairs in surgery. This group supports female surgeons at various career stages. Currently, the American Surgical Association (ASA) has a female committee president, Robin S. McLeod. Among the ASA Foundation - Fellowship Recipients, there are females.

Wirtzfeld et al. summarize qualitative research on female surgeons. There are several reasons why women select surgical specialty: inspiring female and male role-models; the intellectual and technical challenge; they believe that their personality fits the specialty. Some factors hold back women from surgery, for example, the lack of encouragement, the perception of the specialty of a challenging, time consuming, not family-friendly one that provides a

non-controllable lifestyle. Brock (2018) also stated that there are still boundaries between women and surgery, like the work-life balance, the professional network in the workplace, and the lack of suitable role models.

Furthermore, female surgeons face other challenges. According to a survey study, 58% of their American female surgeon respondents experienced sexual harassment within 12 months (Nayyar et al. 2019). As another report shows, 31,9% general surgeon residents experienced gender-based discrimination; 16,6% racial discrimination; 30,3% was a victim of verbal or physical abuse or both; and 10,3% has sexual harassment in their workplace. Women experienced more mistreatment than men: 65,1% of female respondents reported gender discrimination – a frequent source of it is the patient or their family, just as in the case of race-based discrimination (Yue-Yung Hu et al. 2019). In conclusion, it is not impossible to succeed as a female surgeon today, but there are still gender-related career barriers on the way.

3.2. Representation

Representation of female scientists in the popular culture already has academic reception (Flicker 2003; Haynes 2017). Fictional images of science in books, films, and series tended to build on male characters. Similarly, medical dramas used to depict medicine as a masculine field; early productions had only male protagonists. In medical series, female doctor characters have come a long way to the TV screens. Building on Joseph Turow's monograph, this section overviews the evolution of the character type from the ,50s until the premiere of *Grey's Anatomy*. From 2005, I apply the findings of my Ph.D. research.

Female doctors and surgeons appeared much sooner in hospitals and operating rooms than on the television screen. Before the ,70, television medical series did not include female doctor characters; it was the period of the white medical kings. The first trials with the new character type were unsuccessful – as show creators stated that the genre mainly has a female audience and the wish to watch handsome male protagonists. The first medical series with a female protagonist was the *Having Babies* (ABC, 1978), in which Susan Sullivan played the gynecologist-obstetrician Julie Farr. For the failure, the lousy script was also blamed. *Dr. Quinn, Medicine Woman* is not a typical medical drama, instead a medically themed period drama that had more significant success in the early ,90s: the representation of the 19th-century wild-west is one potential component of its success. At the time of scientific progress, the protagonist faces the discrimination and prejudices of the era: she cannot attend a regular medical university, so she graduates in a female college. Her father was a metropolitan doctor, he took the risk to work with his daughter, but after his death, the woman was not accepted by the patients anymore. She moves to Colorado Springs, but in rural America, she gets no respect and has no medical authority at the beginning.

In 1994 *ER* started to promote a more inclusive picture of doctors. The series had 15 seasons, and it has nine female protagonists, including emergency specialists and surgeons at various career stages (medical trainee, resident, chief resident, attending, department head). Female protagonist had a different racial and ethnic background, their sexual orientation was also diverse. However, *Chicago Hope* premiered in the same year with no female doctor characters. New characters appeared from the second season, including female cardio- and neurosurgeons, but the rate of male and female doctors remained unbalanced. A successful medical series of the 2000s, *House MD,* presented a female endocrinologist as a hospital director; and the show had a female emergency specialist, immunologist, an internalist, and a prison doctor female character. In 2005 *Grey's Anatomy* debuted with a female protagonist, Meredith Grey, whose name appears in the title of the production. However, the male protagonist, Derek Shepherd (Patrick Dempsey) was her strong competitor until Dempsey left the series in 2015. The series was a great success from its beginning; thus, in 2007, the first spin-off, *Private Practice* came to the screen with also a female protagonist, gynecologist-obstetrician Addison Montgomery (Kate Walsh).

Despite these positive tendencies, not every medical drama series succeeded with a female protagonist: *Emily Owens M.D.* and *Heartbeat* had only one season. New medical dramas of 2010 (*Chicago Med, Code Black, New Amsterdam, Night Shift, The Good Doctor, The Resident*) had no solo female protagonist, but these productions regularly displayed competent women doctors. *The Knick* as a historical medical drama reflected on the gender-based discrimination in medical education that was a characteristic of the early 20th America.

3.3. Plot analysis: Protagonist

This part analyzes the character development of Meredith Grey by focusing on the professional parts and among these the research and innovation related storylines. The way how *Grey's Anatomy* presents the situation of female surgeons is also discussed.

In season 1, Grey started her residency program, and by the time she wins the Harper Avery, she is the head of the general surgery department. In the early seasons, she planned to select the prestigious and competitive neurosurgery specialization, but after misconduct, she got a prohibition. Thus, she decided to orient on general surgery – as described above, this specialty is the most traditional field of surgery. However, operating on the abdomen is not as prestigious today as it was in the early period of modern medicine (Norredam and Album 2007).

Regarding surgical innovation, Grey had to wait for the success: before the abdominal wall transplantation, two of her formal trials had failed. As a talented resident, she served as a research assistant in an Alzheimer's trial, and she violated the methods of the standardized, double-blinded clinical trial to help a patient she knew for a long time (Season 7). Later, at the beginning of

her career in general surgery, she aimed to 3D-print a liver graft, and for this, she did systematic laboratory trials and surgeries on test animals. While being stuck with the project, Cristina Yang (Sandra Oh), a cardiothoracic surgeon, got the printer to create a heart conduit to help a patient. According to Yang, Grey professionally withheld by her kids.

Interestingly, Yang was nominated for the Harper Avery Award, but she never won it. The story of the 3D printer implies that instant life-saving is a priority comparing to a long-term research project, the authority of cardiothoracic surgeons, and the drawback of mothers among surgeons (Season 10). Later seasons of the series represent a more empowering image of female surgeons in which the family is not such a direct barrier for women. According to the rhetoric, every woman can succeed in surgery: talent and hardworking attitude are the only factors that matter. Grey's female colleagues perform in highly prestigious fields of surgery like cardio- or neurosurgery, and in specialties that required physical strength in the past just as traumatology and orthopedic surgery. Among them, there are heads of departments and chief residents. In the world of *Grey's Anatomy*, specialties with a high number of female professionals do not lose their prestige as being „pink-collar" fields – contrary to reality (Norredam and Album 2007).

The series represents discrimination and glass ceiling as the history of medicine. It happens by the introduction of Ellis Grey's career: the award-winning surgeon is the protagonist's mother who had to fight for being accepted as a surgical resident. Similarly, sexual harassment positioned as harm experienced by the generation of elder Grey.

Among the characters, there are indeed competent male surgeons, so the empowering female representation does not build on the absence of a male doctor or the diminishment of male surgeons' competency and achievements in the surgical field. Some of the male characters embody the traditional white, masculine surgeon ideal; others have a diverse racial background. Female surgeons are equally competent, confident, and powerful as their male colleagues, they have the same amount of authority, and these tendencies represented as natural in the present time of the series.

4. Place

4.1. Reality

As historian Thomas Schlicht (2007) writes, power and authority of surgeons come partly from their work environment. The space of the OR provides permission for the invasive procedures that would be unacceptable outside this space without proper medical indication. Operating theaters are distinctive hospital areas; however, even from the period of modern surgery, these plac-

es went through significant changes. In her architectural study, Annamarie Adams (2018) differentiate three periods: the age of *Victorian amphitheaters*, surgical suites, and operating rooms.

Like colosseums and opera houses, Victorian amphitheaters are monumental buildings that allow many people to witness the operations. It has minimal contact with the patient wards; in cases, it is placed at the edge of the hospital, or even in a separate building. Amphitheaters usually have a cloakroom, lobby, and restroom for the audience. Its entrance is visible from the street, and windows are big enough to let sunlight[2] in. The operating table fixes the patient in the middle of the space where the surgeon takes a central position, other doctors, medical students, family members of the patient, and those who are interested in operations take their seats around them. The surgeon performed as an actor to provide verbal interpretation for the audience. There was no boundary between the operating area and the viewers; before the 1880s, surgeons had no scrubs for the operation – it was the period before the establishment of antiseptic and aseptic surgery. For the beginning of the 20th century, sterilization areas and restrooms for operated patients appeared, smaller amphitheaters became widespread, but hospitals started to have more than one amphitheater. In this period, parallel operations began with the exclusion of the audience.

Then the operating area moved to the inner space of the hospital, usually upstairs. The new *surgical suits* were smaller and less spectacular than the amphitheaters; from the outside, these were like other hospital areas. Influenced by the avant-garde, some suits had an extraordinary architectural arrangement, identical to domes or eggs. Galleries with plastic or glass became universal, to host the professional audience – sound systems and binoculars helped them to witness the operation. The big surgical lecture as a teaching method became outdated; the new trend was to let smaller groups of students to the suits and let them watch the operation closely.

Operating rooms are private spaces, invisible from the outside, isolated, not available for those who are not authorized. Hospitals started to have multiple, identical, artificially lighted, and ventilated ORs with common preparation areas. This work hyper-sterile environment is not affected by any influence from outside; the surgeon has complete control – the OR is like a bubble inside the hospital.

4.2. Representation

Medical series are professional dramas in which *„the plot, the characters (...) are defined by and dependent on a specialized professional environment'* (Laudisio 2018). As the location is a central plot element, this genre depicts realistic hospi-

[2] Later artificial lighting provided more control to the surgeons, they became less dependent on the daypart and the weather.

tal settings from its early years (Turow, 2010). Medical dramas tend to enhance the feeling of reality and accuracy; for this, show creators mix facts with fiction. State of the art medicine appears in an imaginary healthcare system where the financial sources are unlimited, or real-life technological advancements come into existence because of fictional romantic storylines. Symbols of the medical profession (stethoscope, white coat) appear on the screen together with the visual displays of medical specialties (scrubs on surgeons, plastic cover on emergency doctors) and naturalistic depictions of injuries, disease, and their treatment. The fictitious doctors use proper medical jargon, they refer to prestigious real hospitals, and the usage of titles demonstrates the professional hierarchy of the healthcare system. Locational realism means that fictional hospitals look real with their furniture, equipment, spatial arrangement, and colors. As my previous studies on medical series (Nádasi 2016, 2017) argues, these productions provide insight into those places of hospitals that are familiar for laypeople (corridors, patient rooms) and to the hidden spaces (OR, laboratory, sterilizing areas). The feeling of familiarity makes the representation of hidden spaces more convincing.

Despite these shared characteristics, the atmosphere of hospitals in medical series is quite different. Historical medical dramas tend to represent the Victorian amphitheaters – for this, Adams brings the example of *The Knick*: the OR of the fictional Knickerbocker Hospital modeled after the OR of the real New York-Presbyterian Hospital. In many cases, the scenery presents a nightmare hospital, and this is in parallel with the intention of its director, Steven Soderberg, who did not intend[3] to raise nostalgia towards the past of surgery; instead, he highlighted the brutality of early 20th century hospitals and operating rooms especially. *ER* depicted a crowded, metropolitan, public teaching hospital in the ,90s and early 2000: the moderately run-down emergency department and operating rooms displayed in an old building with darkish artificial lighting. It is an ordinary hospital: nothing is too outdated or progressive, the financial limitations of the institution are visible in the setting. Contrary, *Grey's Anatomy* sets in an ultra-modern but cozy-looking hospital; the lighting is mainly artificial but warmer; the Grey-Sloan Memorial Hospital has big windows and spectacled corridors between different parts of the building. It is indeed a wealthy-looking dream hospital in which the modern environment suggests modern treatment methods (Adams 2018).

4.3. Plot analysis: place

The professional center of the Grey-Sloan Memorial Hospital is the surgical department, more precisely, the OR where surgical innovation comes into

[3] Steven Soderbergh: ‚I wanted The Knick to feel aggressive'. https://www.telegraph.co.uk/culture/tvandradio/11135879/Steven-Soderbergh-I-wanted-The-Knick-to-feel-aggressive.html (16th August, 2020).

existence. The sterile and non-sterile area of the operating room is precisely divided. In the selected scene, the surgical team in scrubs and surgical hats just finished a life-saving surgery; they already removed their rubber gloves, masks, and plastic glasses. The operating table is empty and clean. The seconder location of the scene is a gala hall in Boston, where the Harper Avery Foundation hosts a black-tie event in honor of those surgeons who were nominated for the award. Instead of being there, Grey stands where she saves lives daily: in the OR of the Grey-Sloan Memorial Hospital, Seattle. The two mentors of Grey, Richard Webber, and Miranda Bailey, stand behind her during the announcement. At the gallery, her colleagues and family members celebrate her in their scrubs, white coats, and elegant dresses. They are great surgeons, but now they cannot come close to the award- winner in a physical sense. Grey imagines how her mother would be standing in the crowd (the woman who was also a general surgeon died years before). Ellis Grey is in front of her daughter, not behind her, and it also has a symbolic meaning: she was a role model but a strong opponent as well since she criticized her daughter for being ordinary regularly.

Regarding the analyzed storyline, reconstruction has a threefold understanding–first, the new abdominal wall of the patient that needs to be changed. Second, the room of Meredith Grey served as an inspiration for the surgery through the simple fact that it needs new wallpaper. Third, the hospital. Before Hunt's arrival, there was an explosion in the building; thus, some areas are under reconstruction. The bombing in which Hunt got the surgery and the explosion are parallel storylines; there is a direct analogy between the rebuilding of the body and the location. The Chief of Surgery, Miranda Bailey, makes a direct connection between the work of surgeons and the reconstruction workers.

This storyline suggests that the OR is the primary space of surgeons. For Grey, work is more important than her representative role and the celebration of her success. She lives her success in the OR, not in a gala hall. It is a rather committed representation if not workaholic – however, *Grey's Anatomy* tries to represent surgeons who manage to keep the work-life balance.

5. Conclusions

This part discusses the overall importance of television representations by giving a theoretical explanation, an analysis of *Grey's Anatomy*'s messages about the surgical field and female surgeons, and it discusses the potential learning outcomes and social effects.

Viewers of the series potentially cultivate a technologically optimistic image of surgery and, more precisely, the innovations of transplantation surgery. The representation of the competent and acknowledged Meredith Grey might eventuate more social trust in female surgeons, and Grey as a role model can

encourage younger generations to apply for medical school. Grey's willingness to create a new surgical method to save the patient is heroic and empowering.

On the other hand, this representation of doctors might lead to high expectations for real doctors to provide groundbreaking treatments. A negative perception of doctors who use only proven methods might raise. Another potential harm is that the depiction of limitless possibilities in female surgical career and the absence of difficulties might have adverse effects as well. It is worth to consider Linsay M. Cramer's analysis on *Grey's Anatomy* that problematizes the lack of discourse about race in the series as the production depicts *„a racially progressive, postracial, and color-blind society"* (Cramer 2016, 474). As she writes, this obviates the presence of contemporary racism and its effects on individual and social levels. Representations like this *„reverse the efforts of anti-racial movements and civil-right struggles and present this backward motion in a deceiving disguise of forward progress"* (2016, 485). Thus, an overly optimistic representation of female surgical career might cover the existing struggles and the importance of those initiatives that aims to get equal opportunities for women in medicine.

The representation of the surgical procedures (just like the award winner abdominal wall transplant) and the setting of the series can enhance the cultivation effect. Creators of medical drama series aim to present hospitals, diseases, injuries, diagnostic and treatment procedures in a realistic manner and factual accuracy. Locational realism, including furniture and equipment, the medical language spoken by the characters, and the well-known visual symbols of doctors serve these aims. Perceived authenticity has a significant effect on the audience: because of the factual accuracy, the messages interpreted in and by this environment might be regarded as also accurate – this is how genre-specific cultivation comes into existence in this television genre. Furthermore, as Kato et al. (2017) clarify, emotional engagement with the fictitious content enhances the potential of entertainment-education. As the Introduction chapters show, the audience tends to learn from medical dramas, even though it is an entertaining genre that mixes facts with fiction. More emotional involvement leads to more attention to the content. The melodramatic storylines provide an opportunity to get emotionally involved with the depicted medical cases. Regarding the analyzed scene, the audience got an emotional background story: the patient spent a decade as a hostage in Iraq, where she took care of an orphaned boy, her brother, and groom work in the Grey-Sloan Memorial Hospital and they have a touching reunion. Grey tries to save the woman despite that she is having an affair with her groom, who thought that Hunt is dead.

Furthermore, the cultivation effect of *Grey's Anatomy* is reinforced or even enhanced by other television medical drama series that display competent female surgeons, such as *The Good Doctor* and *The Residents*. Furthermore, there are medical series that have skilled female doctor specialized in other fields of medicine – such as the heroic and challenging emergency medicine

in which characters deal with life or death situations daily. Beyond medical series, it is also necessary to consider the effects of other genres of medically themed popular culture and media (for instance, medical reality shows) and other genres. Furthermore, the current period is a golden age of female protagonists in television – the different images of a competent female protagonist also reinforce the representation of *Grey's Anatomy*.

In summary, the analyzed series depicts a progressive, inclusive image of the surgical field that might be empowering for patients and new generations of doctors as well. However, the word that is represented by *Grey's Anatomy* is not a reality yet, because female surgeons face challenges today that should not be underestimated based on the optimistic but seemingly realistic – portrayal of the specialty. It is important to be conscious about the double effects of this representation of medical careers.

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Trust in robot futures: The role of sociotechnical potential

The aim of this paper is to develop an approach that conceptualizes the role of sociotechnical potential in the discourse around trust in emerging technology. Thereby it focuses on robotics as an example of an emerging technology which is subject to many expectations concerning its future. The paper first provides a general overview of the thinking on trust in philosophy of technology. In the section after that, the paper argues for the importance of adding the perspective of technological potential by emphasizing how the discourse around emerging technologies like robotics is often referring to a world-to-come. Based on this idea, the final section argues for an approach to trust in technology that is based on the perspective of multiplicity of technology narratives. As such, the goal is to build and foster trust in the future of robots based on a notion of technodiversity.

Keywords: *futures, robotics, speculation, technodiversity, trust*

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How to cite this article:

Jesse de Pagter. "Trust in robot futures: The role of sociotechnical potential." *Információs Társadalom* XX, no. 2 (2020): 55–69.

https://dx.doi.org/10.22503/inftars.XX.2020.2.4

Introduction

During the last decade, philosophy of technology has become firmly involved in the development of conceptual frameworks that address social and ethical issues that arise around emerging technologies. As such, the field has developed a considerable voice in discussions on policies that deal with the (future) implications of new technologies such as robotics and AI. By bringing ethical and societal issues to the foreground, an important goal of those frameworks is to represent the human factor in technology. In this way, „human" values like dignity, autonomy and equality should be safeguarded when it comes to the further introduction of new technologies to our societies (Ethics Advisory Group 2018).

In this paper, the goal is to understand future implications of emerging technology from the perspective of trust in technology. While the influence of new technologies is a continuous concern in our societies, trust in emerging technologies is also on the rise as an issue of concern. The topic of trust has therefore become increasingly important in recent discussions on technological development and has aroused a discourse around the attitude of users, consumers, publics and citizens towards automation and robotics. In this context, surveys have demonstrated that the trust in robotics and other emerging technologies is a multidimensional concept that entails many different social, economic and political aspects (Miller et al. 2020; Edelman 2020). Important to note is that when it comes to emerging technologies, many of the discussions about the societal effects of those technologies are referring to consequences that have not yet been fully exhibited. A considerable part of such discussions is therefore based on future expectations and imaginations (Suchman 2019). Even though emerging technologies are not yet fully developed and might even fail to correspond to those different expectations, this paper considers the speculative element of those discussions to be of relevance to philosophy of technology exactly because of the sociopolitical effects that expectations and imaginations have (Rowland and Spaniol 2015).

In this paper, an approach to trust in (robotic) technology's futures will be developed in three sections. The first section will provide a short overview of the way in which trust in technology has been addressed in contemporary philosophy of technology. Several major themes will be distinguished in order to describe this relationship. The section after that, the paper will introduce the topic of sociotechnical potential in order to grasp the concept of speculation as part and parcel of technological futures. Finally in the last section, the paper will use this concept in order to discuss a narrative approach towards trust that is based on the notion of technodiversity.

Philosophy of technology & trust in technology

The topic of trust in technology is an interesting issue in philosophy of technology, especially because it can be directly connected to several major topics

that have been prominent within philosophy of technology in recent decades, as will be explained below. Several important notions and ideas about trust in technology will be described and divided into three, interrelated, subsections. The first subsection will deal with the normativity of technology, the second with the appearance of technology and the final one with the reliance on technology. The topics of those subsections are consciously chosen, but alternative distinctions would certainly be possible. Furthermore, most of the literature that is featured comes from philosophy of technology and, when useful, references to the case of robotics will be made.

Trust and normativity of technology

The study of norms and values embedded in technologies and technological objects has been very prominent in philosophy of technology for a long time. Langdon Winner's famous 1980 article 'Do Artifacts Have Politics' is an often-cited example from this tradition (Winner 1980). Winner argued that technological artefacts themselves can be the embodiment of political values. In this context, his article demonstrated that technological artefacts have traditionally been strictly exempt from understandings that recognized their important role as carriers of norms and values. In research on trust in technology, this discussion on norms and values also has an important place, because it is often (implicitly) argued that trust in technologies can be increased by looking at the norms and values behind them (Vermaas et al. 2010). The processes of designing, introducing and using technological artefacts are key in such conceptualizations of technological trust.

For that reason, activities that try to (re)conceptualize and characterize technologies and technological artefacts constitute an important field of study. A central idea in this focus on technological objects as normative elements in sociotechnical systems is often referred to as the concept of the „black box" (Pinch 1992). An important notion behind this concept is that a lack of transparency in design-processes and artefacts can harm the fundamental open character of democratic societies. They allow for monopolization of power through technology while discouraging co-design practices. Moreover, artificial agents, such as robots and AI could pose existential threats to humanity since their strategic and practical advantages can lead to a whole new series of values: robo-defined values instead of human-defined ones (Danaher 2019). In this way, a lack of insight into the technological object itself has been connected to a lack of trust in that technology, since blackboxing of technology renders the value conflicts within the design process invisible (Pasquale 2015). Arguing from this rationale of transparency versus black boxing, the development of trustworthy technology can be achieved by rendering the technology's design less opaque (European Commission AI HLEG 2019). While understanding technology as a culturally constructed phenomenon, especially research

from science and technology studies (STS) has made a strong case for opening those black boxes. Technological artefacts are in that regard to be understood as elements of sociotechnical systems where they are part of a co-production process in which multiple stakeholders are participating (Sabanovic 2010). By analysing the social practices and cultural values that constitute such sociotechnical systems, technological objects can be rendered more transparent and become subject to deliberation.

In relation to the opening of black boxes, some philosophers of technology have been arguing that the engagement with design and engineering practices themselves can foster trust in technology (Cook 2010). Arguing from this point of view, philosophers of technology have emphasized the important role of responsible research and innovation for the sake of increasing trust in robotics (Stahl and Coeckelbergh 2016). In order to develop trustworthy robots, the idea is that open and responsible design processes can help to understand and influence the norms and values that are inscribed into them. As such, the development of the notion of trust in technology has been evolving together with initiatives to include ethics as a part of the design of technologies (Dignum et al. 2018). Arguing from that point of view, technology ethics has been providing important contributions to different approaches that try to improve the design process of new technologies. A good example is the approach of Participatory Design (PD), where the main goal is to involve the stakeholders into the process of designing new technological artefacts (van der Velden and Mörtberg 2014). Another prominent example is Value Sensitive Design (VSD), which tries to further an approach where norms and values become directly embedded in design and engineering practices (Umbrello 2019). By doing so, the aim of those and other approaches is to democratize the design processes and enable users to gain a voice in those processes (Kensing and Greenbaum 2012).

Trust and appearance of technology

The insight into the role of technologies' and technological artifacts' appearance is an area of research that spreads over many different disciplines. Robots are a particularly interesting type of technology in that regard, because their appearance has many different technocultural connotations, as is for instance demonstrated in the widely used concept of the uncanny valley (Misselhorn 2010). Especially when it comes to humanoid embodied robots, the conceptualization of the artefact's appearance has become an important part of the discussion on the trust in them (Graaf, de and Malle 2017). Philosophy of technology has mainly been contributing to this issue through its conceptual work on the understanding of such appearances behind the perceived agency of technological artefacts (Coeckelbergh 2012). An important issue in that regard concerns the current (Western) conception of (moral) agency, which is increasingly turning out to be problematic with regards to new technologies such as robots. The main

issue being that on several levels (e.g. moral, organisational, legal), it is becoming theoretically tangible and practically useful to treat robots at least partly as morally responsible agents (Gunkel 2018; Sullins 2011). In this way, robots problematize categorizations of human morality and extend the class of entities that can be potentially involved in moral situations (Floridi and Sanders 2004).

Those considerations concerning the agency of technological artefacts have important implications for the discussion on trust as they have become a fruitful and widely used model for the analysis of robots' positions in our societies (Gunkel 2012). In order to deal with the moral implications of the changing agential status of technologies, the concepts around their morality help to guide the discussion on the ways in which those technologies can be controlled (Bryson and Kime 2011). A successful example of one of those concepts is that of „artificial moral agents" (AMA's) (Wallach and Allen 2009). Whereas it is in this case not really a discussion if those AMA's possess consciousness and/or sentience or not, the question is rather how appearances of robots can lead to derived forms of interpersonal trust (Nickel, Franssen, and Kroes 2010). Moreover, the issue regarding moral patiency of robots is an important one, because it asks to what extent robots (and other non-humans) are constituting an „other", to whom moral duties and responsibilities should be appropriated (Allen and Wallach 2012). This is an important debate because it conceptualizes robots as AMA's that enforce new ethical dynamics in our societies. In that regard it is important to understand the new ways in which robots can become defined within such a society. This is for instance explicated by looking at the ways in which robots can be held responsible for their actions (Pagallo 2010).

This discussion on robot appearance and the mechanisms behind this appearance also has effects on the way in which robot design can lead to more trustworthy artefacts. Their societal contribution might be improved if we equip them with norms that increase their perceived moral competence (Malle 2016). Such discussions have therefore led to an increasing call for more transparent robotic artefacts. Especially in fields like Human Robot Interaction (HRI) and other fields this has increased initiatives that aim to make robots more transparent with regards to their appearance and behavior towards users (Wortham and Theodorou 2017). Especially in a governance context, those approaches have been urged in order to foster trust in technology (Winfield and Jirotka 2018). An example of a governance context where this has happened is the legal notion of "electronic persons" which has been proposed by the European Parliament in 2017 (EP 2017, § 59f).

Trust and reliance on technology

Finally, within philosophy of technology the question of technology's ambivalent position when it comes to reliance on technology versus mastery and control through the use of technology has been present for a long time. This theme

can already be found in the work of authors like Heidegger and Mumford, where it is used to discuss how technology is shaping human practices and perceptions of its environment (Coeckelbergh 2015). Important in this regard is the understanding of technology as an empowering extension of human faculties, while simultaneously problematizing its role as mediation between humans and their environment (Floridi 2014). As such, this perspective on technology emphasizes the notion of technological infrastructures creating novel realities which are (co-)defining the conditions under which humans live and speak (Coeckelbergh 2017).

When technology is conceptualized in this manner, the above-mentioned issue of reliance versus mastery becomes connected to the notion of trust through the issue of vulnerability. Whereas technological infrastructures need a certain amount of trust in order to function, this trust can only function if trusting agents accept the vulnerability that comes with their trust (Mcknight et al. 2011). With this constitutive character of technology in mind, trust can best be conceptualized as confidence: rather than just relying on technology, the process of technological mediation is to be understood in a sense of constitution. This entails that humans trust themselves *to* technology, whereby humans recognize how their subjectivity is partly constituted by the technologies that they rely on and entrust with authority (Kiran and Verbeek 2010). This notion of human reliance on technology is important, as it constitutes a technological risk and is therefore creating a certain degree of trust in spite of this risk (Nickel 2013). Furthermore, another important element of this discussion of reliance on technology is the idea that large and complex technological systems constitute a certain risk of breakdown (Viklund 2003). In cases of malfunction of (components of) those systems, human lives can potentially become threatened. In that regard it is important to recognize the vulnerability of complex societies, especially since the trust in technological systems can shift to an attitude of mistrust in situations that showcase vulnerability, such as disasters or other cases that expose shortcomings of technological infrastructures (Winner 2004).

Interpreting technology as constituting the environment in which humans operate while constituting a certain vulnerability is especially useful when analysing large-scale trends within society (Dierkes and Grote 2005). As technologies play an important role in our societies, the issues of trust and risk continue to be relevant to discussions on large topics such as human rights and the maintenance of democratic values. A prominent example in that regard has been the trust in digital technologies (Taddeo 2017). Also in relation to this perspective, several approaches from STS have been useful, especially by drawing attention to the perspective of trust as part of the entanglements that constitute the relationship between humans and technological artefacts (both virtual as well as physical ones) (Simon 2010). The topic of trust is in that regard a very ambivalent one, as trust is on the one hand important for technological systems to function, but can on the other hand be very misleading for

the individual users. Trustworthiness and transparency are also in this case important topics: developing technologies to be more trustworthy by making them transparent, explainable and accountable can help to analyse and expose the way in which large sociotechnical systems constitute new power-relations.

Emerging technology and the role of sociotechnical potential

After developing a short overview of the thinking on trust in philosophy of technology in general, the goal for the rest of this paper is to develop an understanding of the role of technological speculations when it comes to trust in emerging technologies. Robotics is thereby used as an interesting and useful example, since it can be understood as an exemplary case of an emerging technology that is projected to have a considerable impact in the (near) future. Following the anticipated importance of robots in the society of the future, governments and corporations have a considerable stake in the increase of their citizens' or customers' trust in robots (Miller et al. 2020). When it comes to the mechanisms behind such trust, philosophers of technology have a firm theoretical background that allows them to develop valuable insights into the societal ramifications of those developments, as the section above has shown. Next to the technophilosophical value of elaborating on such topics, they also present an opportunity for philosophy of technology to gain a direct involvement in decision-making processes around technology governance, as has already been shown with regards to robot ethics (Bösl and Bode 2018). Having said that, this section develops a complementary theme to the ones offered in the section above. This theme being the engagement with the role of speculative and imaginative elements in emerging technologies when it comes to the issue of trust. The paragraphs below will explain the consideration of this theme as a complementary perspective. After that, the last section will consider what this perspective entails for the understanding of trust in technology. By adding the element of technological futures to this discussion, the aim is therefore to enrich the conceptual framework on trust.

As has been argued in the introduction, the notion of the projected rise of robotics is generating many different forms of speculative imaginaries regarding its future. Moreover, even though robotic artefacts are already quite actively deployed in different manners, many components of the policies and strategies concerning robotics are (unsurprisingly) referring to robotic futures (Bösl and Bode 2018). Crucial thereby is that the rhetorics surrounding those expectations are often based on diverging assessments regarding the future of those technologies. Some of those assessments refer to the possibility that robotic artefacts will possess a plethora of novel properties and abilities which provides them with a revolutionary and transformative future potential (Fox 2018). Other assessments however rather point at the potential effects of robotics on the labor market or the potential challenges they

pose to fundamental human rights (Koops et al. 2013; Freeman 2015). In that regard, the robots of the future are very much the objects of imaginations and projections regarding their societal impact, together with other emerging technologies such as AI, nanotechnology, and biotechnology (Heffernan 2019). Whereas the uniqueness of this new robotic wave of automation should still be viewed with a healthy amount of scepticism, the goal of this paper is not to discredit such visions of the future. Rather, the paper's goal is to understand how speculative thinking constitutes new understandings of emerging technologies and their futures. In order to do that, let's get more insight into the analysis of technology's speculative character.

The focus on the analysis of technology's speculative character as such is nothing new in philosophy of technology. There are several accounts within that point at the ideological or even eschatological character of technological speculations (Burdett 2014; Geraci 2010). Moreover, speculations concerning technological potential are within philosophy of technology often conceptualized as part of the human drive for mastery over its environment; a drive that became particularly „successful" in Modernity in which ‚modern man aims at actively controlling fate' (Mul 2014, 18). Others have connected this speculativity to the fictional character of expectations in contemporary societies while understanding them as an element of the ‚dynamic restlessness of capitalism' (Beckert 2016, 90). Another interesting view on the speculative element in technology has recently been made by Daryl Cressman. Arguing for a stronger engagement with the topic of (sociotechnical) potentiality regarding the study of technological artefacts, Cressman argues for a renewed attention for dialectical philosophy of technology, thereby prioritizing the dynamic tension between ‚that-which-is and that-which-could-be' (Cressman 2020, 4). While referring to the work of Andrew Feenberg, Cressman develops an understanding of sociotechnical potential as a principle that is based on the imaginative capacity to project a better future. In this way, Cressman mainly locates the imaginative and speculative element in the *user* of a technology when he writes that ‚users transformed the function and meaning of technology to better realize concrete potentials that were not considered in the original design' (Cressman 2020, 8). This is an interesting approach to the issue, especially because it calls for an engagement with the potentiality in technology by emphasizing the importance of the user's imagination. However, whereas this paper subscribes to Cressman's vision on the potentiality of technological objects, it cannot focus on the user in the same way as Cressman does. While this focus is certainly not considered invalid or less valuable, it does not fully suffice for the specific case of this paper because of two main reasons.

First of all, the focus on the user is often not feasible, exactly *because* of the speculative possibilities of robots. Oon the one hand, many anticipated robots are not yet being used, while their potential use is already being negotiated on the other hand. They are developed or projected to be developed, but at the same time they are often already part of the people's imagination of the

future. So while their meaning and function is already being negotiated, these negotiations are not happening on the level of the actual users of the artefact. One might question the need for a study of a technology that does not yet (fully) exist, but that is exactly what this article is aiming at: as the already mentioned surveys regarding public perception of emerging technology have demonstrated, those expectations and imaginations have an effect on the trust in the future of those technologies (Miller et al. 2020; Edelman 2020). In other words, while in many cases, consumers, users and other potentially relevant personas do not yet have the ability to transform the function and meaning of technologies in their capacity as users, they do have the possibility to engage in the different imaginations concerning the consequences and possibilities of robotics and other emerging technologies.

Second, even if users were able to interact more closely with robotic artefacts, their very status as an emerging technology entails a notion of widespread socioeconomic effects. One of the most essential features of emerging technologies is that they are projected to have a considerable effect on people's socio-economic situation, while there are many cases in which those people are not necessarily going to be direct users or consumers (Hilgartner 2009). As is the case with the point above, those projections do have an effect on the way in which trust in those technologies is developing (Stebbing 2009). To wit, the expected socioeconomic implications of emerging technologies often reach beyond the contexts of „users" and „consumers". Robotics is in that regard a good example, as there are many projections regarding its future applications and potentials for societal change while not being limited to its effect on direct users and consumers. Furthermore, the complexity of this problem lies in the fact that there is often a strong rhetoric that surrounds emerging technologies. The expectations that those rhetorics purport do nevertheless lead to substantial financial and sociocultural investments in the future of those emerging technologies (Hilgartner and Lewenstein 2004).

When it comes to those two points, it is particularly important to define where the potentiality resides when it comes to the trust in (robotic) artefacts as objects of speculation. As shown, Cressman locates this mainly in the (lay) users, whereas a considerable share of robotic artefacts do not allow the access as a direct user. Nevertheless, the imaginative access to the technological artefacts is happening through the representation of the robotic artefact's futures through media, public debates and the like (Geraci 2010). In this way, the potentiality of emerging technologies such as robotics is something that gets negotiated beyond the perspective of the direct user or consumer. To summarize, Cressmans understanding of potentiality in technology provides a useful insight into the issue at hand, albeit that the focus on the direct user cannot be maintained. The goal for the last section of this paper is therefore to develop an approach to trust that is based on the notion of sociotechnical potential of technology. In line with the points above, this approach will aim to reach beyond this focus on the direct user.

A narrative approach to trust in emerging technology

When it comes to the trust in the sociotechnical potential of (emerging) technology it is important to emphasize again that the rhetorics and discussions concerning their futures are widely diverging. Therefore, in order to reach beyond the perspective of the direct user, the proposal is first of all to focus on the narratives *about* robotics. Comparable to Cressman's engagement with the user's everyday experience with technology, the approach would in this case be to engage with the narratives created around the (speculative) artefact. Furthermore, while critically engaging with narratives about technological artefacts, the proposal is to maintain and promote a concept of „technodiversity" as it has been developed by Yuk Hui (Hui 2019). One of Hui's main objectives regarding this concept is to develop philosophical reflections on technology that can reconcile Eastern and Western thinking on technology. With regards to his notion of technodiversity he writes:

> The fundamental question is the regrounding of technology. We have to emphasize that this is not to add an ethics to AI or robotics, since we won't be able to change the technological tendency by just adding more values. Instead we have to provide new frameworks for future technological developments so that a new geopolitics can emerge that is not based on an apocalyptic singularity but technodiversity (Hui 2019, 277).

As becomes clear, Hui uses his concept of technodiversity to plead against „adding" ethics and/or values to technology. Instead, Hui argues for a „new framework" which is based on his notion of technodiversity. While contrasting this notion of technodiversity with the synchronization and convergence of (global) capital, Hui argues that emancipatory politics are difficult to imagine when living in a world that is strongly pushing towards technological singularity. It is here where Hui's concept of technodiversity can be interpreted and employed as an argument for the inclusion of notions of technological development that aim to engage with the *multiplicity* of futures concerning the potential use of artefact (Rowland and Spaniol 2015). Therefore, this approach would aim for the active engagement with the *different* narratives of the technological future. In other words, next to negotiating the values behind technological artefacts and technological systems, this paper proposes to develop concepts that can help develop new, diverse narratives about robot futures. Therefore, following Hui's approach, the task of philosophy of technology would be to develop concepts that can stand at the basis of a multiplicity of narratives while engaging with the norms and values that are present in the possible different futures of robotics.

In the same way that Cressman argues for the study of the users' notion of technoscientific potentiality of the artefact, the argument here is for the study of the narratives regarding the future role of the artifact. Apart from engaging

with the norms, transparency and power-relations in the design of technological artefacts, the argument here is for explicit engagement with the narratives about the future of those technologies. In this way, philosophy of technology would participate in (collective) speculations and imaginations that try to make sense of the sociotechnical world as it could become in the future. This would entail conceptual frameworks and new understandings that can help to systematically develop multiple futures of emerging technologies. The approach that this paper proposes is therefore to explicitly argue for a close engagement with those possible futures, in order to develop new concepts that help to understand emerging technology and the way its multiple futures play out. In this way, narratives about new technology should hopefully be able to push a more diverse array of visions concerning the future of those technologies. In this way, it can help to develop theories and concepts in order to grasp those futures and create a society that anticipates those futures in a democratic, inclusive and trustworthy manner.

Conclusion

The aim of this paper was to frame the development of alternative multiple technological futures as an interesting and important part of the discussion on trust in technologies and their artefacts. Furthermore, it has argued for an engagement with such futures. Crucial for this approach is to emphasize again that it contains an explicit call for a strong engagement with the narratives concerning the potential of technologies, thereby aiming for an approach that looks for new ways to foster technodiversity. Philosophy of technology is one of the fields that has a considerable knowledge base which can develop new understandings by engaging with different, alternative futures of emerging technolog-y and its artefacts. In this way, different narratives on technologies can arise and foster new understandings of future artefacts. Thus, by exploring different, alternative scenarios ‚we can help set in place today factors that will increase the probability of more desirable futures happening' (Dunne and Raby 2013, 6).

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Newly graduate engineers' development of expertise and personal competencies

The case of Tampere University

This paper investigates importance and development of expertise and personal competencies of newly graduated engineers according to academic staff members, industrial employers and the graduated engineers themselves. The aim was to discover how graduated engineers perceive the importance of competencies at the time of graduation, and how various competencies have developed during their studies. For such purposes, a national-wide graduate survey was adopted as a basis for research.

The results show that engineering degree programmes highlight theoretical foundation rather than generic competencies, whereas industrial employers favor personal competencies and attitudinal factors. Furthermore, according to graduates' ratings, some competencies have developed more than appears to be necessary at the beginning of their career. These competencies were the most valued in degree programmes. Similarly, some competencies that were least valued in degree programmes were part of the least developed competencies in studies, but also part of the most important competencies for graduates.

Keywords: *Competency-based education, Curriculum development, Engineering education, Personal competences, Professional development, University-business cooperation*

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How to cite this article:

Pyrhönen, Veli-Pekka, Sonja Niiranen, Eila Pajarre. "Newly graduate engineers' development of expertise and personal competencies."
Információs Társadalom XX, no. 2 (2020): 70–83.
https://dx.doi.org/10.22503/inftars.XX.2020.2.5

1. Introduction

Over the last decade, universities have shown growing interest in developing competence-based approaches and including generic competencies into their curricula (de Justo and Delgado 2015; Fallows and Steven 2000; Chan et al. 2017). For newly graduates' employment, possessing disciplinary knowledge taught on students' study field is not enough. Instead, employers are putting increasingly more emphasis on graduates' generic competencies such as communication skills and teamwork skills (Freitas et al. 2018; Nguyen 2008). Overall, social skills such as persuasion, emotional intelligence and strong social and collaboration skills will be in higher demand across industries than narrow technical skills (The World Economic Forum 2016).

However, even though the importance of generic competencies has been largely recognized, there are differences in how universities have adopted them into their curricula and how professors and faculty value those (Freitas et al. 2018; Nguyen 2008). It has been recognized that graduates often feel that they have not gained enough generic skills during their university education (Andrews and Higson 2008).

In engineering disciplines, it has been discussed how situativity should be seen as a dominant perspective by emphasizing the role of the environments that require extensive content knowledge and analytical skills to engage in learning (Johri and Olds 2011; Pleasants and Olson 2019). There has also been an increased concern about the need to develop a better understanding of how people learn engineering (Johri, Olds and O'Connor 2013) and how they build engineering identity. In addition, the interests towards active learning and activating instructional procedures have increased when studies have reported its' connections with greater achievements in student learning and, especially lately, in generic working life skill or competence development (Hartikainen et al. 2019).

2. Research Questions and Methods

The main contributions of this paper were to investigate how expertise and personal competencies of newly graduated engineers have developed during university studies relative to their perceived importance in the working life of Finnish engineering field, and how competencies were valued in the degree programmes of FES (Faculty of Engineering Sciences) of former TUT (Tampere University of Technology). FES consisted of the following degree programmes: Automation science and hydraulics, Mechanical engineering and Materials science. The study also investigated how important expertise and personal competencies are for industrial employers in Tampere area. To answer these research questions, a national-wide graduate survey of TEK (Tekniikan akateemiset, Academic engineers and architects in Finland) (Piri 2016)

that measures the importance and development of 26 expertise and personal competencies on the scale 1–7 was adopted as a basis for research.

First, newly graduated engineers evaluated the importance of each competence using integers on the scale between 1 [“Not at all (important)”] and 6 (“Very much”) with an option 7 (“Cannot answer”). Using the same scale, the newly graduate engineers also rated how each competence has been developed in studies and in work, respectively. These formed two development profiles; namely, “Development in studies” and “Development in work”. Then, the development profiles of each competence were compared to the perceived importance.

In 2017, a teaching development event was arranged among the staff members of FES. In total, 69 staff members consisting of teaching staff, researchers, Ph.D. students and professors who were all involved in teaching practices participated to the event. The purpose of the event was to find out how various competencies are valued in faculty’s engineering degree programmes. For such a purpose, FINEEC (The Finnish Education Evaluation Centre) reference programme learning outcomes were adopted. FINEEC framework describes the knowledge, skills and competencies that learning processes should enable engineering graduates to demonstrate *after graduation*. It was used to ensure that educators see how their degree programmes are benchmarked against an accreditation standard in Finland, and which competencies are valued in the degree programmes of FES. This was the first instance when competencies were closely examined throughout the faculty, which made the competency profile of the faculty more transparent. With the newly formed competency profile, it was possible to make judgements on the observed competency development of newly graduate engineers.

The FINEEC reference programme learning outcomes are based on EUR-ACE (European Accredited Engineer) framework standards of the ENAEE (European Network for Accreditation of Engineering Education). The reference programme learning outcomes are divided into the following five categories: 1) Investigations and information retrieval, 2) Engineering practice, 3) Multidisciplinary competencies, 4) Knowledge and understanding, and 5) Communication and team working, which have their own set of competencies.

Nonetheless, staff members were first divided into six programme-specific groups to ensure that each group shared mutual understanding of each rated competence. Then all groups rated the importance of all competencies in their curriculum using options: 3 (“must have”), 2 (“should have”) and 1 (“nice to have”). The interpretation of the above labeling is: “must have” means that a competence is widely included into a degree programme and it must remain there in the future as well. In addition, “must have” competencies are emphasized in most of the individual courses within a degree programme. The label “should have” means that a competence is included into a degree programme and it should be there in the future as well. These “should have“ competencies are found in several courses within a programme. The label

"nice to have" means that a competency is not meaningfully represented in a degree programme, but it could be a "nice" insertion there, although not in priority compared to the other types of competencies. Finally, the results of each programme-specific group were summed together so that the maximum score a competency could achieve was 18 points, whereas the minimum score was 6 points.

Furthermore, in 2018, 24 industrial employers ranging from small and medium size enterprises to large enterprises participated in interviews as part of ESF-funded Tyyli-project (Tyyli-bridging the gap between university studies and working life) that aimed to investigate, which competencies are important in their workplace and which competencies they expect newly graduates to master when they recruit them. There were 1–3 persons interviewed per each enterprise and each interviewee rated the importance of each competence within the set of 26 competencies.

3. Results

In this section, the results from the TEK graduate survey, FES staff members' ratings and industrial employers' ratings are presented along with some analysis and interpretation.

3.1. Results from TEK graduate survey

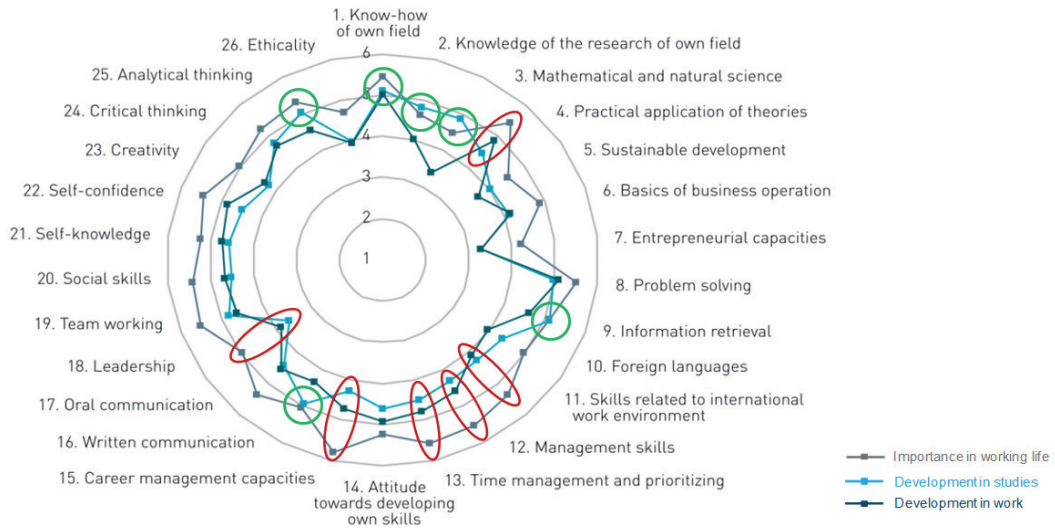

Figure 1. Newly graduates' ratings: Importance in working life, Development in studies and Development in work profiles of expertise and personal competencies, (Piri 2016)

The gathered importance and development values of each competence were averaged and then displayed in a single figure in-line with the others, which is depicted in Fig. 1. Then the development profiles of each competence were compared to the perceived importance, which revealed both similarities and discrepancies between the importance and development profiles. In case of differences, the amount of mismatch and its orientation were also captured. This study focuses especially on comparing the "Development in studies" profile of newly graduate engineers of FES to the educational competency profile of the FES itself.

In total, 12 competencies have been more developed in studies than in work. In fact, most of these competencies are expertise competencies, which are related to traditional engineering study activities. In turn, 14 competencies have been more developed in work than in studies. Many of these competencies are personal competencies, which are outside the scope of traditional university study activities. All competencies have been categorized in Table 1 according to their main source of development.

	More developed in studies		More developed in work
No.	Name	No.	Name
1	Know-how of own field	4	Practical application of theories
2	Knowledge of the research of own field	6	Basics of business operation
3	Mathematical and natural science	7	Entrepreneurial capacities
5	Sustainable development	8	Problem solving
9	Information retrieval	12	Management skills
10	Foreign languages	13	Time management and prioritizing
11	Skills related to internat. work environ.	14	Attitude towards developing own skills
16	Written communication	15	Career management c apacities
19	Team working	17	Oral communication

24	Critical thinking	18	Leadership
25	Analytical thinking	20	Social skills
26	Ethicality	21	Self-knowledge
		22	Self-confidence
		23	Creativity

Table 1. Newly graduate engineers' development of competencies according to their source

Furthermore, the six most and least important competencies in working life of newly graduated engineers are collected into Table 2, respectively.

	Most important competencies		Least important competencies
No.	Name	No.	Name
15	Career management capacities	7	Entrepreneurial capacities
1	Know-how of own field	5	Sustainable development
19	Team working	3	Mathematical and natural science
13	Time management and prioritizing	2	Knowledge of the research of own field
8	Problem solving	26	Ethicality
4	Practical application of theories	6	Basics of business operations

Table 2. Most and least important expertise and personal competencies for newly graduate engineers

In particular, competencies that have developed most, *in studies*, relative to their perceived importance in working life have been marked using green

circles in Fig. 1, whereas competencies that have developed least, *in studies*, relative to their perceived importance have been marked using red ellipses. These competencies have been collected into Table 3.

Most developed competencies		Least developed competencies	
No.	Name	No.	Name
3	Mathematical and natural science	15	Career management capacities
2	Knowledge of the research of own field	18	Leadership
9	Information retrieval	11	Skills related to internat. work environ.
16	Written communication	12	Management skills
25	Analytical thinking	13	Time management and prioritizing
1	Know-how of own field	4	Practical application of theories

Table 3. Most and least developed expertise and personal competencies, in studies, relative to the perceived importance

According to Fig. 1, the developments of competencies 2, 3 and 9 in studies have been rated higher than their importance in working life. No other competence has been rated such that its development in studies or in work shows larger value than its perceived importance. Moreover, competencies 2 and 3 are simultaneously part of the most developed and least important competencies for newly graduates, while the developments of 2 and 3 in work display very low values. These observations indicate that scientific fundamentals and theoretical foundations are mostly learned during university studies. A much more difficult issue is to argue, whether competencies 2 and 3 are nowadays too much emphasized in higher engineering education. After all, theoretical cornerstones and scientific research form the basis of academic thinking, which is one of the main function of universities, and universities must educate researchers as well.

Note that theoretical-oriented competencies like 2 and 3 are one of the most developed, but Practical application of theories (4) is one of the least developed, which was an unexpected result. One possible explanation for such observation might be that engineering education in parts of former FES, including

teaching and learning activities, assessment as well as intended learning outcomes, was intentionally practiced such that knowledge and understanding of science and theoretical matters were much more favored compared with engineering practice and practical application of theories. In addition to 4, competencies 13 and 15 belong simultaneously to the set of most important and least developed competencies according to graduates' ratings.

However, it should be noted that the results in Fig. 1 represents viewpoints of newly graduate engineers only. At the time of answering the survey, competencies that may seem unimportant to them, or with respect to their current job description, may well become important in future, say, five years later. These could e.g. be sustainable development, entrepreneurial capacities, and ethicality, which belong to the set of least important competencies according to newly graduates' ratings. Ethics, sustainable development and entrepreneurial capacities have just recently been included in planning of higher engineering education of Tampere University, and hence, they may seem unimportant to newly graduates only because they have been explicitly missing from the degree programmes.

3.2. Results from staff members ratings

Competencies that received most and least amount of points during the teaching development event are collected in Table 4, respectively. The results provide an insightful view for the educational competency profile of the whole FES. Furthermore, there were additional competencies included in FINEEC reference program learning outcomes and one of them received notable amount of points: Ability for life-long learning (17p).

	Most valued competencies		Least valued competencies
No.	Name (points)	No.	Name (points)
9	Information retrieval (18p)	12	Management skills (10p)
1	Know-how of own field (18p)	18	Leadership (11p)
16	Written communication (18p)	23	Creativity (11p)
17	Oral communication (17p)	5	Sustainable development (12p)

8	Problem solving (17p)	26	Ethicality (12p)
3	Mathematical and natural sciences (17p)	4	Practical application of theories (12p)

Table 4. Most and least valued expertise and personal competencies for staff members of FES

It is interesting to observe that four out of the six most valued competencies (1, 3, 9 and 16) according to staff members' ratings are the same competencies that graduates have evaluated as the most developed in studies. Similarly, three out of the six least valued competencies (4, 12 and 18) according to staff members' ratings are the same competencies that graduates have evaluated as the least developed in studies. These observations partly validate the learning outcomes of the degree programmes of FES, because some of the most valued competencies have been most developed in studies and vice versa.

3.3. Results from industrial employers' ratings

The most and least important competencies according to industrial employers in Tampere area have been collected into Table 5.

	Most important competencies		Least important competencies
No.	Name	No.	Name
14	Attitude towards developing own skills	7	Entrepreneurial capacities
8	Problem solving	18	Leadership
19	Team working	2	Knowledge of the research of own field
1	Know-how of own field	5	Sustainable development
16	Written communication	15	Career management capacities
13	Time management and prioritizing	6	Basics of business operations

Table 5. Most and least important expertise and personal competencies for industrial employers in Tampere area

Note that competencies 1, 8, 13 and 19 exist in the set of most important competencies for industrial employers and for newly graduate engineers. The same observation holds for the competencies 2, 5, 6 and 7 as part of the least important competencies. In addition, competencies 1 and 16 exist in the sets of most important competencies for academic staff and for industrial employers. Similarly, competencies 5 and 18 are part of the least important for both stakeholders. It is quite surprising that the importance profiles of graduate engineers and industrial employers have many common competencies as opposed to the importance profiles of academic staff members and graduated engineers.

Furthermore, the industrial employers were also asked to list competencies that newly graduates lack most. These were: 19. Team working, 20. Social skills, 13. Time management and prioritizing, 6. Basics of business operations, 22. Self-confidence, and 21. Self-knowledge. It seems that industrial employers in Tampere area favor personal competencies and attitudinal attributes over expertise competencies. In particular, 13, 14 and 19 are the most important from their perspective. Moreover, many employers highlighted several other competencies, which newly graduated engineers lack but which were not captured by the graduate survey's items. The most commonly mentioned competencies were: humility, motivation, respect towards other people, manners, adaptability to change, and flexibility. Lastly, industrial employers were asked to list competencies, which they expect to be important in near future. The six most frequently occurred competencies were: 19. Team working, 20. Social skills, 5. Sustainable development, 23. Creativity, 11. Skills related to international work environment, and 13. Time management and prioritizing.

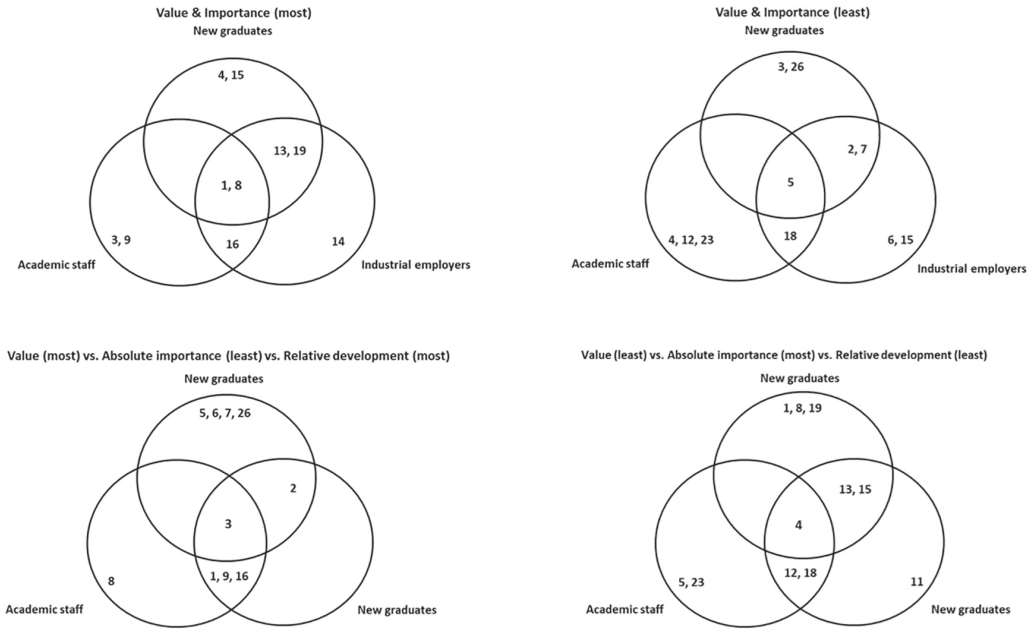

Figure 2. Set diagrams of absolute importance and relative development

Nonetheless, set diagrams showing overlaps between important competencies for all stakeholders as well as relative development of graduates have been collected into Fig. 2.

Several interesting features can be extracted from the figure: Know-how of own field (1) is one of the most important competence for all stakeholders (upper left diagram), and it also is one of the most developed, in studies, relative to the perceived importance in working life. Sustainable development is one of the least important competence for all stakeholders (upper right diagram). Mathematical and natural science (3) is one of the most valued in degree programmes, but it is also one of the least important for newly graduates and relatively most developed in studies (lower left diagram). Practical application of theories (4) is one of the least important in degree programmes, but it is also one of the most important for newly graduates, and relatively, one of the least developed in studies (lower right diagram). Problem solving (8) is one of the most important for all stakeholders, but it does not exist in the set of most developed competencies of newly graduate engineers.

4. Discussion

There are many driving forces currently affecting industries that are expected to have a significant impact on jobs but also to widening skills gaps (The World Economic Forum 2016). Thus, educators at the university are increasingly challenged with engaging students in lifelong learning agenda, which has emerged as a global concern within education policy and is a focus in several educational contexts (Drew and Mackie, 2011). The findings of this study revealed that all stakeholders of higher engineering education in Tampere region share similar viewpoints regarding to the importance of engineering graduates' expertise and personal competencies. However, there are some differences in these views: academia puts more emphasis on engineering specific knowledge, science and theoretical matters rather than on generic competencies. On the other hand, industrial employers highlight the importance of attitudinal factors, self-concepts and personal competencies. Surprisingly many competencies were found within the sets of most and least important competencies of industrial employers and graduates engineers. Unfortunately, some of the most important competencies for newly graduate engineers were also least developed in studies, whereas some of the least important competencies were most developed in studies. Furthermore, many competencies that were most valued in the degree programmes were also the most developed in studies and vice versa.

In relation to some exact competences, it was shown that industrial employers rated competencies, which newly graduates lack most e.g., team working, social skills, self-confidence and self-knowledge. In addition to those, they presented competencies, which newly graduated lack but which were not

captured by the graduate survey e.g., motivation, adaptability to change and flexibility, and suggested several competencies, which they expect to be important in future working life e.g., team working, social skills, creativity, time management and prioritizing. In order to provide students' education that would help them to achieve these skills, new type of educational strategies should be adopted into higher engineering education. Students should be seen more and more as learning agents of their own learning, who engage in a continual process of 'retooling' their knowledge and skill base by taking more responsibility for their own learning (Drew and Mackie 2011).

Previous studies have shown that a deep approach to learning has stronger relations with academic competencies than the other approaches (Postareff 2007; Tuononen 2019). Students with a growth mindset embrace challenges, persist when facing some setbacks, see challenges and effort as ways to the mastery, learn from criticism and find inspiration in the successes of others (Alink et al. 2018). Teacher can support this in many ways e.g., by activating students during teaching and moving towards student-centered teaching and learning practices. However, a course designer must have the ability to understand the situational and contextual constrains by analyzing the practical learning problems i.e. one must understand the position of the learner (Ertmer and Newby 2013).

Learning of competences leads naturally to an actualization of knowledge and methods, bringing them closer to professional practice (de Justo and Delgado 2015). Thus, attention should be given to alignment between the course learning outcomes or aims, activities and learning tasks during the course and assessment methods in the course. Furthermore, by investigating engineering education competencies, our aim was to provide valuable insights for the development of teacher trainings in engineering education and for trying to fill the observed skill gaps of newly graduates' engineers.

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ELLEN SJOER, PETRA BIEMANS

A design-based (pre)recruitment approach for new professions: defining futureproof job profiles

In a rapidly developing labor market, in which some parts of jobs disappear and new parts appear due to technological developments, companies are struggling with defining future-proof job qualifications and describing job profiles that fit the organization's needs. This is even more applicable to smaller companies with new types of work because they often grow rapidly and cannot hire graduates from existing study programs. In this research project, we undertook in-depth, qualitative research into the five roles of a new profession: social media architect. It has become clear which 21st century skills and motivations are important per role and, above all, how they differ in subcategory and are interpreted by a full-service team in their working methods, in a labor market context, and in the talents of the professional themselves. In a workshop, these "skills" were supplemented through a design-based approach and visualized per team role in flexibly applicable recruitment cards. This research project serves as an example of how to co-create innovative job profiles for the changing labor market.

Keywords: *21st century skills, future-proof job profiles, design-based recruitment approach*

Acknowledgement

We wish to thank our project partners, an SME of social media architects and a high school; in particular, the interviewees for their openness and ability to explicate the core of their profession. Furthermore, we want to thank our researchers Jeany Slijper, Frans Jacobs and Rachelle van Harn. Finally, we should also thank The Taskforce for Applied Research in the Netherlands (in Dutch: Nationaal Regieorgaan Praktijkgericht Onderzoek SIA) for subsidising this project.

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How to cite this article:
Ellen Sjoer, Petra Biemans. "A design-based (pre)recruitment approach for new professions: defining futureproof job profiles." *Információs Társadalom* XX, no. 2 (2020): 84–100.
https://dx.doi.org/10.22503/inftars.XX.2020.2.6

1. Introduction

The labor market is changing rapidly. New technology and globalization are the main drivers of economic development. As a result, many new jobs are being created (Miller and Atkinson 2013). Who had ever heard of a drone pilot or ethical hacker before? Technological change, though, is "skills biased". New technologies tend to favor certain skills while devaluing others (Dachs 2018). Specific skills, such as those required for routine tasks have become superfluous (Frey and Osborne 2013, 2017). For many professionals, e.g. in administrative professions, this means a decrease in their employability. On the other hand, a labor shortage is expected for professions with interpersonal, technical, digital, and creative roles (DenkWerk 2019). In these job roles, other qualities are important, these are also referred to as "21st century skills".

As the world keeps developing, there is increasing demand from industry for a workforce with different skills and potential (World Economic Forum 2016). Sustainable employability and lifelong learning feature prominently on HR agendas. Many employers need to reconsider the job profiles of existing staff and of new staff being hired. This is not an easy task. The rate of change is fast and the future is uncertain. The coronavirus shows that the job market can change almost overnight.

It is even more complicated for small enterprises with new types of professions to find the right personnel. These companies are often fast growing, and are looking for an organizational structure that is a natural match with the business process. They often do not have an HR professional or a structured recruitment and selection procedure in place. Our education system does not supply graduates for newly created jobs, making it difficult for companies to find the right staff. For these companies wanting to hire new employees, it is important to gain insight into the novel profiles and the corresponding future job qualifications, often referred to as "21st century skills".

As an example, we decided to study one appealing new profession: social media architect (SMA). An SMA helps companies to develop and execute a (media) strategy to achieve impact on a specific target group. It is a crossover between communication and technology. Together with an SMA, we explored a design-based (pre)recruitment approach, which includes additional attention for future-ready 21st century skills. The result could be of interest to all companies that are struggling with new or (radically) changing job positions. If you want to hire a person with future-proof skills and potential, a profound change is needed in the traditional approach to 1) defining future-proof job qualifications (forecasting) and 2) describing the job profile that fits the organization's needs.

The goal of the research is to renew the way companies define job profiles to recruit the most suitable talent for newly created job roles by supporting a small company in the creative sector with a new profession to hire

the right employees. Moreover, it shows how the 21st century skills can be used in a meaningful way. Finally, this study serves as an example of how universities and SMEs can jointly address the challenges of a changing labor market.

The research questions are as follows:

1. *What 21st century skills does (do) a (team of) social media architect(s) need for which professional activities and professional results?*

2. *How can these 21st century skills be visualized per team role so that they can be used in recruitment and selection?*

2. Theoretical framework of the 21st century skills

The term 21st century skills was introduced to clarify the fact that our future workforce requires different qualities than merely disciplinary knowledge and some soft skills. Several frameworks were created, primarily at schools and universities, to describe the qualities that will become important (Voogt and Roblin 2012). There is a lot of criticism of these "lists" of 21st century skills. The term 21st century skills is considered vague and confusing since there is nothing new about these skills. Moreover, skills such as collaboration and communication are higher-order skills and silo concepts that cannot be developed and measured in a reliable way. Furthermore, research into the debate on the 21st century skills identifies neo-liberal discourses about what constitutes an ideal student (Hilt, Riese and Søreide 2019).

We agree with most of the aforementioned points of criticism. We, too, believe that frameworks of 21st century skills will not help sufficiently to educate students or to upskill or reskill employees (Biemans et. al. 2017). Moreover, "skills" is probably not the right term. Nevertheless, it is helpful to use a framework to give an idea of the capabilities of our future workforce. We chose to use the "Framework for 21st Century Learning" (P21 model), among other things, because this model is very popular and well documented (Battelle for Kids 2019). The model has been jointly developed in the United States by education, business and government. However, there are some questions about the motives of the P21 Skills Group (Sawchuk 2009). According to some critics, technology companies want to gain more influence over the classroom. The P21 group responded that the opponents do not believe that the education system should be more responsive to business needs.

The P21 framework describes the skills, knowledge, and expertise students must master, represented by a rainbow, to succeed in work and life (see figure 1). It is a blend of content knowledge, specific skills, expertise, and literacies. In this P21 model, the 21st century skills are divided in three clusters, and several components. (see table 1).

Life and Career Skills	Learning and Innovation Skills	Information, Media and Technology Skills
Flexibility and adaptability	Creativity	Information literacy
Initiative and self-direction	Critical Thinking	Media literacy
Productivity and accountability	Collaboration	ICT literacy
Leadership and responsibility	Communication	
Social and cross cultural skills		

Table 1. Clusters of 21st century student outcomes (P21)

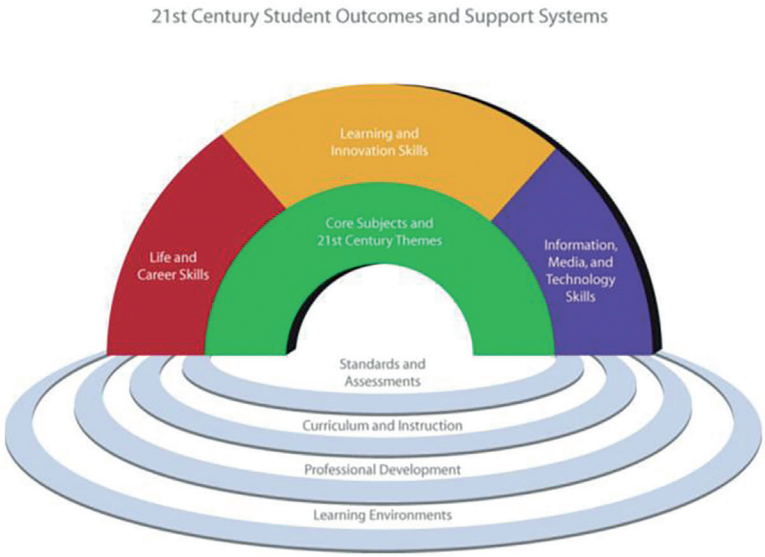

Figure 1. P21 framework of 21st century student outcomes

Besides these skills clusters, proficiency in "core subjects and 21st century themes" is also important for student success. Key subjects include reading, mathematics, history, etc. It is notable that 21st century interdisciplinary themes such as global awareness, entrepreneurial literacy, civic literacy, health and environmental literacy should be intertwined with these key subjects. P21 views all the components of the framework as fully interconnected in the process of 21st century teaching and learning (Battelle for Kids 2019).

3. Methodology

The Taskforce for Applied Research in the Netherlands financed the "Crossovers in Technology-Related Jobs" research project, which consists of six steps (see table 2).

Step 1	Preparing the research instruments.
Step 2	Collecting information about the professional activities and the essential 21st century skills of a social media architect and the context in which the company operates.
Step 3	Analyzing the data with a first sketch of a professional image (of a team) of SMAs as a result.
Step 4	Deepening the concept in a workshop and designing a professional image of the SMA team together.
Step 5	Validating the different team roles of a social media architect and creating material for use in recruitment and selection.
Step 6	Disseminating the results in a knowledge café and starting a discussion on how to use the material and take it a step further.

Table 2: Activities per step in the Crossovers in Technology-Related Jobs project.

We executed steps 1-3 to answer research question 1 and steps 4-5 to answer research question 2. In this chapter we will describe the data collection method and the data analysis in more detail.

3.1. Respondents and procedure for research question 1

We conducted a qualitative interview study to describe the professional activities and the associated 21st century skills of an SMA. According to the practitioners, this new profession consists of six roles, which taken together, form the professional profile of an SMA: strategist, designer, copywriter, content manager, videographer and a team head. In the near future, the role of designer and videographer will be combined. This role will be defined by the word: "creative".

Five SMAs were interviewed for approximately 75 minutes each (see table 3). The semi-structured interviews were conducted using an interview template with six blocks of questions. Each interview started with general

questions about their age, educational background, professional experience. The second block contained questions concerning the area of activity, such as stakeholders, sectors and emerging economic and social trends. This was followed by blocks of questions about the professional activities and the qualifications and competences to meet the objectives of an SMA. The interviewees did not get a list of 21st century skills, but they got questions such as: What is absolutely necessary to do the job well? What would you look for if you want to hire a colleague in your role? Finally, there were questions relating to the motivation for the job and career development. The interviews were recorded and transcribed. All transcripts were then analysed with a software programme, using the six blocks of questions.

	Role	**Background (study)**	**Professional experience**
1	Strategist	Commercial communication management (higher vocational education)	7 years: communication officer/ manager (at a large tech company); 4 months at SMA agency
2	Designer	Associate degree in graphic design and art college (UAS)	3.5 years at SMA agency
3	Copywriter	Upper vocational secondary education in business and administration	Graphic designer in Screen printing shop; designer and copy writer ad agency; (Chief) editor publishing company; 6.5 year at SMA agency
4	Content manager	Communication and Media (Erasmus University); Master Corporate Communication (University of Amsterdam)	Full time in restaurant business; online marketer; 4 months at SMA agency
5	Videograph/ teamhead	Economics at university of applied sciences (minor at art college)	Video-head at large e-commerce company (3 years, in total 7.5 years at this company) + own company (in film/video, such as wedding videos); 3 months at SMA agency

Table 3. Background of the respondents

The five interviewees are all working in the same company, which is a small, innovative company with 16 employees, located in one of the Netherlands' major cities. The roles in table 3 are assigned to the employees and they operate in this role in one of the three full service teams that exist within the company. Nearly all the interviewees are about the same age: 28-29, apart from one respondent, who is 52 years old.

3.2. Respondents and procedure for research question 2

The second research question is design oriented because we want to make something that supports the SME in their recruitment process. How can these 21st century skills be visualized per team role so that they can be used in recruitment and selection? We designed a workshop together with the strategist of the SMA, who is an expert in design thinking. First, we defined the "why" of a social media architect. The why provides clarity, meaning and direction. It refers to the unique contribution (activities) of an organization and indicates the impact of the work on the environment ("footprint"). It directs the decision making in any organization and is, therefore, important for selecting the most suitable talent for the organization.

The workshop participants consisted of three employees of the company, three researchers and two teachers from a high school who wanted to learn more about new professions to provide better advice to their pupils. High school teachers were involved to address the entire chain. We are currently preparing a publication about the study choice trilemma which explicates that new professions and the changing labor market are not sufficiently taken into account.

In this workshop, we also created a profile of an applicant. The purpose of this was to reveal the characteristics considered important in a whole person. Furthermore, potential candidates must also be attracted to work for this company and industry, so it is vital to know what the team should do to win the hearts of these potential candidates. In groups, we created a persona of an applicant of a specific team role, based on demographic data and several questions such as: What are his/her interests? What does (s)he lose sleep over? What makes him/her happy? What makes him/her proud? And what is (s)he good at and not so good at? We also discussed what might help visualize the 21st century skills and we kept the things we considered important in an applicant per role.

Alongside the workshop, we validated our findings from the interviews in more detail with two SMAs who were not interviewed (step 5 in table 2). They responded to the listed professional activities and the qualifications and competences per role. We recordered and transcribed their responses.

Finally, an educationalist, who is an expert on 21st century learning, checked and assembled the entire set of material.

4. Results

4.1. Professional activities and "21st century skills" of an SMA

The results of the first research question were presented at the SEFI conference in Budapest on September 16, 2019 (Sjoer et al. 2019). To understand the meaning of the 21st century skills per role, and to clarify the 21st century skills that should be visualized for recruitment and selection, we will also present these outcomes in this chapter 4.1.

Frequently mentioned 21st century skills of an SMA team
The "21st century skills" needed to develop and execute a (media) strategy for a client with a team of SMAs, are shown in Figure 2.

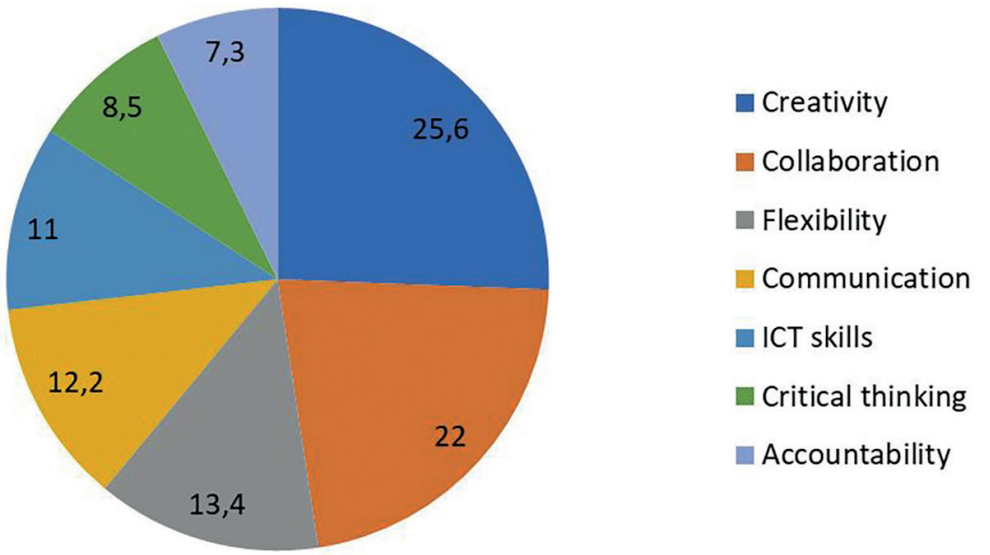

Figure 2. Frequently mentioned 21st century kills of an SMA

The two most frequently mentioned skills are "creativity" and "collaboration". These are two big clusters of skills that seem to be important. The second largest groups are "flexibility", "communication", and "media and technology skills" (in short: ICT skills). The third most important groups of skills are: "critical thinking" and "accountability".

The narrative of these important groups of skills can be defined as follows. In this company, SMAs work as a team. To achieve their common goal they have to be creative (together). They are communicating with each other frequently and thoroughly, as well as with the client. Furthermore, as a person,

they have to be flexible, media literate and able to apply technology effectively. Finally, as an SMA, you have to manage time and projects successfully and take responsibility for the final results.

To provide an idea of the final results, we give the following example. One assignment is about generating positive media attention during the period that an important tunnel is closed in the city. In order to create understanding among the public, who often used the tunnel, so-called "fixed columns" have been created, generating a constant stream of media attention. When monitoring the impact, it shows that the interaction is good, thus "engagement" continues to rise. Every now and then the team SMAs try their hand at "newsjacking". At Christmas time, the idea was to make a short movie, "our building heroes" about the people who renovate the tunnel, to acquire an attention peak on social media and "to surprise those algorithms again". (After the strategist's story).

Roles and tasks of SMAs differ in the team and with it, the emphasis on particular skills. A strategist seeks for the question behind the clients question and converts it into a communication or media strategy for a specific target group. A designer designs the images and a copywriter writes short, well-chosen texts and scripts. A videographer makes appropriate, surprising videos and a content manager spreads the message that a client wants to communicate. He/she literally posts on Facebook. Finally, a team head (in this case also a videographer), ensures that the team functions well.

Deep dive into the 21st century skills

The results of the most frequently mentioned 21st century skills: creativity, collaboration, flexibility etc. are not enough to recruit new entrants to the profession. Therefore, we dove deeper into the matter and we made a summary of the professional activities and results per role, the essential knowledge, and the most important 21st century skills that come with it, according to the respondents. Furthermore, we looked at their value proposition, asking questions like: What makes this so cool and interesting for you?

When we take a closer look at what **creativity** entails, we discover what it means for different roles. For a strategist, it means to use idea generation techniques to gain new ideas (together) and to turn these ideas into a (media) strategy or approach that has an effect on people. Creative thinking and a useful contribution to the client (the result of creativity) are the most important elements. Whereas for the designer, creativity mostly means to be able to demonstrate originality and inventiveness in concrete work, e.g., a logo. A content manager can be confronted with negative reactions after posting a message, and s/he should be creative in re-thinking, which was described as: "to analyse and evaluate own ideas and flip them to the positive side".

To be able to work as an SMA at this company you should be a "**team player"**. All SMAs have to demonstrate their ability to work effectively within a team. Each play a part in a theatre piece, or a music band, so to speak. They

value each other's contributions, have a willingness to be helpful and to make compromises to accomplish a common goal. "We talk a lot with each other. It's a new industry, it's new work, so there are no paths we can take. [...] Within the team we always consider: are we doing this because we did this last time, or because it works best." (content manager). They also work together with external parties: printers, website builders etc.

Yet, this collaboration requires something different from a copywriter than from a videographer. Although they are both part of a team, the latter can make a video all by him/herself from start to finish, whereas a copywriter's work is often fragmented. S/he should revise many texts of colleagues, or write small texts for different multimedia presentations. This requires **flexibility both in time and mindset**: "If something needs to be online this afternoon and colleagues want to have it checked, I can say that I don't have time for that, but that won't help anyone. [...] But it also means switching from writing something for a cycle repair shop to writing for a lawyer". A copywriter must be able to adapt to schedules and contexts and has to work in a climate of changing priorities. Adapting to changes also applies to the content manager in relation to the client: "Imagine your content is ready for this week and then the customer calls: "something is happening now and that needs to be communicated quickly". [...] Then all content goes to next week, or to the trash and then you start creating something else."

Especially creators of tangible products such as texts (copywriter) and images (designer) mentioned that being flexible also means incorporating feedback effectively. "If a colleague thinks something is ugly, you must not relate that too much to yourself". Also with the client, both gave examples of understanding, negotiating and balancing diverse views to reach workable solutions. "If you get the answer [from the client] „that it doesn't feel right", they actually mean that it is not entirely how they see it. But if that is what their target group is aiming for, if it does what you want to get done, it's best to think about it for a while. [...]. At first I do not agree. I want to talk with the client again." (copywriter) Another example of understanding and balancing diverse views: "As a designer, you must be able to work for someone else. Sometimes you have to be careful with your own style. We never make things that we don't like, but sometimes you have to make concessions."

The core-business of an SMA is **communication**. Almost all SMAs emphasise the ability to listen and to read emotions. Customer empathy is important for the strategist to ask the right questions to get to the real problem; for the designer to get information about the context and intentions; for the copywriter to understand the target group better; and for the content manager to develop a relationship with the client: "they should see you as a colleague". All SMAs use communication for a range of purposes and utilise multimedia and technology. Their core knowledge is about how to judge their effectiveness a priori as well as assessing their impact. The reason that **information, media and technology skills** did not comprise the most important group of skills

may be that they take their ability to access and evaluate information, to analyse media and to apply technology effectively for granted.

Regarding the **knowledge** component, disciplines such as marketing/sales, psychology, communication, and journalism are mentioned. Up-to-date information on legislation (AVG), software expertise (knowledge about packages and programmes, knowledge about the operation of websites, algorithms) and of course role-related knowledge are also mentioned; for example, for the videographer, knowledge of camera equipment and technical expertise about making videos: "what makes a nice shot?". Nearly all SMAs talk about awareness of new (technological) developments. "What's new in social media?" Upon asking this question, current trends according to the respondents are: more images, ultrashort, personalisation, passion for data.

To have some understanding what **drives and motivates** SMAs, we asked: What are you most proud of? Four categories emerged from the data:

a. Happy customer: "Who is really satisfied and his expectations have been exceeded."
b. Teamwork: "A final result that everyone has contributed to."
c. Results: "Seeing the result if you pass it or if it is on social media." and "Starting with nothing and creating something very beautiful that tells a story."
d. Effect on the target group: "If it elicits responses that you had hoped for, yes, then I am proud."

4.2. Recruitment cards: comprehensive description of the different roles

In a workshop, attended by all consortium partners, we took the following steps towards a new job design:

1. Why session: with what do we want to create (which) impact (in the future)?
2. Who/what do we need for this? A complex new profession was divided into several roles and combined in full-service teams each with their own focus. What can be split up? What belongs together? What talents do we already have in each team? How do they fit together?
3. What does an ideal applicant look like? We created personal images (personas) of an ideal applicant. This fits in the design-thinking approach: examining the target group. More applicant characteristics could be added to the results of research question 1.
4. How do we make the new job profiles practical for recruitment and selection?

Future-proof recruitment starts with the (re)design of the direction for the future. In the aforementioned workshop, three SMAs, three researchers and two high school teachers defined the most important characteristics of

an SMA. They conducted a so-called "why" session (step 1) with the following result:

"A social media architect is immersed in the needs of the customer and target group, and, in co-creation, translates this into (digital) content to ensure the conveyed message touches and moves the target group."

The company CEO had already executed step 2. At the workshop, the company owner presented the organizational structure. When he founded the company, he performed all the roles himself. As the company grew, so did the number of roles and the complexity of the tasks, requiring the recruitment of more role specialists. The concept of the three full-service teams with the assigned roles, however, is still subject to change. During the research, the role of designer and videographer have been combined, for example. This role will be defined by the word: "creative."

Since the 21st century skills should be visualized per role to recruit potential candidates, we need a better idea of the target group (step 3). Step 3 of our research revealed what the teams want from a new colleague and the requirements to attract the right person. By developing personas, it became increasingly apparent that the whole person, with their needs, passions, ideals, should be part of every new job profile. We also observed that the partners from outside the company contributed with a broad scope of application. "You need someone from a hotel education background!" stated one of the consortium partners. We jointly created a personal image (persona) of an applicant; an example is shown below.

1	Name:	Samira
2	Age:	25-35
3	Place of residence:	Nearby
4	Profile:	Higher-order working and thinking capabilities (but not necessarily academic(!)), catering / hotel training or experience
5	Background:	Job-hopper (someone who knows what's going on)
6	Interests:	Broad general knowledge, curious person
7	Media:	Social media minded (digital and offline)
8	What does (s)he lose sleep over?	Faltering collaborations
9	What makes him/her happy?	Combining ingredients into a beautiful dish
10	What is (s)he very good at?	Rhythm, empathy, communication, planning collaborations, connecting people, bird's-eye view
11	What is (s)he not so good at?	Not someone who dots the i's.

From the results of the interviews and the workshop it was possible to list professional activities and the drivers and competences (21st century skills) per role. We validated the results of this role design. Based on these validated results, we designed five recruitment cards, representing the five team roles of a social media architect. This role design, combined in the recruitment cards, fits the stage of the organization. The cards can be used in a manner that best suits the company (not in this paper).

Table 4 provides an example of the role of the content manager and a copy writer (summarized) to show the clearly distinguishable roles with the different requirements for each role.

Role 1: Content manager	Role 2: Copywriter
Professional activities Responsible for publishing everything that is created on the web (on time and correctly). For this, the content manager needs approval from the customer. Monitoring social media channels, and looking at responses to posts. […] 99% of the time at the computer. Content manager and team lead are an important duo in the team. The content manager is the creative spider in the web, and the team lead is the practical linchpin. Knowledge Knowledge of how a website works: "understanding that a Facebook algorithm works in a certain way […]" Aware of technological innovations and developments in social media Passion: "You must be data-driven, passionate about anything new." Collaboration [Love] collaborating with colleagues on concrete assignments: "having a brainstorm with the whole team, because you get multiple disciplines and expertise together and you simply get the best ideas." […] Communication [Very good at] communicating with the customer and with the customer's target group […]	Professional activities Responsible for all texts Writing texts, such as scripts, blogs, but also short texts such as headings, and brand names. Editing and correcting text written by others […] Work is very fragmented. Trends: ultra-short! Text into images Knowledge Knowledge of spelling and grammar […] Passion: Delivering high-quality, original texts, and overcoming any of the customer's initial doubts about the effect on the target group. "We are all happy with the outcome: This is how it ought to be!" Collaboration: [Likes] creating something together: "We worked very hard on a tender last week. All five of us were literally working on the same document. I looked at the texts, another at the design, and another colleague dealt with the budget. It was very satisfying." Communication: Takes communication (including spelling) seriously […] Being able to make complex matters concrete and easy to explain: "You have to be able to state everything in one or two sentences. Or at least to persuade someone to read on." […] The ability to listen, to read emotions and to understand the customer, and most importantly, the customer's target group.

Creativity creating just a little bit […] Critical Thinking The content manager analyzes the (patterns of) impact of social media posts by providing data. The strategist takes the lead and draws conclusions based on the provided data. […] IT skills [Good at] being able to apply IT: the con-tent manager is the one who posts everything Flexibility Adapts to schedules and contexts […] Organizational and planning skills Remains calm under pressure and thinks on their feet: "make sure that everyone's on board." Accountability A content manager must feel a special sense of responsibility towards a project. […]	Creativity Demonstrates originality and inventiveness: "If I have to write a script for a motion graphic or have to come with a new name for a brand, I sometimes sit on the bike with a scrap of paper in front of me." Critical thinking When dealing with colleagues and customers, you must remain critical and sometimes dare to stay firm. IT skills Just basic skills Flexibility Incorporating feedback effectively, from colleagues and customers Understanding, negotiating, and balancing diverse views to reach workable solutions Flexible with time: can adapt to schedules Flexible mindset: "Switching from writing something for a bicycle shop to a piece for a lawyer." Organizational and planning skills Being able to organize your time well: "A creative may be working on one or two design jobs, but I sometimes work on twenty different things […] it is very fragmented."

Table 4: Two examples of recruitment cards

5. Conclusion

In this paper, we researched the pre-recruitment phases of a new hiring for a small company of social media architects. Social media architect (SMA) is a new profession. It combines several roles: strategist, designer, copywriter, videographer, content manager, and team lead. Small social media architect enterprises are growing rapidly and they need more detailed information on the qualifications (21st century skills) of new hires since they cannot fall back on relevant study programs or work experience. In line with the working methods in the creative sector, we explored a design-based (pre)recruitment approach. In this approach, in co-creation we defined the role qualifications and described a job profile connected to the organization's needs. An SMA, two universities of applied sciences and a high school jointly addressed the challenges of a changing labor market.

First, the university researchers thoroughly investigated this newly created job by conducting in-depth interviews with the SMAs. The 21st century skills that a team of social media architects need most are from the learning and

innovation skills cluster of the P21 framework: creativity and collaboration. From the cluster of life and career skills: "flexibility and adaptability" and "productivity and accountability" stand out. An SMA should be able to adapt to change, and must work effectively in a climate of ambiguity. Surprisingly, the information, media and technology skills cluster was mentioned less often, but it was named in conjunction with the required knowledge of an SMA. Moreover, we think that SMAs take the IT-related skills for granted. If a social media architect is known for anything, they are known for the crossover between (social media) communication and (multimedia) technology. An interest in social media, customer empathy and creativity go well with creating media products and using digital technologies effectively.

However, knowing what the frequently mentioned 21st century skills are does not automatically lead to new job profiles. We need to look deeper into the different roles, the professional activities and results, and the desired qualities. In this way, the 21st century skills framework can be used in a meaningful way. For instance, take "creativity," if we compare all the creativity quotes for the roles an SMA can adopt, a strategist should be good at organizing "creative thinking" (together), a designer and copywriter should provide "creative work" (with others) – meaning demonstrating originality and inventiveness in work such as logos, appealing text lines – and a content manager should be good at "implementing creative innovations". Furthermore, in the interviews we also asked about the passion, drivers and emotions that go with the job. "What makes you proud?" These motivations and driving forces are important and reveal the role's professional identity.

The second research question was a design-oriented question aimed at exploring a new approach and creating a practical product that can be used for recruitment and selection. In most companies, job descriptions are standard or sample job specifications are easily obtained for most existing jobs. That was not the case in this company, however, as social media architect is a new and developing job in a fast-changing market. The recruitment process is unstructured and intuitive and mainly carried out by the company owner. The challenge was to remain flexible, while providing some structure.

In line with the way SMAs work in the creative sector and the development stage of the company, the job roles and corresponding profiles were built bottom-up and in co-creation in this study. SMAs, university researchers and high school teachers shaped the roles together. First, they delved deeply into the rapidly changing context of an SMA, the companies development strategy (working in full-service teams), the contribution of every team member and what this requires of a person (see research question 1). Not only did they consider the "skills" and required knowledge, but also the emotions, values, and motivations. Second, in this rapidly changing world, you cannot rely on standard HR methods and procedures. Instead, we used marketing techniques to indicate the future direction, create the elements of personas and design job roles. This approach provided clearly distinguishable, flexible roles with

corresponding qualifications. After which, we processed all the collected data into five customizable recruitment cards.

The strength of this approach is that we start with collecting rich data about roles instead of jobs or functions. An SMA team comprises multiple roles and it is possible to combine (part of) these roles, depending on the talents of the employees and/or applicants. Breaking down the complex SMA function into roles and then dividing (aspects of) the roles, based on what a person can do and what the organization needs, offers several advantages. This method enables an organization to remain flexible. Furthermore, the company can offer people space to develop themselves.

Further evaluation research is needed into how the recruitment cards can be implemented successfully. We need to know more about the effectiveness and efficiency of the cards to improve them and scale up the approach. From this study, it became clear that for new job profiles fitting the needs of growing SMEs in the fast changing labor market, it is helpful to:

- Take a design-based approach to developing job roles, together with other parties (outside the company);
- Delve deeper when considering appropriate "skills," otherwise frameworks such as 21st century skills will be meaningless;
- Use methods from other disciplines that fit the organization's culture, in our case elements of design sprints for HR purposes;
- Include the "knowledge" required alongside "skills";
- Intertwine the "skills" (that are often not "skills") with the personal narrative of the applicant to reveal the needs, beliefs, emotions, passion, etcetera ("role identity");
- Have the courage to go beyond traditional job descriptions listing job responsibilities and required education and credentials;
- Look at the rapidly changing context and the value this company (staff) wants to add together.

The recruitment cards we made are not static products. The company could add new cards, and the content is subject to change depending on the direction of the organization, the possibilities for growth and the people who work there. In this way, we can incorporate flexibility, which is necessary for a new profession and for companies with changing job positions to enable them to stay future-proof and provide opportunities for lifelong development.

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EUGENIA STAMBOLIEV

On Care Robots and the Ethics of Tracking

A Transdisciplinary Ethics on Care Robots seen through a Posthuman and Performative Discussion on Tracking and Data Availability

This paper establishes a transdisciplinary exploration of care robots and their tracking capacity as an ethical performance. It does this to highlight the concerns around the ubiquity and availability of data in care contexts. In my attempt to scrutinise care robots beyond being humanoid and sociable actors, but instead as data tracking technologies, I link robot ethics, media and surveillance studies with posthuman and performative ethics to redefine tracking as an ethical microcosm within care robots. I do this, first, by challenging how to look at care robots and robot interactivity, particularly in reference to tracking as an ethical, not necessarily moral, question of interactivity and relationality. This angle will challenge the ethical timing and evaluation around tracking as an inherently ethical relation. Second, by arguing that the common ethical views on tracking are about concerns of privacy intrusion and data infringement while overlooking that a main ethical issue might not be a robotic intention to spy but the availability of data because of robots. Consequently, what deserves more attention in the ethics of robots is the growing ubiquity of care robots, the sensitivity of care contexts, and the acknowledgement of data appropriation; the latter being especially important considering the vulnerability of health care environments, and the growing commercial value of health data.

Keywords: *Robot ethics, posthuman ethics, performative ethics, care robots, tracking, media and surveillance studies, health data, dataveillance*

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How to cite this article:
Stamboliev, Eugenia. "On Care Robots and the Ethics of Tracking – A Transdisciplinary Ethics on Care Robots seen through a Posthuman and Performative Discussion on Tracking and Data Availability." *Információs Társadalom* XX, no. 2 (2020): 101–117.
https://dx.doi.org/10.22503/inftars.XX.2020.2.7

1. Introduction

A transdisciplinary or transethical understanding of care robots, tracking and data as an entangled and ethical performance allows to rethink several aspects around care robots, which fall short in robot ethics. *Tracking* means multiple things in this paper. Technically, it refers to visual/haptic detection software and recognition systems or to *tracking systems* (Lin et al. 2012; Rossini 2012). Further, tracking can also refer to a strategic intention to survey and to collect data and information about customers, users, clients, or the elderly (Ball et al. 2012). Keeping this ambiguity on purpose will support me manoeuvring between these various dimensions throughout this paper as I position tracking as an ethical performance. The perspectives from posthuman and performative ethics used to expand on robot ethics will highlight the relationality of tracking and enable a critical discussion on care robots without having to focus on them as moral actors, or as un/suitable care takers, and without drifting into AI ethics. Instead, I will draw insights on thinking data concerns from media and surveillance studies to understand data availability differently. This will reposition the problem on tracking as surveillance from one on privacy intrusion towards one of data availability and robotic ubiquity. The difference being that I do contest the moment or approach when technology is considered ethical or morally charged in most ethical discussions by viewing tracking as inherently *ethical*.

The focus on tracking as a particular insight into the ethics of care robots is motivated by three different angles; to expand on robot ethics, to address the commodification of data and care, and to acknowledge the sensitivity of the care context. The first motivation lies in the necessity to blur the divide between anthropocentric and material discussions around robot technology to address the limits of moral evaluation in techno-economical innovation (Braidotti 2006; Donaghy 2001), which will offer new insights towards understanding robots holistically. The second angle on the robotisation of care links to; the ongoing digitalisation of health care, or 'Health 4.0' (Kickbusch 2019); the concerning growth of the commercial value of health data (Knoppers and Thorogold 2017); the commercialisation of care (Aulenbacher et al. 2018; Ford 2015); health technologies continuously converging with internet structures (Frank 2000); and the accelerated effort to position robots into elderly care, even if this is still at an experimental stage (Royakkers and van Est 2016; Lin et al. 2012). The third motivation to understand tracking better makes this discussion very specific, even if the angle on tracking and data seems transferable to other digital devices; the context of care is particularly ethically sensitive since it exposes vulnerable groups of people to an emerging data technology they might not understand fully, nor avoid exposure to.

2. On the ethical issues around care robots as companions or assistants

In my attempt to scrutinise care robots[1] not only as humanoid and sociable actors but as data tracking technologies, I bypass most discussions on why these devices are 'un/suitable' caretakers, or care assistants, and discourses dealing with the moral capacities, appearances, or actions of care robots (Royakkers and van Est 2016; Lin et al. 2012; Coeckelbergh 2009, 2010, 2018; Vandemeulebroucke et al. 2018; DeFalco 2017; Vallor 2011, 2016; Draper and Sorell 2017). Instead, I am establishing a transdisciplinary and transethical study on care robots to challenge what counts as ethical in robot ethics while focussing on posthuman and performative angles.

However, I would like to give a brief overview of the ethical discourses around anthropomorphism and care robots first. If viewed as humanoids, companions, or as assisting devices only, for the last twenty years robot ethics has dealt with various scenarios in which care robots or care technology assist, replace, or cooperate with human caretakers in care environments.[2] Discussions around the ethics of the care robot are frequently occupied with their growing implementation in relation to the sensitivity of the people interacting with them (Turkle 2011; Wu et al. 2012; Krämer et al. 2011; Royakkers and van Est 2016; Lin et al. 2012; Sharkey and Sharkey 2010; Coeckelbergh 2009, 2015; van Wynsberghe 2012). Most ethicists in this field agree that if seen as a sociable companion (Krämer et al. 2011), robots should and will be treated as *more*-than-computers ultimately (Royakkers and van Est 2016). Therefore, their future acceptance as 'social actors' (Heerink 2011) is especially important in ethical terms considering that elderly care is a sensitive, communicative and trust seeking context in which the patients' dignity and safety is especially protection worthy (Sharkey and Sharkey 2010).[3]

On the one hand, anthropomorphic projections and intentions interrogate if and how robots will, or should be, positioned as assistants or replacements for human caretakers. Some argue that the implementation of care robots,

1 '*Personal care and companions*: Robots are increasingly used to care for the elderly and children, such as RI-MAN, PaPeRo, and CareBot. PALRO, QRIO, and other edutainment robots mentioned above can also provide companionship' (Lin et al. 2012, 944).

2 'According to the European Commission (2012), the proportion of those aged 65 years and over is projected to rise from 17% in 2010 to 30% in 2060, with the peak occurring around 2040. (…).' (Royakkers and van Est 2016, 62).

3 For now, care robots are mainly linked to anthropomorphic concerns (Duffy 2003). Media and surveillance studies (or cultural studies, feminist technology studies) does not deal with care robots as a technology since the field is rather interested in digital materiality or computational agency of the digital (Galloway 2012; Andrejevic 2012), while the socio-economic canons, which look at care, would rather look at the marketisation of care as ethically problematic and to robots as instrumental in this process (Ford 2015; Green and Lawson 2011).

especially as companions, could be an isolating process for the elderly (van Wynsberghe 2012); could objectify the elderly (Sharkey and Sharkey 2010); or that it could be understood as deceptive on the grounds of robots affording, but not exhibiting, emotions or care (Sharkey and Sharkey 2011; Turkle 2011). Another ethical critique lies in the very principle of anthropomorphism, as social robots are meant to push our 'Darwinian buttons' (Scheutz 2012, 215) under a 'false pretence', which can 'automatically trigger inferences about other agents' mental states, beliefs, desires, and intentions' (216).[4]

On the other hand, techno-philosophers, like Floridi (2014), consider any form of 'anthropocentric agenthood' (187) misleading by mistaking the robot for an entity. For him, data issues around robots must be detached from the perception or thinking of robots as human-like entities, which represents wider approaches of AI or data ethics towards robots. Dumouchel & Damiano (2017), or Coeckelbergh (2010, 2018), suggest another approach towards *relational* thinking of social robots that also questions the agenthood stability initially drawn from Cartesian modelling of robots (and humans). While both angles have moved beyond ontological thinking, relational (moral) 'patiency' theories (Gunkel 2012; Coeckelbergh 2018) still emphasise the social and embodied element of technology without declaring the robot as instrumental, or as a data machine only.

3. From monitoring to an ethical and performative view on tracking

While my concerns are not specifically linked to how robots are perceived, I do not transfer this discussion into AI ethics or to research on algorithmic morality (Floridi and Taddeo 2016), nor do I suggest ignoring discussions on robots as moral artefacts (Kroes and Verbeek 2014). As I leave the previous discussions on anthropomorphism without dismissing their concerns, my research is mainly concerned with expanding these through new ethical and disciplinary angles (Stamboliev 2019). Despite my ethical position advocating for posthuman and performative perspectives to join, the discussion I am about to establish is not being fully transformed into a posthuman nor processual one. The main reason is that neither posthumanists nor performative approaches are necessarily concerned with looking at one particular technological body or implementation, let alone at care robots, and this would leave no space to address the sensitivity of care contexts. However, both posthuman thinking and performative approaches have arrived in philosophy of technology (Coeckelbergh 2019) as well as in

[4] Anthropomorphism does not have to be understood as deceptive mistake (Duffy 2003), but is a helpful predisposition to increase the acceptance of robots, especially within environments such as elderly care, where the resistance towards bulky and scary devices could be significant (Wu et al. 2012).

science and technology studies (STS) (Licoppe 2010) challenging ontological stabilities increasingly, but rarely the focus on moral philosophy.

Next, I will scrutinise the existing view on tracking in robot ethics to then suggest a performative perspective on tracking, which then ultimately shifts to a media-material view on data leading to the concerning part of this paper; dataveillance and elderly care.

The various angles I propose will contest how we understand data issues around care robots and when these emerge. The focus on the timing of the ethical discussion is crucial. What I mean by *timing* can also be understood as the difference between evaluative ethics and structural ethics. I argue that an ethical understanding of technology does not have to be only evaluative or problem-based, but can view robots as inherently ethical structures, which is an *apriori* discourse opposed to the projections and concerns often raised in robot ethics. The latter focuses – like most moral philosophy – on specific moments, issues, errors, or on virtues. The ethical issues, which keep reappearing in robot ethics, focus on deception, isolation, and a lack of emotionality (see I.), or as explained next, on tracking as spying. These are evaluative concerns that often guide the ethical discussions by raising questions on virtues and abilities – or the lack thereof.[5] The difference being that posthuman ethics views technology as inherently ethical describing and contesting its relation and structure to subject formation, environment, and capitalism (Braidotti 2006).

On the difference between tracking-as-spying and tracking-as-ethics

Tracking has not gone unnoticed as a concern. Mainly because it is often linked to surveillance technology and viewed critically by media and surveillance scholars. Researchers from information and technology studies, like Nissenbaum (2010), refer to monitoring and tracking simultaneously as the ability 'to watch over people, to capture information about them, and to follow them through time and space' (10), while in computing and web design, tracking also has negative connotations and is linked to the instalment of cookies and strategic surveillance (Acar et al. 2014).

Tracking is a concern for robot ethics as well, but less so when it comes to care robots, since these usually drop out from the narrative of being a potential spying technology (see I.). Still, in some care robot discussions, tracking is mentioned as aligned with monitoring and privacy intrusion and often used synonymously. While I understand why this is a valid concern, I do not fully agree with the belatedness and evaluation of this process and its alignment

[5] The motivation behind any posthuman thinking is critical towards moral philosophy or philosophy of technology. Often, posthuman approaches challenge standardised and universalized debates on subjectivation, technology, morality and expose capitalist interests in the making of emerging technologies (Braidotti 2006).

to *immoral* monitoring (Stamboliev 2019). For instance, two prominent robot ethicists, Sharkey and Sharkey (2010) state that:

> 'Robotic surveillance devices have already been developed for warfare, for policing and for home security (Sharkey 2009) and these could easily be adapted for monitoring the elderly. A robot that traverses the house, and relays information picked up by its sensors, is something that is well within the current technological limits' (2010, 32).

For them, monitoring is problematic (while having positive aspects too), because it enables unconsented *spying* on the elderly (I assume they mean by the caretakers?). This would intrude upon people's privacy, which is a worrisome possibility. While they also highlight that it is not clear who has access to the data robots gather or its management[6], they do not fully unpack the scale of this data problem. Hence, my intervention comes in at this point: I state that even if robot ethics is (rightfully) concerned, most views on tracking are somewhat limited.

For instance, tracking is always moralised when mentioned, even if it is not per se moral in its technical intentionality. Still, it is not a *neutral* process, while it is not simply spying either. It might be intentional, but it is not conscious. There is no ethical (relational) debate on its becoming, while I argue there should be, because tracking negotiates between human values and input, and technological capacities and output. Further, there seems to be a lack of acknowledgment that the ethical issues around digital tracking technology are intimately embedded in social robots being interactive data devices. If one wants robots to be interactive technologies, tracking is a minimum technical requirement, and the handling of data is part of this process. This does not have to be *per se* problematic, and yet it is. Hence, the challenge in redefining tracking will be about how to think the potential of data and not the intention to spy; each exhibiting a different approach to when technology becomes ethical.

To understand this better, I need to explain how tracking functions. The technical side of tracking refers to recognition/detection modules or systems, which are mostly researched in the field of Human-Robot-Interaction (HRI) or in computer studies. Just like any interactive technology, care robots must exhibit a certain level of aliveness and responsiveness to be placed into human contexts and to not be perceived as uncanny (Mori 2012; Ravetto-Biagioli 2016). Yet, tracking is extremely difficult to *perform* – ethically and technically

6 '(…) forget that the robot was monitoring them, and could perform acts or say things thinking that they are in the privacy of their own home. Moreover, who should have access to the information, and how long it should be kept for? With the massive memory hard drives available today, it would be possible to record the entire remainder of an elderly person's life, but this is not something that they would necessarily consent to if they were able to' (Sharkey and Sharkey 2010, 32).

speaking. What is even harder, is its synchronisation to locomotion and movement (Brèthes et al. 2004; Rossini 2012). Why is this the case? Tracking systems require a certain sophistication building on 'advancing biometrics capabilities and sensors, and database integrations' (Lin et al. 2012, 946), which enables synchronisation of input with output (and best case, with locomotion). First, the robot's tracking module requires clear instructions and accurate concepts of what to detect (human, gesture, emotion).[7] Second, these steps rely heavily on the computational capacities of the robot to be (operationally) autonomous and able to process information in real-time; otherwise, no interaction with a human, no HRI, can be established (Tseng et al. 2016).

Tracking as a performative and ethical relation

Advocating for an *ethical* perspective on tracking (not a moralistic one) means to focus on the relationship between computational capacities of robots as interactive data machines, and on the programmer's input or commands as being *entangled*, not viewing them as distinct entities. Since tracking requires data input and processing capacity to allow for the robot to interact, the robot and data are always *entangled* in their becoming. Hence, tracking acts as a microcosm that demonstrates why an ethical discussion on robots does not begin with the privacy intrusion or monitoring, and why it could even be seen as a form of posthuman *caring* emphasising the relationality embedded in its performance. Thinking the robot's capacity to track human movement as a form of posthuman *caring* could even allow for the human and non-human interaction to be understood as a (visual) computational feedback loop, which should not be understood as a romanticised thought about the robot becoming emotional. The reinterpretation of caring *as* tracking, and tracking *as* caring, only makes it easier to consider technological interactivity as a fluid performance of attention, recognition, and responsiveness.

Further, tracking could also be viewed as *performing* ethics through robots, less through attributing moral codes to technological capacities, neither as a linear nor a neutral chain of commands, but as very relationality between human and robot. Barad's take on *performativity* (2003) is helpful in this thought experiment since not only can tracking be a form of caring, but the fluidity and processuality questions the human and non-human borders inherently. Barad (2003) proposes 'a posthumanist notion of performativity—one that incorporates important material and discursive, social and

[7] One underlying program embedded into a tracking module, is, for instance, Ekman's Facial Action Coding Scheme, *FACS*. The FACS is still a highly popular psychological scheme on emotional expressivity designed by Ekman in the 1970s. It suits the detection of 'basic' emotional states in human faces. It is also heavily critiqued by now for being reductionist, and also culturally and racially biased. See Knapp and Hall (2014) and Gates (2011).

scientific, human and nonhuman, and natural and cultural factors' (809). She relates this to the work of Butler on performativity, and on the materialisation and becoming of gender. Without fully making this a processual discussion, I place the attention on the dynamics of the 'ongoing reconfiguration of the world', not as distinct entities, causalities or attributes (818)' (Barad 2003). This view is linked to thinking data as ethical, therefore, every level in the robot (aka in *every* technology) can be discussed in this manner, and most importantly, nothing is ever non-ethical. To some extent, this view relates to early machine morality research. Wallach and Allen (2009) were two of the early scholars to point out that the engineer's intention and values influence computational decision making to a high degree.

Avoiding an ontological causality between engineer and machine, the performative and posthuman thinking (which is interrelated, but not identical) refuses to deal with entities or ontologies of *the* human and *the* robot (among other things) – and specifically refuses any moral universality (Braidotti 2006). Instead, an ethical view on tracking as an ethical and performative *entanglement* of human concepts and technological capacities does lead to new 'ethical complexities' (Braidotti 2006: 16) that further do 'not intend to provide guidelines for a practical morality' (Luhmann 1989: 112). This amplifies the fluidity and continuity between human and non-human agencies coming together in the becoming of matter and meaning of technology as ethics. This also enables redefining the boundaries between intention and possibility, between predicting and moralising potential future interferences and errors from the human-centred perspective; or studying the capacities and networks from a technology-centred perspective.

Ultimately, what the discussion on the performativity of tracking magnified is the relationality and fluidity between human and posthuman intentions, as potentials and interactions within the becoming of technology, which I define as ethical. The reason why this discussion is not aligned to AI ethics or data ethics is the posthuman and performative element that expands the ethical without deepening a discussion on morality. Yet, the issues with tracking are not unknown in robot ethics (neither in AI ethics). The difference in my approach is that I understand tracking as an inherently ethical relationship between robot and human, and not as a question or process of privacy intrusion through im/morally guided robots. The inherently ethical potential of tracking, however, shows more; it points out that the robot's interactivity is dependent on an interplay of data *throughout*.

From this, a new concern arises; tracking generates data, even without carrying an intention to spy on anyone. To explain the ethical potential of tracking generating data, I will situate the discussion back to the care robot as technology in elderly care. From understanding tracking ethically, I move towards explaining why the care robot's implementation into care runs the risk of becoming a different form of surveillance, nonetheless.

4. On the ubiquity of care robots, data availability, and the sensitivity of elderly care

Tracking being ethical and performative is one thing, tracking enabling *dataveillance*[8] is another. The latter implies an actual ethical (sometimes legal) issue enabled through tracking systems, which is not as such one about an immoral spying through/of robots or their developers, but is one about making data even more available through ubiquitous technology.

As I define it, tracking can become problematic in two ways, which are both still grounded in the previous discussion. First, creating and programming tracking modules is an inherently ethical performance charged with *future* information. According to Gitelman (2013), such information is embedded in the *potential* of data.[9] Hence, one must understand that the availability of data already carries a concerning and ethical potential prior to the actual misuse of data through *immoral* robots, or them spying. Now, someone could argue, this still adds a *disguised* moral judgment to the debate. Yet, I insist on this *not* being the case since this viewpoint does not identify any specific wrongdoing, or evaluative judgement in this process.[10] When data becomes available, it will very likely be appropriated. This is its structural potential. Still, this gets problematic, if this very potential is not taken seriously and understood fully. Therefore, second, by expanding on the use of social robots into care as a sensitive context, we do increase the potential for the previous possibilities to become an actual ethical issue.

Andrejevic (2012) argues, from a media and surveillance studies perspective, that one essential change in the logic of surveillance in our era of automated data collection and processing is that such has moved away from traditional surveillance. For him, surveillance does not require any subject's (nor robot's) internalisation of a monitoring gaze while he is particularly alert to the ubiquity of information technology accelerating the 'ubiquitous' structure of technology towards a 'ubiquitous surveillance' (91) – by default, not by intention.

8 Clarke (1988) defined it as a 'systematic use of personal data systems in the monitoring or investigation of the actions or communications of one or more persons' (499).

9 I do not draw a clear distinction between data and tracking, whereby, I consider tracking in the centre of this discussion. However, even data can be viewed as ethically charged. Galloway (2012) argues that data has a 'phenomenological claim' (82), but it is not yet information. Gitelman (2013) highlights that data already carries the potential of future information. Gitelman most resonant statement is that there is no raw data (2013, 1), which becomes a crucial tenet for critical data studies (Richterich 2018). She warns that our lack of criticality allows us to ignore the fact that data is always designed, stored, collected, gathered, etc. Hence, at 'a certain level the collection and management of data may be said to presuppose interpretation' (3).

10 My concerns focus on a lacking technical transparency rather than on a lack of good or conscious robots as I do not expect any moral judgment from robots. However, I do not advocate for an amoral discussion about robots at any point, but in this paper, establishing new techno-ethical dimensions seem more fruitful and closer to my background as a media philosopher.

As the pervasion of communication technologies has further broadened the spatial infiltrations, care environments might not be exempt from these developments. Increasingly more environments are regulated under the umbrella of 'networked interactivity' (92) allowing for the technologies to 'recognize us wherever we go, responding to our presence in ways that incorporate information about our histories, desires, needs, and wants' (92).

Ball et al. (2012) emphasise these changes being a refiguration from the traditional 'strategic surveillance' towards one that is a distributed, non-strategic information structure (Ball et al. 2012, xxv). This 'new form' of spying has become a by-product of simply applying a digital and data gathering technology in new contexts. Gathering *more* data would lead to more data being appropriated. Enhanced by this very robotic ubiquity, we run the risk of creating more dataveillance[11] through structures already put in place (and simultaneously expanded upon). This, theoretically, less strategic spying is referred to as an 'algorithmic surveillance' (Introna and Wood 2002), because it is structurally entangled with the algorithmic and computational level from which it feeds. What scholars, like Andrejevic or Ball, clearly present is that an intention to spy is not required (but still possible) as data collecting has merged with communication and digital structures. We face a new paradigm towards spying as enabled by the promise of a comprehensive data collection. This allows prediction and pre-emption to replace deterrence (Andrejevic 2019).

This angle has supported my argument about the ethical *timing* as I argued that privacy intrusion might be a belated concern in robot ethics since such only emerges when intrusion or misuse is to be avoided, while not asking if the care robot is in principle a problematic device by implementation and capacity. However, there is already research that pays much more attention to the importance of design and ethics. For instance, van Wynsberghe (2012) developed her approach towards *Care Centered Value Sensitive Design* (CCVSD) to rethink the role of design into the ethical sphere, but also to interrupt what calls the 'vicious circle'; an unchallenged dominance of industry in the implementation of robots. Others focus on integrating ethical design approaches (Dodig Crnkovic and Cürüklü 2012) also having in mind the improvement of robot virtues (Vallor 2018) whereby the ethical dimension of tracking or data prior to the concern of data misuse or infringement, is often neglected.

Eventually, the expansion of automated and ubiquitous data structures (devices) the possibility of endless data appropriation, definitely multiplies the concerns around care robots. Especially, as more digital technologies are merging with medical health services (Knopper and Thorogood, 2017), it is worrisome when Schermer (2007) states that 'surveillance practice will become more efficient, more user friendly, and more complete through the use

[11] The term dataveillance is rarely used today, since mostly referred to as Big Data, but to emphasise the shift from surveillance to data-veillance, I have stuck to this term on purpose.

of agent technology' (133). While I still question the possibility of strategic surveillance of care patients, or in health environments, becoming legal or socially accepted, I strongly anticipate growing commercial interest in the data circulating in these contexts.

4.1. The practical side of robots, tracking, data concerns, and elderly care

Is the potential danger of robots in elderly care to be data-mongering surveillance technologies just a far stretched and fatalistic outlook from a media philosopher? Let me contextualise my previously raised critique within the practical tendencies found in present robotics research. I will present two problematic application issues around social/care robots, which demonstrate the existing developments for my concerns. First, I will address the issue that care (social) robots are easily hackable, and second, I will point to their application being fused with Big Data analytics.

First, the social robot Pepper (a prominent research/social robot applied for elderly or health care in Japan) has already faced system breaches and was labelled as an 'insecure' and easy-to-hack technology (Chirgwin, 2018). In 2018, Giaretta and colleagues tested the data security barriers of humanoids like Pepper and NAO and discovered that these devices are extremely easy to hack; accessing their servers was easily achieved. Resulting from this, it can be argued that it is much likelier that we are about to implement hackable and data-sensitive robots into elderly care than friendly humanoid companions. The argument in the study differs from mine in this paper since the researchers deal with the already mentioned moment of ethical error or conflict, which means they assume that the data is initially neutral *prior* to being hacked, which I presented as a belated ethical concern. However, independent of the ethical approach, what they find equally alarming is the lack of urgency around data security in social robots. Sylvia's (2016) view on how privacy protection is approached in this field, is much more direct by arguing that discussions on data protections are presented as *red herring* debates that mask 'a much larger argument about the changing character of the risks stemming from the power differential created by corporate control of information' (20).

Second, there is a more explicit linkage to the critical point I made about dataveillance, which proves that service (or care) robots are attached to Big Data software *and* to elderly care already. Under the assumption that humanoid service robots are becoming an increasingly big part of our daily lives, Jiang and Zhang (2015) suggest to synchronise these with Big Data Analytics software 'equipped with distributed and scalable data processing and intelligent analysis ability' (144) as a 'flexible and efficient method to support incremental data collection, storage and knowledge model', which allows to enhance robot-robot communication but also 'distributed collaboration' (144). If understood correctly, this means plainly; data is *collaboratively* exchanged

between robots, fetched from contexts such as elderly care or educational contexts, which they specifically refer to, and moved and stored on various clouds and online storages while access and ownership remain open points. This research does not raise any ethical flags for the authors, but is described as technically complex, which it surely is.

While the research of Jiang and Zhang shows that aiming for synchronisation of Big Data Analytics to emotion and gesture tracking in elderly care, or in education, is a technological challenge and not an ethical one, I strongly urge not to distinguish between these two. Especially, when we consider the sensitivity of data and the vulnerability of people exposed to robots, the technological advancements must develop in parallel with an ethical understanding thereof. In the end, we are debating the rights and dignity of people who despite not being a homogenous group at all, will be potentially exposed to unknown devices in moments of pain, helplessness, confusion, or inability to consent or understand. Gaining or managing the data from vulnerable groups is an inherently problematic process, and if we include the sociably acceptable companion position of robots, even more so. These devices might become more than mere entertainment but might gain in status and importance in some people's lives. The tracking capacity of care robots cannot be regarded as the same concern as this would be for computers, or on digital platforms, given that the latter are part of people's lives *by choice*, while no one's life depends on their usage. This might be a very different scenario considering the future dependency on care robots or care technology.

5. Conclusion

The care robot is a very particular technology considering what relationship it will afford. Maybe we will accept it as a humanoid and social actor, but surely, it will function as a data gathering device. As an example of technological innovation affecting a vulnerable group of people, the care robot enabled a transdisciplinary review on how technologies are always social, ethical and consequential. Instead of asking if care robots are deceptive or isolating companions for vulnerable humans and focusing on their appearance only, I argued that robots are more than un/suited caregivers; they are already good enough data tracking machines. What I emphasised was to look at tracking as a performative and ethical performance related to design, data collection, and implementation of care robots. As such, I came to suggest that it is not sufficient to address the concern of privacy intrusion as a potential ethical issue in robot ethics, and in addition, that we should change our perspective on data. The reason being that data changes in its functionality and can be appropriated, and commercialised after being gathered.

Linking robot ethics; media and surveillance studies; and posthuman and performative ethics, not only enabled an understanding of tracking as an

ethical microcosm within care robots, but it pointed to the ethical and performative dimension of tracking, and the sensitivity of data and elderly care. Focussing on tracking as an inherently ethical process led to questioning if privacy intrusion and data infringements could be a belated concern of robot ethics pointing to a difference in ethical timing. The new ethical perspective I suggested shifted the focus from data infringement towards data availability, and opened a discussion on ubiquity as it positioned care robots as potential dataveillance.

Still, it is not that AI or robot ethics has not raised similar concerns about the sensitivity of health care environment, or on data fetched from robots. Yet, my approach was meant to change the discussion through altering the ethical approach, and timing, and through creating a transdisciplinary engagement that left robot research and moral philosophy aside at points. Even though the linkage between surveillance and care robots could evoke some resistance from ethicists or roboticists defending a purely utilitarian motif towards improving care technology, I pointed out that the hackability of social robots and their tracking capacities being fused with Big Data software raises underestimated and unnoticed ethical red flags. If what van Dijck (2017) proclaims as the 'normalization of datafication as a new paradigm in science and society' (39) aligns with the increased 'mediatisation' of social structures (Hepp and Krotz 2014), care contexts might face various data and infringement issues, which might be easier to identify by looking at ethical schools that do already place critical, yet not technophobe, angles on emerging digital technologies as being problematic data gathering technologies. Ultimately, the ongoing transformations of professional care and labour conditions; the implementation of digital data machines; the commodification of care and robots; the vulnerability of patients or clients; and the value of their data – each topic demands a much broader and transdisciplinary attention beyond picking techno-philosophical traditions without neglecting disciplinary expertise and foci, but by encouraging new synergies and linkages to understand techno-ethical concerns even better.

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Sustainable Development and Diversifying Competencies Curricula

This paper explores the question how to approach thinking about curriculum construction for European engineering schools in the age of sustainable development. We present a theoretical argument that curriculum thinkers need to broaden their focus from the "restricted competences" paradigm (RCP) in curriculum thinking to consider how to make curricula within a diversifying competences paradigm (DCP). We claim that the best response to the challenge of sustainability is to produce more skill-diversity among engineers while simultaneously training engineers to make the most of this diversity. We support this claim with two arguments. First, we explore the problem-solving power of diversely skilled collectives, suggesting that this increases relative to homogenous collectives when confronting complex problems. Then we show that sustainable development is not only a complex problem, but an extremely complex or wicked problem. Based on these two conclusions, we propose a mixed-medium curricular model which illustrates how engineering schools might be reformed in order to produce greater student competence diversification.

Keywords: *sustainability education, complexity, diversity, curriculum theory, media studies approaches to curricula, competence-based education*

Acknowledgement

The authors would like to acknowledge the support of the EU Erasmus+ funding body under grant number 2018-1-FR01-KA203-047854 and to thank both our colleagues at the ENSTA Bretagne and the members of project A-STEP 2030 for their support, feedback, and intellectual stimulation.
The European Commission support for the production of this publication does not constitute an endorsement of the contents, which reflect the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

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How to cite this article:
Tabas, Brad, Klara Kövesi. "Sustainable Development and Diversifying Competencies Curricula." *Információs Társadalom* XX, no. 2 (2020): 118–131.
https://dx.doi.org/10.22503/inftars.XX.2020.2.8

1. Introduction

Sustainable development is a keyword in contemporary European discussions on the future of engineering education. This paper aims to contribute to that discussion by exploring the idea that increasing competence diversity among engineers is a means of increasing their collective problem-solving capacity, which would in turn assist in the struggle to develop sustainably. This paper begins by expounding the argument that greater diversity amounts to greater problem-solving potential, simultaneously indicating ways in which the implications of this argument challenge hegemonic thinking on sustainability education for engineers. In the second half of the paper, we explore in more concrete terms what taking diversity seriously might mean for the future of engineering education, presenting a mixed media model curriculum is aimed at improving skills diversification relative to current norms. Our overall aim is not to present a study of what exists but to propose a possible model for future curricula that might inform future sustainability-oriented innovations in European engineering curricula.

2. Restricted competences

Curriculum theorists typically consider the minimum set of subjects or competences that each and every student ought to acquire during their studies. We call this the restricted competences paradigm (RCP) of curriculum thinking. One of the recent trends in RCP thinking is an attempt to revise core curricula to include sustainable development and RRI competences. In the case of the CTI, the body overseeing the accreditation of French and many other francophone countries' engineering degrees, these include at least three core competences: a) the capacity to identify ethical and professional responsibilities; b) the capacity to take into account environmental challenges; c) the capacity to take into account social impacts. A recent literature survey (Tabas et al. 2019) carried out in the context of the European project A-STEP 2030 (Attracting Diverse Talent to the Engineering Profession) reveals that almost all of the research on training engineers for sustainable engineering similarly operate within an RCP framework. There are many reasons why such a restricted approach is attractive, including clarity, simplicity, and practicality. Other reasons for pursuing this approach include institutional legitimization and a desire for standardization, often tied to the perceived need to meet or establish national and international certification standards (for instance those of the CTI, ENAEE, EI, etc.), or a need to justify point by point the contents of curricula to companies, students, and other social actors. Yet it must also be said that the RCP approach sets out to establish a minimum action towards incorporating sustainability within their curricula. It must also be noted that RCP approaches implicitly assume that engineers will be confronting sustainable

development challenges alone, to the extent that each and every student is prepared with the skills required for individually confronting development.[1] Yet it remains worthwhile to pose the question of whether meeting the minimum requirements for addressing sustainability is the same thing as doing what is best for preparing future members of the engineering profession to address sustainability. We suggest that thinking about sustainable development curricula within what we call the *diversifying competences paradigm* (DCP) may help future curricula come closer to this optimum.

3. Diversifying Competences

A DCP curriculum does not aim to train students in a standard minimum number of required competences, rather it aims to maximize the total diversification of the portfolio of competences acquired by the student body as a whole. By competences, we intend skills of all sorts, both math and science skills as well as skills such as language and leadership skills. By diversity and competence diversity we do not primarily have in mind ethnic or gender diversity, even if these kinds of input diversities matter for producing curricula with significant output diversity. Competence diversity as we understand it involves the possession of different sets of competences or differing cognitive portfolios: different viewpoints and ways of describing and modelling problems, different bodies of knowledge, different heuristics and problem-applicable tools, etc.. Diversity is not randomness. For competence differences to matter for engineers, they must be relevant to sustainability problems: differences that make a difference.

Why foster competence diversity?

Diversity trumps homogeneity when confronting complex problems. This has been demonstrated across numerous domains ranging from empirical studies to computer models. This point has been made in general terms by Surowiecki (2005) and Scott Page (2007, 2010, and 2019). In ecology, diversity has been linked to the robustness of ecological systems (Krakauer 2006; Olivier et al. 2015; Whitacre and Bender 2010). The business case for diversity has been extensively documented (Robinson and Dechant 1997; Richard 2000; Erhardt et al. 2003). Diversity also positively correlates with increases in collective creativity and innovation capacity (Sawyer 2007; McLeod et al. 1996; Livermore 2016).

Why does diversity work? One answer has to do with cognitive capacity: each individual can only master a certain range of things. Yet when cognitive

[1] This is because different problem-solving logics apply to individuals and groups. One recent study, Quelhas, et al. (2019) explicitly states that they conceive of engineering problem solving as an individual activity. As they put it, they seek to isolate: "the competencies that can contribute to the formation of *an engineer capable of bringing adequate solutions to the conflicts of sustainability* in the twenty-first century." Note the usage the singular here.

power is pooled, it can be greater than that possessed by any individual. But this does not directly explain why diverse groups beat homogenous ones. Page (2010) offers two explanations for the power of diversity.

The first explanation offered by Page involves what he calls "averaging". He shows that it is on average statistically more probable that one of the tools will be adapted to any given situation when you have lots of types of problem-solving expertise (i.e. lots of diversity within your group) than if you have less diversity. The second explanation that he offers he calls "diminishing returns to type". The diminishing returns hypothesis argues that like-minded problem solvers each have relatively less to add to solving a problem than does a diverse group, because the additive synergy of like-minded problem solvers' capacities is less than that of a diverse group.

In reality, if we can predict which problems we will encounter, and we can specify clearly what will count as adequate solutions, then we have little reason to cultivate diversity. Diverse groups only manifest their superior problem-solving abilities when confronting unexpected or highly complex problems. For example, the power of "averaging" is manifest when unpredictable systems serve up simple problems: a broader set of tools is most likely to possess one that fits each situation. The "diminishing returns" argument is relevant when confronting highly complex problems which demand creative and innovative solutions (innovation is here understood as the power of finding relevant and novel connections between elements (Runco and Jaeger 2012).

What kind of problem is sustainable development? As we will argue in the following, it is a problem of the highest thinkable degree of complexity, hence one where competence diversity among problem solvers is desirable.

4. Comparing RCP to DCP

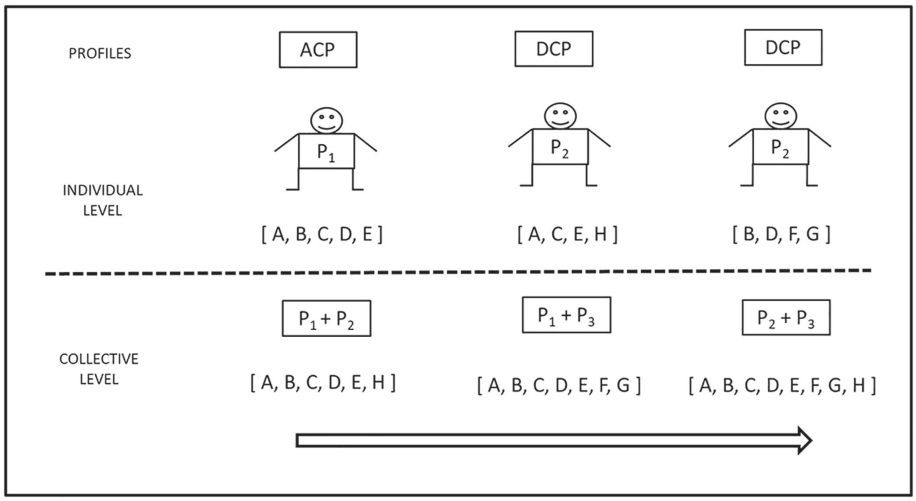

Figure 1. Competence diversity model

Before exploring the hyper-complexity of sustainability, let us recapitulate by illustrating the differences between ideal student outputs of restricted and diversifying competence logics.

The three engineers have different "capacity" profiles. P1 has a broad and highly rationalized set of skills—they correspond to the key skills isolated by RCP theories. P2 and P3 have differing and superficially less "organized" sets of skills corresponding to theoretical DCP outputs (we illustrate P2 and P3 as having fewer individual skills than P1 for demonstration's sake. In reality, P1, P2, P3 could possess quantitatively equal capacity portfolios. In reality, too, the connections between the DCP skill sets are just as "logical" as that of the A-B-C organization of the RCP skills—their connective logic is simply less evident). What the model shows is that when collaborating, P2 and P3 combine to bring more knowledge and problem-solving capacities than P1 or than any collective of P1s.

5. Sustainable Development as a Wicked Problem

The value the DCP paradigm depends upon whether sustainable development is a complex problem that will throw up unanticipated challenges and which will call for significant creativity and innovation. Echoing a number of commentators, we submit that attempting to engineer sustainable development involves tangling with a supremely complex problem, even a "wicked problem" (WP).

WPs are the very apotheosis of complex problems. This is a simplified statement of Rittel and Webber's initial definition (1973). For them, WPs have 10 key characteristics: 1) No definitive formulation; 2) No 'stopping rule'; 3) No 'true-false' solutions; 4) no 'ultimate' tests of a solutions efficacity; 5) every attempted solution also creates problems; 6) WPs cannot be exhaustively described nor resolved; 7) are singular; 8) are part of an entangled web of problems; 9) any proposed solutions only fix part of the problem; 10) erroneous solutions are consequential.

Sustainable development is a WP. Suppose we try to formulate the problem of sustainable development as an equation, as is done in Elkington's "triple bottom line" approach to sustainability (Elkington and Rowlands 1999). A "smart" technical like Industry 4.0 may initially seem to address sustainability perfectly through a neat balancing of the triple bottom line. Industry 4.0 can increase efficiency, lower costs and reduce waste. According to Elkington's formula, this balances economics and environment. Industry 4.0 would lower production costs, giving customers access to better products, a social positive. Industry 4.0 seems like a win-win-win proposition from the point of view sustainability. Yet looking again within a longer time frame will reveal the wickedness of the problem (aspect 9). While smart factories may lower the relative environmental burden by reducing waste, they also encourage and reinforce path dependence (aspect 5). The production efficiencies that they promise may reduce the waste consumption of certain key resources, but economic histori-

ans have noted that this will likely lead to a global expansion of resource consumption, as reduced demand leads to lower resource prices, which in turn prompts innovators to seek new forms of resource exploitation (aspect 8). One might also consider environmental externalities (aspect 2) such as Industry 4.0's reliance on coltan, a currently unsustainable resource (Nest 2011). From a social point of view, Industry 4.0 is likely to create job losses, and it is possible that it could likewise contribute to undermining our environmental future (aspect 10). All of these complexifications reveal the wickedness of sustainable development as a problem, and the danger in accepting any simple formulation of sustainability problems (aspect 1). Sustainable development problems (not to mention sustainable development as a problem) are maximally complex and escape from neat true-false solutions (aspect 3).

That said, WPs can be dealt with in better and worse ways, and approaching WPs with a diverse collective of problem solvers is one way of increasing the probability of having better rather than worse outcomes.

6. Challenges Associated with Creating Diversifying Curricula

If it is desirable to generate diverse collectives of engineers, making up a curriculum that is capable of fostering diversity is far from obvious. A diversifying curriculum is not a chaotic mangle. Students acquire different skills and cultivate different perspectives, but these must track with real world needs. A diversifying curriculum must be able to generate differences that will make a difference for confronting real-world problems, and it must be able to train differently skilled actors that are capable of working together.

Any attempt to generate curricular diversity will have to meet the following criteria:

6.1. Feasibility

The feasibility of a diversifying curriculum is far from obvious within a traditional institution. Most engineering schools host a limited number of classrooms and teachers, and they generally stipulate a minimum number of students for each course. Decreasing class sizes and teacher numbers increases student competence diversity, but it also raises costs and increases scheduling difficulties. In short, the limitations on the instructional medium of the brick and mortal institution imply that almost all students following any specialization at the school will come out having very similar skill sets: most will have learned the same skills in the same lectures taught by the same teachers. Increasing the differentiation of student outputs can only be accomplished with significant cost inputs.

Another related feasibility concern involves accreditation and examination. Non-standard outcomes challenge the expected comparability of degrees. One of

the central feasibility challenges for any diversifying curriculum is to build in quality control, oversight, and comparability mechanisms which permit employers and others to identify student success and engagement in a meaningful way.

6.2. Optimizing Collaboration among Different Actors

One of the advantages of an RCP format is that it has a clear core that assures that each individual can work independently. DCP schools also need a core curriculum, but this must be aimed towards teaching students how to learn how to learn independently as well as training them in the skills required to work collectively. Some key skills necessary for optimizing collective productivity might include:

A. Common Orientation: The word curriculum comes from the Latin word for path, and RCP curricula provide students with a strong narrative orientation because every element in the curriculum has been selected by administrators as part of a single developmental narrative. DCP curricula challenge or obscure this institutional meta-narrative, by allowing each student to follow and independent competence development logic. One of the requirements for effective collaboration among diverse actors is the possession of common objectives and values. Fostering collective narrative orientation within difference and complexity is possible, but diversifying curricula need to make a particular effort to encourage students to generate meta-narratives which reinforce intersections between their individual and collective teleologies. One keystone of this orientation would be the cultivation of sustainable values. Despite the hopes that may be placed in green markets, it is important to recognize that sustainability will only be achieved if we value it. For this reason alone, students need to be encouraged to care about sustainable development as a project.

B. Collaboration Skills: Profiting from diversity requires that core curricula teach diverse individuals how to work together. Many engineering schools see diversity as a problem, not a solution. In part this explains the preference in RCP theorizing for imagining engineers as autonomous actors. Diverse groups can only take advantage their diversity if they are inclusive. According to Mor Barak (2015), a group is inclusive if all individuals feel that they are part of both formal and informal collective activities. This cannot happen if team members suffer from the epistemic or hermeneutic injustice described by Fricker (2007). It will not happen if diverse groups submit to group think (Surowiecki 2005; Sunstein and Hastie 2015). Avoiding these traps requires specifically training students to become aware of the cognitive biases and social habits that currently reinforce non-inclusion and poor collaboration.

C. Seminal Skills Training: Students in DCP programs need to be capable of learning for themselves. Yet even if each student will head towards a different endpoint within the curriculum, identifying and training students in certain basic skills remains necessary. Nelson and Kosselyn (2017) have identified that some skills are seminal, meaning that they are like seeds that later will permit

self-directed learning and competence acquisition. One can illustrate this notion of seminal skill through the example of alphabetization. Learning to read allows one to learn many other things through reading, though the right of passage into this wide domain of self-empowered learning is the ability to recognize letters, their sounds, and how they fit together to form words. DCP curricula need to introduce students to seminal skills that will best begin learning for themselves via experimentation within the general framework of their specialization.

7. A DCP Model Curriculum

To illustrate how a DCP curriculum might function in practice, we now present a model DCP curriculum. Our presentation of this curriculum is influenced by media studies, and in particular by the idea that different educational media are best for encouraging different types of competence development. Our model illustrates how we can go beyond the traditional curricular medium of the brick and mortar school to make new levels of student competence diversification possible. Though this model is theoretical, we have been inspired by the curriculum of Charles Sturt University Engineering (a school cited by a recent MIT global study as one of the world leaders in engineering education (Graham 2018) - we mention this to encourage interested readers to perform empirical case studies.)

7.1. Overview

Our DCP curricular model is based around the complimentary integration of three medially differentiated approaches to education: 1) Project-Based Learning (PBL); 2) Internet-Based Learning (IBL); 3) Classroom Learning (CL).

7.1.1. PBL

PBL is a good medium for fostering diverse competences. Through in-school challenges, in-company internships and off-site humanitarian interventions, PBL allows each student to develop a unique skill set based on their individual experiences, also allowing each student to validate the value of difference by confronting the same challenges in different ways. Engaging in team challenges can help students to develop core teamwork competences by playing different but complimentary roles within their teams. PBL ensures not only talent diversification but also skill relevance.

7.1.2. IBL

In complement with PBL, our model replaces lecture-based courses with IBL. While completing their internships, students can remotely follow lectures and

validate their mastery the lessons learned using online testing tools. The IBL component can offer a vast range of online tutorials. At CSU, for example, students are required to master 200 core competences and 400 elective competence modules (600 in total) out of more than 1000 options. Given the massive stocking abilities of servers, the total number of competence modules available would expand, particularly if resources were shared across institutions. IBL appropriate subjects are those that can be explained and evaluated according to simple problem-solving heuristics. By simple we do not mean basic or introductory, but rather such skills whereby true-false evaluation is possible (this is rarely the case with values-based, interpersonal, and reflective skills, for example). IBL appropriate subjects mostly overlap with subjects currently taught as lecture courses with multiple-choice or similar evaluations. Replacing traditional lectures with IBL will not necessarily impact educational quality. As Clayton Christensen (2010) has observed, one of the advantages of the new kinds of scaling made possible by IBL learning is that classes can be tailored to specific kinds of learners (visual, auditory, kinesthetic…). As a medium, IBL permits delocalization and temporal openness. This means that students can choose their IBL modules based upon challenges encountered in their PBL curriculum, and once having completed their IBL exams they can employ the competences that they have acquired in concrete situations, which will allow them to master and to reinforce what they have learned. Morgan and Lindsay (2016) call this a "just-in-time" approach to learning rather than a "just-in-case."

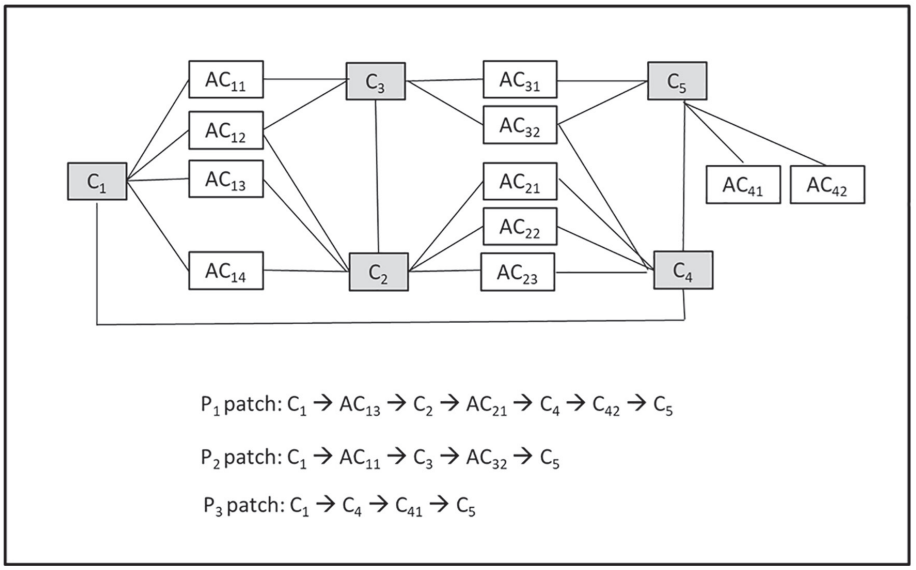

Figure 2. Curriculum patch structure

We envision the IBL course portfolio as supported by faculty, with students being able to consult with faculty members regarding specific PBL problems

and their relationship to the contents of the IBL curriculum. This should help students decide which modules to select and, should the case arise, encourage the production of new and relevant modules.

7.1.3. CL

CL, in the particular form of active small group exercises and discussions remains a key part of our model. The CL periods in the curriculum intervene before and after periods of PBL/IBL learning. They serve to foster collaboration skills, to consolidate student experiences, to reinforce the collective values of the student body, and to instill a sense of self-reflectiveness and orientation among students. Classes might include reflective discussions of the issues and challenges that students have confronted when working with difference and diversity, discussions of the value compromises associated with pursuing a WP like sustainable development, and projective discussions of the future hopes for our society. If most CL learning today involves passive listening, we believe that the CL curricula of the future will maximize the value of face to face encounters and collective discussion. During the CL portion of their education, students will develop a sense of their roles as diverse actors within the unified but diverse movement towards sustainability. They will ask questions and become reflective and responsible engineers.

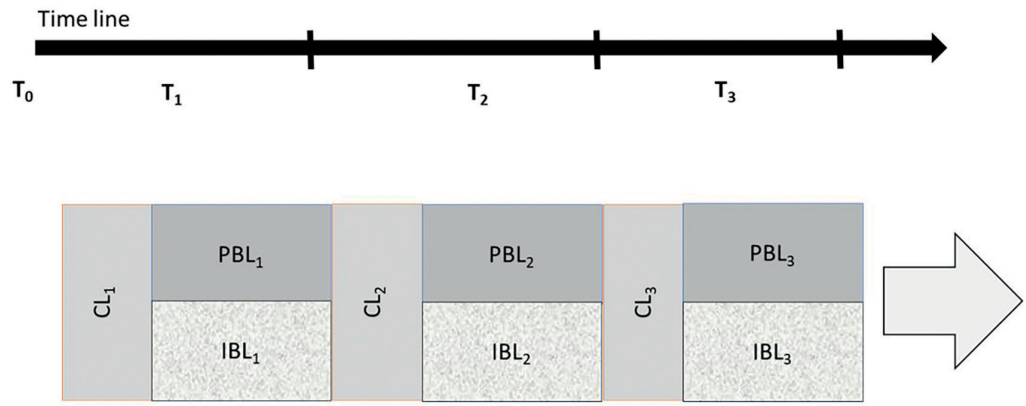

Figure 3. Picturing the curriculum

7.2. Commentary

Let us consider how our mixed-medium DCP curriculum meets our challenges:

7.2.1. Feasibility

The existence of a similar curriculum at CSU demonstrates feasibility, since what is actual is feasible. The economic advantageousness of our model will increase

with scale. The start-up costs for IBL are significant: technology investments and pedagogical adaptations are required. Once these initial outlays have been made costs stabilize. Upscaling in the form of sharing course content and generation across Europe—something that is fully possible with this model—and desirable if we are to understand place as a differentiating medium and part of the informal curriculum—will further reduce costs per student. The costs of the PBL pillar will depend on institutional choices relative to whether institution-funded humanitarian and social welfare projects or industry-funded work placements make up the bulk of the PBL curriculum. We feel that the former will be most beneficial for fostering sustainability (if they are also most burdensome on institutional budgets.) The CL aspects of the curriculum should pose no particular challenge given the structure of existing institutions (if large lecture halls may become obsolete). Teaching staff may need to re-skill, and the transition will not necessarily be an easy one. That said, teaching media are better aligned with intended outcomes than in traditional single-medium curricula, which are quite simply artifacts of another age in media technology. Rather that primarily teaching as lecturers (note that this term hearkens back to medieval classrooms in which teachers read out loud due to the unavailability of printed materials), faculty will need to act primarily as expert competence development advisors during the PBL curriculum and facilitators during the CL curriculum. Despite these changes, the relevance of faculty research and expertise will be unchanged. A benefit of using IBL as a medium for lectures is that it provides a possibility for meaningful data collection and analysis relative to teaching effectiveness. Tracking student success as a function of different communicational strategies will permit the data-driven evolution of teacher-centered instructional approaches.

The IBL modules are all assessed for mastery, thus there is no quantitative assessment issue within this model. Moreover, as skills learned via IBL are directly applied to workplace problems, practical mastery of the skills found in transcripts is nearly guaranteed. Moreover, students will have a broad portfolio of projects to demonstrate their competences and to share with potential employers. Nevertheless, student comparison remains challenging for DCP institutions. Different students really are different. However, this may be a good thing. Instead of asking which of two students is "better" in some abstract sense, employers can look at student skill sets when considering employee fit. Should two students of similar profiles find themselves in competition, employers can compare the total number of skills acquired or they can ask former employers and supervisors if they recommend the student. These seem better employee fit predictors than whether student A got a higher average score than student B on a series of standardized but purely academic exercises.

7.2.2. Optimization of Collaboration

Our model has a core curriculum. Its three functions include inculcating basic elements of technical literacy, fostering the ability to work together,

and the inculcation of sustainability-oriented values. Our model curriculum is a learning machine whose curriculum development is driven by the interaction between PBL, IBL module relevance sorting, and CL feedback loops. Different PBL experiences will yield different skill set demands, so the relevance of curricula to future challenges depends upon the specific historical evolution of problems within the school's larger ecosystem. The evolving curricula of a trans-European network of schools could constantly adapt engineering education to the rigors of achieving sustainable development within the European problem ecosystem. Our model specifically takes into account orientation. This is one of core functions of the CL curriculum. Rather than taking their orientation from a top-down administration-generated narrative, during CL classes students orient themselves via reflection on practical experiences, interactions with their peers, and discussions with faculty. This not only encourages ownership over their own education and the collective project of sustainable development but instills in them a sense of responsibility.

Some noteworthy benefits of our curriculum include its solution to the problem of the skills gap; its ability to be scaled up via the sharing of the IBL modules; and its relevance to solving the looming problem of preparing engineers to be life-long learners. Given that many experts predict the rapid evolution of technology over the next decades, it will be important to train engineers in such a way as to prepare them to stay up to date. The feedback loop between encountering practical challenges and preparing to confront them via IBL study is a method that professional engineers can continue employing throughout their entire careers and may well be a key to adapting engineering education to the innovation economy.

8. Conclusions

In this paper we have set out to suggest that given the complexity of sustainable development as a problem for future engineers, diversifying curricula are both desirable and feasible. We have presented abstract arguments which draw on complexity theory to demonstrate why this is the case. We have also discussed how mixed media curricula can function to enable the training of competence-diverse engineers. Our model is both preliminary and theoretical, though we hope that it will inspire debate and discussion. With this in mind, let us signal a few questions that seem to merit investigation: Which competences are most pedagogically suitable for which media? Which competences are seminal? What procedures can be used to optimize the curricular contents of each medium? What are the problems generated by the complexification of engineering education set in motion by DCP engineering curricula?

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GARETH THOMSON

Which aspects of engineering degrees do graduates most value in their working lives?

The creation and revision of degree programmes aims to build degrees with the correct blend of technical skills and competencies to ensure graduates are equipped to enter industry.

While there may be data on first destinations of graduates there is often little follow up on how useful they felt their degree was in equipping them with the skills needed in industry.

This study looks at the views of 32 graduates who graduated from a mechanical engineering programme over the last decade. Using both qualitative and quantitative methods it asks them to explore the impact of common degree features including project based learning, engineering science, dissertations and internships on their subsequent working lives.

The study shows that while core knowledge and skills are still valued, authentic learning enabled by project based learning and internships are often at the heart of working graduates' daily lives.

Keywords: *graduate, education, employability, engineering*

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How to cite this article:

Thomson, Gareth. "Which aspects of engineering degrees do graduates most value in their working lives?" *Információs Társadalom* XX, no. 2 (2020): 132–141.

https://dx.doi.org/10.22503/inftars.XX.2020.2.9

1. Introduction

When developing curricula for engineering degree programmes, the teams involved have to weigh up the demands from a range of stakeholders. Very often these will include the need to conform to the requirements of a national or international professional body such as ABET (ABET 2018) in the United States or the Engineering Council in the UK (Engineering Council 2014). These bodies will normally define the core academic requirements of professional engineers which in turn may be tied into the competencies associated with the graduates achieving professional registration. Employers at local and national level will also have an influence in the shape and content of programmes either through direct dialogue in industry advisory boards or more indirectly by observing the recruitment patterns of graduates (Lundberg et al. 2018, Sui et al. 2018). 'Employability' is also a much used term in the design of programmes and covers not only the technical engineering competencies expected of graduates but also incorporates many of the personal and interpersonal skills expected of graduates in the workplace. Together with 'sustainability', 'employability' has become arguably one of the key drivers for curriculum shift over the last decade (Kolmos et. al. 2016, O'Leary 2017, Sin et. al. 2019).

Students and potential students are also key influencers in ensuring programmes are commercially attractive and thrive in competitive educational marketplace (Lee & Chin 2017, Morgan, M., Direito 2018). While for students, accreditation and employability will be key factors in their choice of degree so too will be methods of teaching and specific programme focus together with more general factors such as city, institutional reputation, social and costs. (Olmos et. al. 2014, Skatova 2014)

While these factors are all important, they tend to take a predictive approach to curriculum design. They tend to be a best measure of what academics, industrialists and accrediting bodies feel should be the learning outcomes to help furnish graduates with the sorts of knowledge, skills and understanding they might need at some point in the future. This approach, together with other measures such as student surveys tend not to close the loop and check to see if the curriculum succeeded in its aims and if the degrees truly equipped their graduates effectively for their desired career.

It can therefore be argued that a key influencer should be the graduates of the degrees. These individuals have experienced the degree programmes and having transitioned into a graduate role are in the best position to appraise how relevant and useful the degree and its elements were to them in terms of providing the skills needed (Scott 2014, Staffan 2010, Stiwne 2010, Feutz 2012).

This paper therefore looks at this issue and asks "Which aspects of engineering degrees do graduates value most in their working lives?"

2. Method

2.1. Methodology

A survey of engineering graduates from a set of programmes was therefore carried out.

The online survey was chosen as a practical approach to ensure both the anonymity of the respondents and the efficient and consistent gathering of data for a geographically disparate group of individuals.

Formal approval for the survey and associated analysis methodology were sought and granted by the Aston University Engineering and Applied Science ethics committee.

2.2. The Survey

While the survey focussed on the experiences of a particular degree family at a specific UK University, to offer transferability of lessons learned by this work, the survey was structured to draw on key components of many engineering degree programmes.

The survey therefore looked at 5 elements which feature in many engineering degrees:

- Conventionally taught core engineering science and mathematics (*Classic engineering science subjects such as solid mechanics, thermodynamics, fluid dynamics etc.*)
- Applied engineering science (*CAD / Manufacturing / Quality / Societal and commercial aspects etc.*)
- Project based learning (PBL) (*Projects, often with an element of design, build and test in which students, commonly working in groups, engage in structured projects to achieve specific learning outcomes.*)
- Major final year project / dissertation (Final Year Project (FYP) – individual academic year-long project)
- Industrial internship / placement (*Year long placement in industry*)
- In addition the survey had three sections in which the data was actually gathered.
- Demographics: This section featured basic information on when the individual participating in the survey graduated, the industry sector in which they work and their current role.
- Main content: for each of the 5 programme elements students were asked if they used the content taught directly, if it underpinned what they did in their work even if not used directly and if the element developed transferable skills used in their current role. This was done via a 5 point Likert scale in each case and participants could add further comments if desired.

- Further comments: Participants were offered a more open opportunity to discuss areas of the curriculum they would have liked to have added, to have dropped or make any other comments.

2.3. Participants

The graduates who participated in this study were sourced via the author, a former programme director's "Linkedin" network. The participants had all graduated with Bachelor or integrated Masters degrees from the Mechanical Engineering family of undergraduate programmes at the parent University over the previous decade.

Participants who graduated 6 or more years ago followed a relatively traditional curriculum focussed around lectures, structured tutorials and laboratories. Design and more open ended practical work was however relatively limited. A more project based learning (PBL) focus following CDIO principles was introduced for the more recent graduates. CDIO is an educational framework stressing engineering fundamentals set in the context of Conceiving — Designing — Implementing — Operating (CDIO) real-world systems and products and can therefore commonly feature design, build, test type project activity to support learning (Crawley et al. 2014, Edstrom & Kolmos 2014). In addition to the projects embedded in the taught degree, the University also encourages students to undertake a year long industrial placement mid-degree with a little over half of the cohort generally taking this option up.

Approximately 80 former students were approached with 32 volunteering to complete the study. 20 of the students graduated over the last 5 years and followed a programme with significant PBL content with 12 graduating 6 years or more ago and following a more traditional curriculum. 16 of the 32 total took a year long industrial placement with this figure being proportionately slightly less than the full cohort mean for this option.

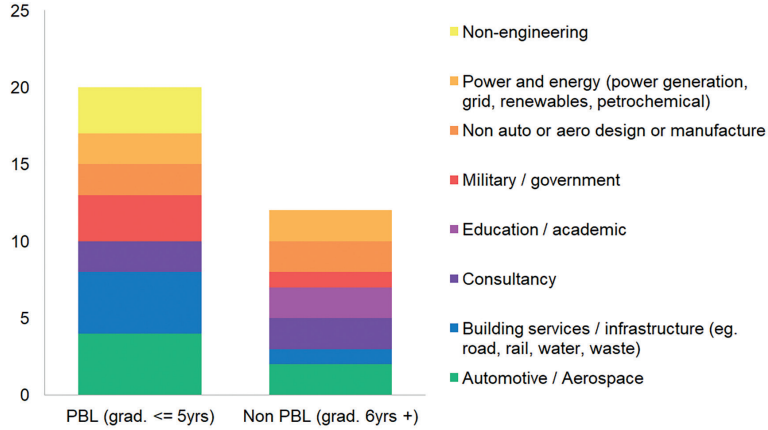


Figure 1. Industrial Sectors of Graduates Participating in Survey

Mechanical engineering is a very broad degree. The result of this is that the graduates produced can have a very diverse range of careers, in a wide variety of industry sectors and this was reflected in the professional roles of those surveyed. A breakdown of the industry sectors in which the graduates who took part in the survey operate in can be seen in *figure 1*.

3. Results

Figures *2* to *4* show the collated results of the investigation. In each case the graduates were asked, for each of the five programme elements, whether in their daily work they used these directly, whether they underpinned what they did and whether the modules helped them develop the transferrable personal and professional skills needed in their role.

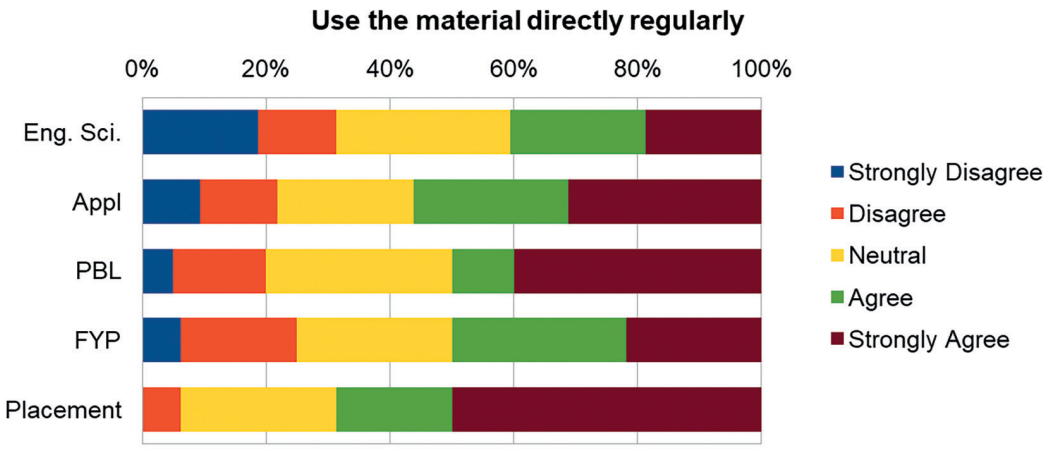


Figure 2. "I use some of the formally taught knowledge and skills gained in (programme element) directly on a regular basis"

Figure 2 shows the extent to which graduates felt they directly used the material taught to them in each of the programme elements. A noteworthy observation is that for the classic engineering science modules which form a significant part of most degrees, relatively few students call on this first principles knowledge at the core of these modules directly on a day to day basis. Other areas including PBL and applied engineering sections also hover around 50% of responses clearly positive. This might not be unexpected given the range of diverse and specialist roles Mechanical Engineering graduates in particular find themselves in where the regular application of the basic broad fundamentals are more likely to be surpassed by industry specific tools and techniques. For some however, particularly those working in perhaps research areas, core skills will still be key to aid in the solving of non-standard

problems. This can be seen by a comment from a graduate working in research and development in the power generation sector:

"I use the skills learned in Solid Mechanics, Thermofluids, Heat Transfer, Engineering mathematics, Turbomachinery on a daily basis."

And from another;

"The strong focus on numerical problem solving… has greatly aided me in my career…. "

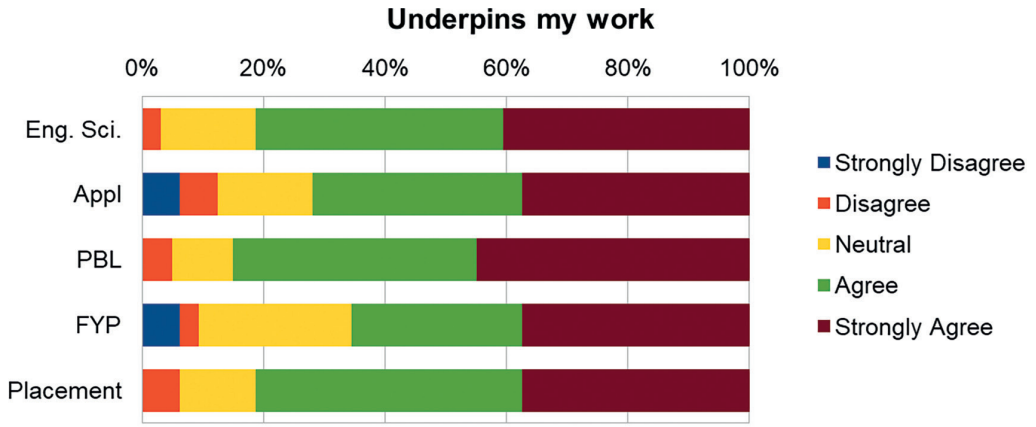


Figure 3. "Whether or not I use the knowledge formally gained in (programme element) directly, I feel it underpins much of my daily work"

Figure 3 shows that the graduates appreciated that even if they may not use the formal learning in a direct sense on a day to day basis they appreciated that derivatives from this work informed their role and added to the depth of understanding of their current processes.

From a graduate working in the military / government sector:

"While I do not use all of the skills directly they have enabled me to become a CEng (Chartered Engineer) and allow me to retain a level of credibility when discussing technical subjects."

From another with a similar opinion:

"The tacit knowledge, vocabulary and understanding is invaluable as an aid for working alongside engineers with a deep technical specialism and translating / facilitating their conversations with the business functions."

Figure 4 shows the impact of those transferrable skills elements which featured in the degree programmes and which help to develop the wider personal and interpersonal qualities of the individual. It was clear that graduates felt this was important and had been a positive support to their career. In particular the project based learning element and the placement were reviewed very positively in this area with in both cases around three quarters of graduates strongly agreeing that it had helped them feel comfortable with more general problem solving, organisational, investigation or personal and interpersonal skills in their daily work.

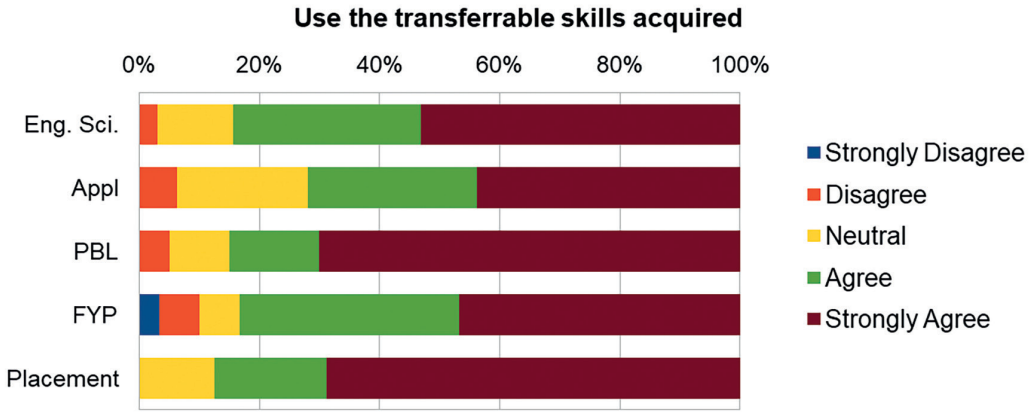


Figure 4. "The (programme element) helped me feel comfortable with more general problem solving, organizational, investigation or personal and interpersonal skills in my daily work"

In regard to the PBL elements some comments from surveyed graduates included:

"….provide a link into reality of engineering problem solving and team work. This section of the degree provided good foundation for project / schedule management skills, working within teams and general applied engineering" and

"*The skills garnered in PBL have been a constant part of my tool set as I have progressed through my career."*

In relation to the placement experience many of the respondents also reflected positively on its importance to their personal development:

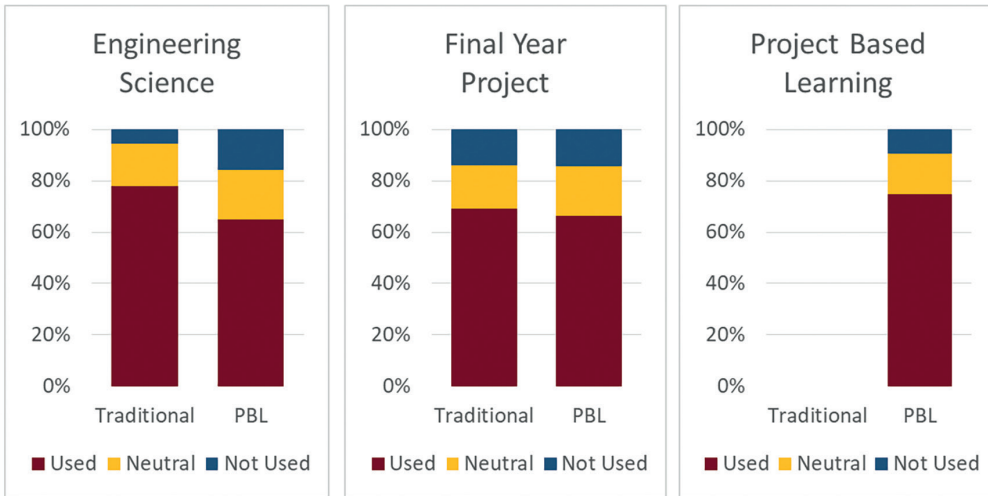
" (the placement) …massively increased my knowledge and improved my professional development and individual development."

And

"Placements are a must for good engineering development and progressing into industry. Additionally the placement provided an industrial mind-set for the final year of study and gave relevance to the final year module structure. "

The students involved in this study graduated over the course of a decade. While the programme structure and detail content varied and evolved over this time, the core elements of engineering science, applied engineering topics, final year project together with the option of an industrial placement were constant. Midway through the decade a major change was the introduction of project based learning elements designed to make the learning more effective and industry focussed. As part of this work we wanted to see if this new element was valued.

Figure 5 shows aggregated results for students on the older, traditional programme versus those on the more recent PBL aided model. For each programme element a comparison has been drawn by aggregating all the Likert responses which indicated use / neutral / limited or no use for direct / underpinning or transferrable skills in the graduates current working role.



(a) (b) (c)

Figure 5. Aggregate comparison of reflections of three programme elements as featured in the traditional and PBL focused degrees.

For the engineering science element *(Fig 5(a))* there does appear to be some slight dropping away of the use to which the more recent graduates place on this. A similar pattern was also observed in the applied engineering section. The follow up interviews will explore this issue to investigate whether this is a genuine trend, a statistical blip given the relatively small numbers surveyed or is related to the increased emphasis on PBL in the newer degree. The project based learning element has been well received and its relevance to graduates as can be seen in *Fig. 5(c)*. By contrast *Fig 5(b)* shows a very consistent appraisal of the relevance of the final year project over time.

4. Discussion and Summary

Graduates are the key outcome of engineering degree programmes and delivering relevant curricula is important to ensure those graduates are equipped for their professional lives. Academic teaching teams work hard to try to deliver effective programmes, balancing constraints of resource with the demands of a range of influencers whether these be their own institutions policies, accrediting bodies, current and future students, external examiners and industrial boards. Graduates themselves, the consumers of the programmes and those who have direct experience of taking the learning into industry are often not part of many formal review processes.

This work has taken some steps in this direction. It shows that, for the graduates participating in the survey, taking a degree has been important in preparing them for and supporting them in their work life. All components of a

degree programme whether the conventional engineering science, placement or final year project deliver direct, underpinning or transferrable skills giving positive benefits to graduates in the workplace.

It does however also pose some possible questions.

While the results were generally highly positive there were some students who reported less than optimum and negative responses for some aspects of some programme elements. It may be that this may be inevitable given the broad range of sectors and roles to which graduate mechanical engineers may go to – a perfect course for a mechanical engineering graduate moving into the rail sector is unlikely to similarly suit a classmate moving into the manufacturing or biomedical engineer sector.

For analysis and transferability, the programme used in the study was broken down into five programme elements common to many degrees. While this was an efficient way to segment the degree it also needs to be recognised that in doing so each element was characterised by a blend of both different content types and different learning modes. Isolating the effectiveness and relative importance of these two aspects of each element will be explored in future interviews.

It is intended that this work will be expanded and explored further. Semi-structured interviews will be carried out to explore and deepen the understanding of some of the issues raised. This will also look at longitudinal issues to reflect that over a decade, regardless of internal issues of content and format within a programme, the students embarking on their studies together with employment market and societal issues will also change and these could also be reflected in graduate views on the merits and suitability of their degree.

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Professional competencies in engineering education: the PREFERed-way

Professional competencies vary across engineering job characteristics. The design of the educational environment should take into account this diversity and enable students to develop career awareness. The European project PREFER (Professional Roles and Employability for Future EngineeRs) has developed instruments to make engineering students aware of the existence of professional roles and their associated competency profiles. These are designed and validated in strong interaction with industry, guaranteeing a discipline-independent, future-proof framework that is ready to implement in the engineering curriculum. In this paper, we describe the integration of this framework in the Faculty of Engineering Technology of KU Leuven, Belgium. The selection of professional competencies based on professional roles, the adaptive level of the professional competencies thanks to electives and the collaborative assessment of the students by experts in professional competencies and experts in technological competencies, are key elements of the new engineering curriculum. All of them are developed thanks to a university-business collaboration. The reformed curriculum will start from the academic year 2020-2021.

Keywords: *competency, career awareness, curriculum development, professional role, engineering education, university-business interaction*

Acknowledgement

This work was supported by Erasmus+ programme of the European Union (grant agreement 575778-EPP-1-2016-1-BE-EPPKA2-KA) and is part of the PREFER project (Professional Roles and Employability for Future Engineers, www.preferproject.eu).

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How to cite this article:
Langie, Greet, Sofie Craps. "Professional competencies in engineering education: the PREFERed-way." *Információs Társadalom* XX, no. 2 (2020): 142–153.
https://dx.doi.org/10.22503/inftars.XX.2020.2.10

1. Introduction and literature review

Engineers are key players in the conversion of research into innovative market applications. The UNESCO sustainable Development goals (UNESCO 2015) force engineers to apply new sustainable models for design, production and marketing of high value-added, innovative products, systems and services. This results in a more strongly emphasized and highlighted reflection on the future of engineering education and the future of the engineering profession.

Many studies have been published about this foresight exercise: The engineer of 2020: visions of engineering in the new century (NAE 2004), Education Engineers for the 21st Century (Royal Academy of Engineering 2007), Thinking like an engineer (Royal Academy of Engineering 2014), The role of engineers in the reindustrialization of Europe (EESC 2015), Engineering skills for the future (Royal Academy of Engineering 2019), etc.

These publications report very similar challenges for engineering education: interdisciplinary and system-based approaches; support for integrating new teaching technologies into the engineering classroom and for preparing engineers for new technologies; demands for an increasingly diverse talent pool of engineers; addressing the lack of hands-on/application experiences for undergraduates; a re-focus on the design side of engineering; an emphasis on the business side of engineering; increasing industry involvement in the education; turning more attention to the preparedness for the workforce; organizing Continuous Professional Development (CPD) and preparing students in general for teamwork and professional communication. In the context of these discussions, one can read very often the suggestion to embrace research in engineering education in order to support curriculum and educational materials development based on evidence-based methodologies (NAE 2004; Borrego 2011).

Several researchers have published papers focusing more deeply on specific topics. For example, the role and specificity of new teaching methodologies is described by Edström and Kolmos (2014). Ford and Riley (2003) focus on the benefits of integrating communication in engineering education. Moreover, Kegan & Lahey (2009) call for new skills such as loyalty, team player, and self-direction in addition to technical and communication competencies. They call it 'self-authorship'. Several authors stress the importance of integrating these professional competencies in engineering challenges, in order to make the tasks authentic (Male 2010; Male, Bush and Chapman 2011; Liebenberg and Mathews 2012; Idrus 2014). These real-world challenges are easier achievable when industry is more involved in engineering education. Since companies play a crucial role in shaping the image of the engineering profession, this might also improve the career management skills of engineering students. When students meet the workspace during their education they also become more aware of the role models, exemplifying the many positions open to technical graduates.

The conclusion is clear: engineers need more than only technical expertise. Technological knowledge is critical, but also the 'broader' competencies are essential for the 21st century organizations. Then one can ask, "Which competencies should be added?" Many studies have been done related to this question: in Australia the DeSeCo framework has been developed based on 300 completed 64-items surveys by established engineers (Male et al 2011), in the UK the Engineering Council sets the overall requirements for the Accreditation of Higher Education Programmes (AHEP 2014). The EUR-ACE Framework is an European Network for Accreditation of Engineering Education (2008) and ABET is the US-counterpart accrediting programmes in applied and natural science, computing, engineering and engineering technology. All of them include non-technological or professional competencies, such as communication, teamwork and lifelong learning.

Integrating the training and the assessment of professional competencies into the curriculum requires time. The options to handle this extra assignment are, according to the National Academy of Engineering (2004, p. 41): "(a) Cutting out some of the current requirements, (b) restructuring current courses to teach them much more efficiently, or (c) increasing the time spent in school to become an engineering professional."

The latter is often impossible because of the financial consequences. So most of the time (a) and (b) need to be combined to some extent.

Fortunately, engineers do not have to shine in all professional competencies. Research reveals that the importance of professional competencies vary across job characteristics (Nilsson 2010; Male et al. 2011; Royal Academy of Engineering 2007). This is exactly what the PREFER project has been focusing on.

2. Objectives of the PREFER project

The European project PREFER (Professional Roles and Employability of Future Engineers) aims to reduce the skills mismatch in the field of engineering by raising awareness of the future self. In order to realize this aim, a well-balanced consortium was built with universities (University of Leuven [Belgium], Delft University of Technology [The Netherlands] and Technical University of Dublin [Ireland]), companies (Engie, Siemens and ESB) and an experienced test development partner (BDO). To establish a stable connection with the engineering labour market, the three national engineering federations in Belgium, The Netherlands and Ireland were brought on board (IE-net, KIVI, Engineers Ireland), as well as Belgium's largest employers' organisation and trade association (Agoria). These federations and associations play an essential role in connecting higher education institutions with a large number of employers that hire engineers. Validation in a wider European network of universities and companies will be tackled by respectively SEFI and FEANI.

As mentioned in the previous section, professional competencies vary across job characteristics. In this paper, we will focus on how education can harness and benefit from this diversity of roles in the field of work. Our conclusion will be based on the outcomes of the following three research questions:

(1) How can we describe the different roles an engineer can take on at the beginning of the career, independently of the engineering discipline (e.g. electrical, mechanical, chemical, etc.)? Can we develop a Professional Roles Framework for Future Engineers?
(2) What are the professional competencies characterizing each role? Can we confirm that the professional competencies vary across job characteristics?
(3) How can we include them in the curriculum in an integrated way, minimizing the loss of current requirements? How can we make flexible programmes, considering the job diversity?

To formulate answers to these research questions there was an intensive interaction between the project partners (universities, companies and engineering societies) and extra volunteering companies interested in the project. This was a rich source for innovation in education. In the following sections, we will first describe how industry was involved in the different stages as well as the methodologies. Second, the main outcomes addressing the three research questions are presented followed by the discussion.

3. University-industry interaction: the magic word

The interaction with industry started already before the start of the PREFER project. In 2015, we analysed 7672 vacancies, organised 5 semi-structured interviews with HR managers and analysed 121 surveys completed by company representatives on job fairs (Hofland et. al. 2015). We aimed to verify the validity of some possible models and the substantial presence of professional roles in the professional life. The Treacy and Wiersema model (1993) was put forward as a promising framework to look at the variety of engineering positions.

3.1. Professional Roles Framework for Future Engineers

In 2018, we conducted a systematic literature review and found a high degree of convergence between the framework suggested by Hofland et al (2015) and those of Kamp & Klaassen (2016) and Spinks, Silburn & Birhall (2007). This allowed us to develop the PREFER model. However, in an attempt to identify distinguishing competencies, we were hindered by the inconsistency of methods and a lack of well-defined competencies (Craps et. al. 2020). So we returned to industry in order to obtain an overview of the essential competencies for each of the professional roles.

3.2. Competencies defining the professional roles

First, we distributed a paper and pencil survey during the job fairs at six different university campuses in the spring of 2018. In total, 188 completed surveys were retrieved in which we measured company representatives' perceptions of the selected Professional Roles Model through descriptive questions. In the second part of the survey, company representatives were requested to evaluate the importance of 15 professional competencies for each of the three professional roles (Craps, Pinxten and Langie 2019). The findings indicated that business/industry professionals hold different expectations towards the three professional roles in terms of the required professional competencies. However, using Likert-type scales, the respondents might have been driven by a propensity to provide the maximum score for each of the competencies. This propensity could stem from a desire for versatile engineers who excel in a wide variety of skills domains. A mixed method approach would allow us to refine our understanding of which competencies are quintessential for each of the three professional roles.

Therefore, we identified 12 different companies from different sectors and asked them to select 6 to 8 engineers and 1 or 2 HR managers or recruiters with expertise in hiring engineers. At each company, we set up an expert panel discussion based on the Delphi methodology (Craps et. al. 2018). A 13th mixed meta panel was organized with experts from different sectors and from companies with different sizes (start-up, SME (small and medium-sized enterprises), large company, independent entrepreneur) in order to consolidate the results of the 12 other panels.

3.3 Professional roles in the engineering curriculum

The industry's view on the curriculum in general is collected through our Faculty Senate and through an extensive survey in 2015 answered by 1948 alumni and 534 companies (KU Leuven 2015). In 2015, technological knowledge seemed to be the most important competency for engineers according to the companies, followed by problem solving, project-based work, managing complexity, teamwork, etc. This sequence remained the same when we asked them how the relevance of these competencies would evolve in the near future, only managing complexity and project-based work interchange. 85% of the participating companies and 89% of the responding alumni is in favour of a compulsory company internship in the curriculum. 44% of the alumni indicated that they would have been better prepared for professional life if there had been specific electives in the study programme. Also in 2015, the Faculty Senate initiated the idea of working with different professional roles. During the following meetings, they confirmed the need for integrating professional competencies in regular activities such as laboratories, projects, workshops,

etc. They advised to organize interdisciplinary teamwork, extracurricular activities, international internships, lifelong learning stimuli, study relevant student jobs, and last but not least more collaboration between industry and academia in education (company visits, guest lecturers, internships, sabbaticals in companies, etc.). Since 2018-2019 KU Leuven has been preparing a huge reform of the programmes in Engineering Technology. Educational staff, as well as students and industry have been involved intensively in this process. The new programme will be implemented in 2020-2021 starting with the first year of the Bachelor's programme, in which every year more than 1200 new students enrol.

4. Results

As stated by Hofland et al. (2015), there is a wide variety in career paths for graduated engineers. Going beyond the typical specialist versus management-dichotomy, this diversity is reflected both in terms of disciplinary wealth (e.g. electrical engineering, chemical engineering, civil engineering …) and the professional roles that engineers fulfil in a particular organization (e.g. service engineer, technical sales engineer, product engineer, process engineer …). An important challenge of the PREFER project is to come up with an integrative framework wherein this multitude of engineering positions is summarized in a manageable and sensible way. However, it is not our intention to put forward a perfect classification model wherein each engineering position holds a unique place that is mutually exclusive. Instead, we argue in favour of a flexible framework wherein engineering positions can be described in overlapping sections if they fit several professional roles.

4.1. Professional Roles Framework for Future Engineers

Based on the analyses of 2015 and 2018, it turned out to be possible to make a categorization of three different professional roles: (1) an engineer that organizes and optimizes processes with a focus on efficiency; (2) an engineer that develops new leading-edge products or technologies with a focus on industrial innovation and (3) an engineer that provides solutions according to the needs of the customer with a focus on customer satisfaction (see Figure 1). Based on the business strategy model of Treacy and Wiersema (1993), we called them: (1) operational excellence, (2) product leadership and (3) customer intimacy (Hofland et al. 2015). The extensive survey distributed in 2018 revealed that 65% of the respondents (easily) recognizes the model for classifying engineering graduates in their respective company and over 60% of the respondents indicated that they could (very) easily apply the model in their respective companies (Craps et al. 2019).

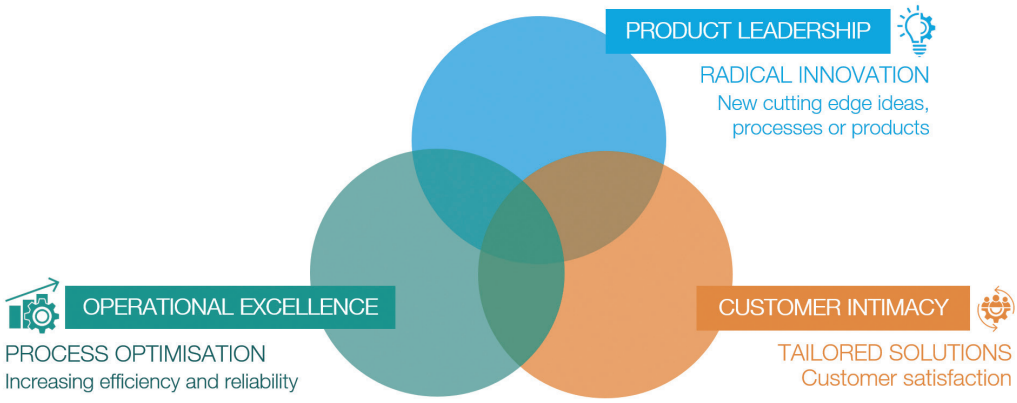

Figure 1. Professional Roles Model for Future Engineers

4.2. Competencies defining the professional roles

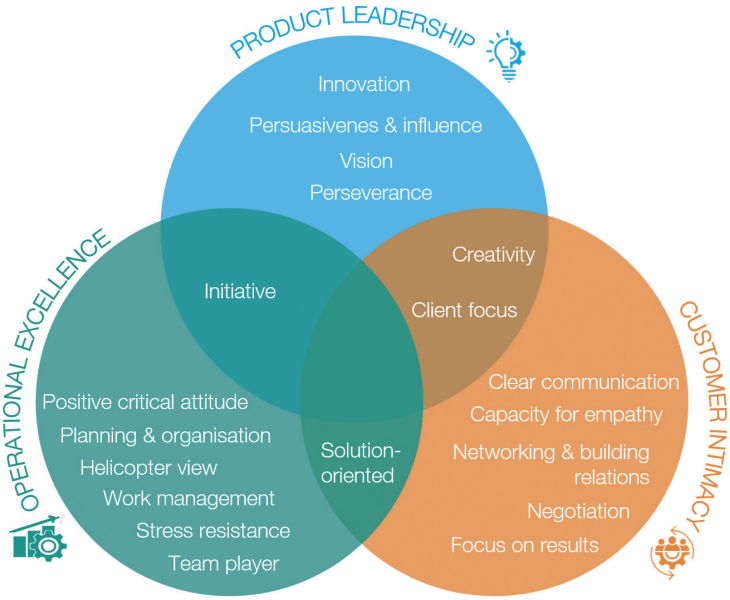

Figure 2. Competency profiles of the PREFER Professional Roles Model

The expert panels organised in 2018 identified 7 to 8 key competencies for each professional role (see Figure 2). Some of them are shared between two roles, but then their meaning might be role specific. For example 'client focus' in a product leadership role means knowledge of the market needs in order to discover gaps which can be filled with new products and processes, whereas in a customer intimacy role the focus is on partnership with the client in order to de-

velop products and processes custom-made for the customer (Craps et al. 2018). A comprehensive overview of the competency mapping process and definitions of the identified professional competencies is subject of a paper in progress.

4.3 Integrating professional roles in the engineering curriculum

One of the key goals of the new KU Leuven engineering programme is 'improving critical reflection about the individual educational paths by increasing career awareness'. Based on literature and the advices of industry and alumni, we will integrate the reflection, the training and the evaluation of the professional competencies into discipline-specific courses. For example, in the first-year Bachelor's Programme 9 of the 60 ECTS points are dedicated to 'engineering experiences', in which students have to operate as an engineer. The integration of information skills, professional communication, project management, teamwork and safety is the essence of this course. First of all the theoretical framework of these professional competencies will be explained during seminaries (1 ECTS point). Afterwards students will apply and train them while performing authentic tasks. Experts and coaches will give feedback during the process and close up the trajectory with a summative assessment at the end. The professional roles will be introduced into the curriculum in a gradual way:

4.3.1. Introduction

In the first year we would like to make students aware of the fact that industry needs different types of engineers. Students will have to job shadow a professional during a day, reflect on the tasks and competencies they have observed and discuss this with their colleagues who have followed other engineers.

4.3.2. Awareness of the different professional roles

During the company visits and the guest lectures in the second year, students will have to assign the appropriate professional roles to the viewed professionals in action.

4.3.3. Reflection on the possible personal professional role(s)

Thanks to the two developed tests within the PREFER project, PREFER explore (Carthy et. al. 2019) and PREFER match, students can align to a range of professional roles based on their interests, attitudes and competencies. The PREFER explore test is a short personal preference test allowing students to explore the different roles and reflect on their professional preferences early in education. The PREFER match tests – one for each role - are a more elab-

orated, engineer tailored, situational judgement tests. These tests, requiring some engineering (educational) experiences and therefor suggested to take in a later stage of the education, give insight in the alignment with the different roles including feedback on the personal role outcome and the judgment of the competencies compared to experts in the field.

4.3.4. Specific skills training

In the Master's programme we intend to label the Master's theses based on the three professional roles and we will include electives that students can select based on the professional role(s) in which they would like to become an expert. Since these electives will be based on the competency profiles of the three defined professional roles, students should have the necessary career awareness and professional competencies when entering the labour market. Important to notice is that it's our goal that each student obtains a minimum level for a set of key professional competencies, independent of the selected professional role. This set of key professional competencies is the same for all students, independent of their discipline, and is selected in close collaboration with industry. The electives will give them the opportunity to become an expert in some specific professional competencies associated to the selected profession role.

5. Discussion

This project started with a clever remark of one of the Faculty Senate members: "The most difficult question one can ask a freshly graduated engineer during a job interview is: What are your strengths and weaknesses? Students seem not to be aware of the professional role they might fit in."

An extensive literature review made by Craps et al. (2020) showed a huge diversity of possible professional roles frameworks, depending on the goals and the context. Since the PREFER project was in need of a flexible and validated professional roles framework that focuses on young engineers (max 3 years after graduation), transcending the disciplines, we further developed the model suggested by Hofland et al. (2015) as it showed high similarities with the model of Spinks et al. (2007). These models seemed promising as both researchers stressed the flexibility of their frameworks allowing to operate in two or more roles or to change roles in the career. This flexibility was strongly recognized by industry (Craps et al. 2019). Students also found the three roles easy to recognize and a valuable instrument to reflect on their professional future (Craps et. al. 2019). It might be interesting to discuss the similarities between the two models.

When one wants to define competency profiles associated with professional roles, one should start from a comprehensive overview of competencies

that are important for success in engineering. Carthy et al. (2018) reviewed papers published in this area that used Likert scale data and had to conclude even so that due to the wide variation in the lists of competencies used in these studies, little agreement was found on what competencies were most important for success in the labour market. No one doubts that the technological knowledge is the most important competence for engineers. However, we are missing a classification and typology for the competencies not specifically related to a particular job or academic discipline, let alone we can name them. Several names can be found in literature: soft skills, professional competencies, employability skills, non-technical competencies, transversal skills, transferable skills, 21st century skills, etc. We cannot compare different frameworks found in literature. In contradiction to the US (ABET 2019), Europe has no discipline-independent obligatory set of engineering student outcomes. We look forward to the ESCO classification (European Classification of Skills/Competencies, Qualifications and Occupations) that is in its final stage for the moment (https://ec.europa.eu/esco/portal/home). We used a well-defined list of 64 professional competencies as our starting point, leaving room for adding missing competencies. This list is made by BDO, Human Capital, our partner in the project, and it was the outcome of both research (Bartram 2005) and BDO experience. We are aware that this approach has also its limitations and should be interpreted within these boundaries. Our discipline-wide curriculum reform is based on many interactions with our stakeholders and a literature study. The study of Graham (MIT 2018) for example and the integrated engineering programme of UCL (Mitchell, Nyamapfene, Roach and Tilley 2019) have inspired us intensively. The spine of Problem Based Learning at UCL is taken over, but we go one step further in the integration: the experts in the professional competencies will collaborate in the projects with the domain-specific experts and assess the students both informal and formal during the process. The impact and the student perceptions of this interdisciplinary coaching will be the subject of future publications. The next step to take is the provision of mentors from industry into these projects.

6. Conclusion

The importance of professional competencies for engineers is no point of discussion. However the weight associated to each competency and the way they should be integrated into the curriculum is university-, discipline- and professional role-specific. We have described how the PREFER project has developed different methodologies to look at it and how KU Leuven will integrate this in the curriculum at the Faculty of Engineering Technology. This can be a potential resource for other engineering institutions when addressing the challenge in preparing the engineers of the future.

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