Towards a Data Driven Competency Management Platform for Industry 4.0

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ABSTRACT
Technological and social advancements have brought us to the brink of the 4th industrial revolution. With the rapid expanse of automation and intelligent machines, the workplace as we know it is changing. This could lead to greater inequality and massive recruitment challenges as societies are simultaneously facing an increase in unemployment as well as growth of talent shortage. The development of a unified competency management platform is proposed that serves as a communication layer between the stakeholders interested in retraining and upskilling of the workforce in light of these challenges. To provide the basis for companies to employ this platform and implement a competency framework, an instrument for the initial competency gap mapping was created and a case study is presented where the instrument was used to gain insight into stakeholder perceptions about and interactions around competency definition and management in the context of an ICT company.

CCS Concepts
Applied computing → Education → Learning management systems

Keywords
Industry 4.0; competency management; lifelong learning

1. INTRODUCTION
At the brink of the 4th industrial revolution, Intelligent machines are getting smarter and cheaper, enabling the human workforce to focus on less repetitive and more challenging tasks [1]. This shift will introduce new risks and demands by triggering changes in the core competencies of certain professions [1, 2, 3, 4, 5]. The shelf life of these employees' skill sets is rapidly decreasing which leads to massive recruitment challenges: societies are simultaneously facing an increase in unemployment as well as growth of talent shortage [1, 6]. Preventing a labor force crisis requires decisive steps to be taken regarding the education, including retraining and upskilling, of the workforce and restructuring education systems [1, 5]. To support the continuous education of the workers, the development of new standards for assessing formal and informal learning is critical [4]. If the concurrent high skills instability is not dealt with in time, industries will be led to massive recruitment challenges and talent shortage, already happening now and expanding rapidly over the next five years [1].

Summarizing from the above, it means that the education system needs to shift from preparing students for a job to preparing them for a career [2] and their development should cover the full life-cycle from professional onboarding until retirement [7]. This can be achieved by establishing an organization and cooperation culture that supports innovation through inclusion of workers into workplace development processes [8]. Looking at the realities today, it is clear that we are still far away from this vision. The inclusion of all stakeholders into the shaping of Industry 4.0 is not a reality today. Particularly, inclusion of workers into their personal and wider workplace development is not the usual case in companies today. It seems digitization is rather seen as a threat to workers, putting pressure on them to adapt to new demands of the labor market. The responsibility for upskilling and "lifelong learning" appears to be shifting more and more from educational institutions and companies to individual workers.

In this paper, we would like to make one step into this visionary future. We present a case study of an Estonian ICT company (Proekspert) in which some of the ideas of worker inclusion into workplace development have already been realized. We use the case study to explore, how in such a setting workers can be included into the future planning process. We use the definition of competencies needed in the context of Industry 4.0 as a case to examine how such planning could be conducted. In the long run, experiences gained in this and other case studies should inform the design and development of a unified platform for competency definition and planning around which a fruitful dialogue of all stakeholders can happen.

The paper is structured in the following way. First, the background of the research is provided, including an overview of the social challenges brought about by the new industrial era, previous studies on competencies in Industry 4.0, and existing approaches and technologies for novel competency management methods. Based on the background information, a common platform is proposed for new-age competency management. The second part of the paper gives an overview of a case study carried out in an ICT company with the objective to prototype an instrument to map the perceived competency gap in the context of an organization and thus help companies to initialize a competency framework. Finally, findings from the case study are provided and the limitations of the current study and plans for further studies are discussed.

2. BACKGROUND
The corresponding term "technological unemployment" dates back to the First Industrial Revolution in the 19th century. Regardless of the fears at the time, economies have adapted to these massive changes in labor markets. For the current changes, it is near impossible to predict the long-term impacts but it is clear that policy makers are facing a race between technology and education. To win this race, it is important to encourage the necessary retraining and upskilling of the workforce. [2]

This requires the continuous cooperation of all stakeholders: individuals, employers, governments, policy makers, education and

training providers, and unions [9]. Schools and companies need to collaborate to devise and implement new formal and non-formal programs, and also promote informal learning [4]. In order for this process to be sustainable, it is important to keep the qualification profiles of occupations up-to-date with new emerging requirements. For this, business organizations can provide valuable input, such as requirements forecasts and labor force evaluation feedback. Besides helping develop curricula, this gives opportunities to create additional projects for upskilling existing workforce to meet the new requirements. Meanwhile, it is the governments' and policy makers' task to establish a supporting and enabling environment [9].

2.1 Studies on Competencies for Industry 4.0

The term Industry 4.0 (*Industrie* 4.0) was initially introduced at the Hannover Fair in April 2011 and thus the research regarding Industry 4.0 is at its very early stage, and the scientific resources rather scarce. Although even scarcer, the existing research on competencies in Industry 4.0 provides a solid basis for further development.

[1] is one of the first reports to estimate the changes to competencies and worker development in light of the industrial advancements. The report is based on a large-scale survey that was carried out with the aim of getting a deeper understanding of the expectations regarding future jobs, work and skills to provide guidance to businesses, governments and civil society organizations, including education providers. Over the course of the first half of 2015, the survey was responded to by 371 individual companies, with the sample representing over 13 million employees across nine industry sectors. [1]

[2] emphasizes the role of digital skills in new-age competency development and proposes changes to the core principles of today's education. They argue that educational organizations should focus on building foundational cognitive and socioemotional skills and ensuring that the students acquire basic ICT literacy and problem-solving skills, as opposed to learning certain skills required for a job. As labour markets are changing rapidly, the latter risk becoming obsolete. The skills students learn should provide a strong basis for continuing learning while already employed. [2]

A study carried out by the European Parliament states that Industry 4.0 workers would most possibly be graduates from a STEM (Science, Technology, Engineering, Mathematics) background but in addition to strong domain-specific competencies they will also be required to excel in general competencies, such as managerial skills, understanding of the specific industries and the interrelatedness of different industries across value chains, supply chains, and processes. There will also be a higher demand for excellent communication skills to promote team work and customer relations. All these new competency requirements advocate the development of entirely new qualifications that comply with the interdisciplinary nature of the work. This means that new learning content and didactic methods need to be established and included into professional education and lifelong learning. To support the continuous education of the workers, the development of new standards for assessing formal and informal learning is critical. [4]

To help stakeholders meet the arising challenges, authors in [3] have carried out an extensive literature overview and used the PESTEL framework to analyse the macro-environmental challenges and considered their political, economic, social, technical, environmental, and legal factors. Based on this analysis, they developed a holistic Industry 4.0 competence model with 4 major categories: personal, social, methodological, and technical competencies.

Table 1. Set of aggregated Industry 4.0 competencies by their categories [3]

Category	Required competencies
Technical	State-of-the-art knowledge, technical skills, process understanding, media skills, coding skills, understanding IT security
Methodological	Creativity, entrepreneurial thinking, problem solving, conflict solving, decision making, analytical skills, research skills, efficiency orientation
Social	Intercultural skills, language skills, communication skills, networking skills, ability to work in a team, ability to be compromising and cooperative, ability to transfer knowledge, leadership skills
Personal	Flexibility, ambiguity tolerance, motivation to learn, ability to work under pressure, sustainable mind-set, compliance

As can be seen in the table, many competencies required in the context of Industry 4.0, are not technical skills usually found in the curricula of vocational schools or universities. In addition, each competency in the table could have a different notion in different companies that may itself change in time. For example, in one company coding skills may mean proficiency in the C++ programming language while in another it may be the ability to compose instruction sets for a particular device. Thus, the competencies in the table serve as abstract groups that can have multiple values. Another, easier example can be drawn with natural languages instead of programming languages: one company may require fluency in Estonian while another in English, but both of these belong under language skills. Such general frameworks are helpful because they can guide competency definitions for Industry 4.0, but they are not sufficiently detailed to help stakeholder inclusion into the process. However, they can be used as the initial basis to define an organization's competency requirements and map the existing competencies in more detail.

[10] analyzed employee competencies for employees with higher education in Industry 4.0 and created an Industry 4.0 competency model based on the SHL Universal Competency Framework (UCF). They argue that for a successful transformation towards Industry 4.0, the needed competencies need to be clearly defined, and the job profiles for engineering, information technology and information systems employees need to be adjusted and updated [10]. The final competency model comprises of 64 competencies and differentiates between Information Systems, Computer Science and Engineering curricula graduates. Some competencies were seen important for only a specific group of graduates, however, many competencies were seen as interdisciplinary, including but not limited to decision making, leadership skills, teamwork, problem solving and creativity.

To establish a common language for ICT competences, skills and proficiency levels across Europe, the European Commission has developed the European e-Competence Framework (e-CF) classifies 40 competences for ICT professionals. The most recent version, e-CF 3.0 was finalized in 2014 and consists of 40 competencies that are allocated into five ICT areas: plan, build, run, enable, and manage. [11] Although thorough, the framework only focuses on technical competencies and the "soft" competencies identified through Industry 4.0 research are not in the scope of e-CF. Another aspect to consider is that the framework was released

in 2014, only 3 years after the first introduction of the term "Industry 4.0" and thus it is reasonable to assume that the term was not widespread during the research and development phases of the framework.

The current study is based on the competency model by [3] due to its focus on Industry 4.0 and compact scope. Although [10] also provide a strong basis for further work, the number of the competencies in the model exceeds the capacity of the current study. Another reason is that the model focuses on three specific ICT curricula: Information Systems, Computer Science and Engineering. Our study, however, focuses on competency development that takes place during employment and includes employees with less specific academic background: in addition to engineers we are also interested in the competency requirements for designers, user experience specialists and other novel professions in ICT.

Due to rapid changes in the core competencies triggered by recent technological and social advancements, labour market competency gap is growing ever faster. This can only be relieved through the cooperation between all stakeholders. It is critical that academic organizations, training providers and entities responsible for professional standards receive constant and up-to-date input from business organizations. This way the competency development of workers can be supported throughout their careers by multiple stakeholders in an integral manner.

2.2 Technologies and Approaches for Competency Management

Industry 4.0 is causing a shift from traditional industrial engineering methods to data-driven functions and cyber-physical systems [5]. Based on this principle, also the human resource management in Industry 4.0 context could adapt their methods to introducing novel or implementing new technologies for connecting learning more directly with job demands [1]. Some companies have already adopted this approach and through cooperation with universities they have built and implemented novel technologies to support worker learning and knowledge management.

For example, IntelLEO, an ICT research project was initiated with the aim of developing intelligent technologies that support learning and knowledge-building (LKB) activities in Intelligent Learning Extended Organization (IntelLEO). The main objective of the project was to enhance motivation of learners by employing technological tools that utilize the synergy between services for efficient management of collaborative LKB activities and access to and supply of shared content, and harmonization of individual and organizational objectives [12]. Motivation is one of the primary factors that affect an individual's engagement in learning and knowledge sharing [13] and thus it is important to align the competency development objectives of the individual and her/his organization. Another important aspect of IntelLEO is its structure that combines different business and educational communities and organizational cultures: industrial, research and educational [12]. This means that in an IntelLEO, several stakeholders are included at the same time, advancing and strengthening their communication

eDidaktikum is an environment initially intended only for teacher education with the objective of facilitating the exchange and collection of didactic information within and across universities. The main aspects of achieving this are the systematization of information, cooperation and social learning, and personal development and evaluation.

eDidaktikum is not bound to any university or school. This means that even after receiving her or his qualification, the user can continue using the system and participate in courses. This is an example of true lifelong learning that prepares one for a career, not a job. Another interesting aspect of eDidaktikum is that it is tied to national qualifications. The teacher competency model used for pilot is distributed into logical sub-sections and based on that, teachers and students can mark down, which competencies a learning activity or evidence covers. [14] Thus, eDidaktikum provides opportunities for continuous development towards the competency aspirations of an individual.

The Learning Layers Project is directed toward developing technologies that support informal learning in the workplace with the focus on Small and Medium sized Enterprises (SMEs). Drawing on a large-scale stakeholder-driven co-design approach [15] within Regional Innovation Clusters, they have developed modular and flexible technological layers for supporting workplace practices that induce and facilitate mass collaboration within and across these enterprises. The concepts and technologies developed help to bridge the gap between scaling and adaptation to personal needs. [16] The tools that Learning Layers provide encourage and facilitate the development of many worker competencies, not just technological, but also the "soft" competencies, including but not limited to communication, teamwork, knowledge transfer, problem solving.

APOSDLE, Advanced Process-Oriented Self-Directed Learning, is a project focused on work-integrated learning (WIL) in which case learning is an intentional or unintentional by-product of the time spent at the workplace performing work tasks [17]. APOSDLE focuses on empowering workers to learn while carrying out their work-related tasks, through task learning, task execution and domain-related support, and competency-gap based support [18]. The resulting APOSDLE environment provides learning guidance through its components. For example, it uses smart algorithms to help users find resources relevant to their work and previous experience, including potential other users who might have advanced knowledge in the area the current user is working in [17].

When looking at these four examples in a unified system, IntelLEO would provide the basis for planning and organizing the competency development of workers while considering the objectives of both the individual and the employer. IntelLEO also includes other important stakeholders, such as the academic organization which promotes communication between the interested parties. APOSDLE environment and the underlying theoretical principles can be used to model competency gap directly connected to worker task execution, and promote work-integrated learning through semi-automated tools. Learning Layers and eDidaktikum would provide the tools for informal and formal learning respectively. In addition, eDidaktikum provides the functionality to map employee competencies against competency models. If used in combination, the different systems and principles would provide a good basis for a more holistic competency development.

2.3 Towards a Competency Management Platform for Industry 4.0

To advance a data-driven approach to learning and competencies the existing systems could be integrated through a common communication layer and supplemented with additional functionalities. This would result in an integral and unified competency management platform that would serve as a central service for all the stakeholders involved in competency development processes. The platform would provide a standard

human and computer readable list of categorized, grouped and versioned competencies for stakeholders to use in their competency management systems. They would be provided with a toolset to assess whether them or their employees possess certain competencies to help map their competency gaps. Based on this data it would be possible to visualize labor market competency gap. For example, business organizations could have a clear overview of available (existing) competencies mapped against needed or aspired competencies. In addition, the data gathered from recruitment portals would give a clear overview of the needed competencies and trends. Academic and training organizations could supplement this data to visualize future competency availability estimations and trends. Based on their personal competency aspirations, the competency gap of the stakeholders, and the labor market need, stakeholders would be given suggestions on their personal development. All this helps to plan future activities. For example, smaller companies can cooperate when developing niche competencies: order joint trainings, and organize workshops and seminars. Governments can identify which competencies they should support through their initiatives. Therefore, the competency management platform can be considered as a hub connecting through different services various stakeholders and communicating with other relevant information systems as depicted on the following Figure 1.

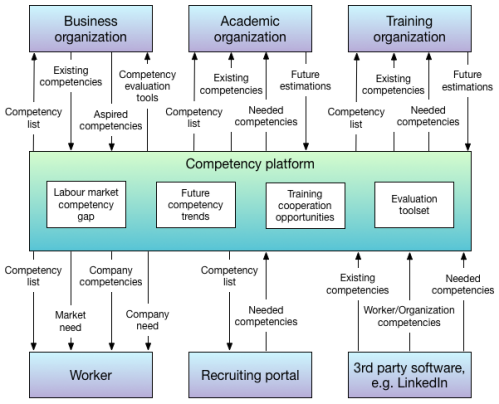

Figure 1. Exemplary platform communication diagram

When compared to the examples drawn in the previous chapter, a number of the elements that would constitute the platform have already been conceived. The main challenge, however, will be to conceptualize it as a "central" platform that all stakeholders agree to use, and around which stakeholder dialogues and negotiations can happen. We have conducted a case study in which these stakeholder interactions around competency definition and management have been studied. In this case study, we concentrate on the Workers and the Business Organizations as a first set of stakeholders. In subsequent studies, we will address other stakeholder groups as well.

3. CASE STUDY: COMPETENCY DEVELOPMENT IN PROEKSPERT

3.1 Selection of the Case

We carried out the first case study in Proekspert, a software design and development company. Being founded in 1993, only two years after the Estonian independence was re-established, Proekspert is one of the oldest software development companies in Estonia. The company focuses on multiple areas, one of them being future manufacturing. The key characteristic of Proekspert is its hierarchical flat structure – there are no managers or departments in this company but instead the company is divided into self-governing teams (Figure 2). Each team serves their own customer and is in many aspects autonomous. In terms of Industry 4.0, such flat structure increases the employee participation and the speed of communication, thus contributing into innovation processes and worker learning [19].

Proekspert was selected as a suitable case because it is an ICT company that has prior knowledge about Industry 4.0 and thus the employees have already formed a partial understanding of the changes that it will trigger. Another reason for choosing Proekspert is its innovative attitude towards the workplace. For example, the company does not have a managerial level. Additionally, the company has adopted a holistic view on employees' lives: it is a common belief at Proekspert that employees perform the best when their work and personal lives are in balance. In this sense, the company fits very well our focus on worker inclusion.

We interviewed the workers to get a deeper understanding of how they perceive the competencies identified by [3] and the gap between a competency's importance and availability. This is vital input when choosing or creating methods for identifying the competency levels of workers and finding out the gap in the market or an organization.

3.2 Methodology of the Case Study

The participants of this study were a convenience sample of employees from the company. The group consisted of nine people of different age and professions. While the exact age of participants was not asked, their ages fell in the range of 21-40. From the gender perspective, participants were almost equally balanced with four female participants. When asked for how long the participants had been working in their area of expertise, most of them selected the range of 2-5 years. There were also participants who had been working for 1-2 years and those with experience for 10-20 years. The participants were either developers, designers, analysts or product owners, or engineering excellence specialists. The researcher responsible for data collection is employed at Proekspert.

The data was analyzed using both qualitative and quantitative methods. For qualitative data, content analysis was carried out where keywords were drawn from the free text entered by the participants and notes written down by the researcher. The keywords were collected using Annotations software by Balcony Production. Based on keywords, themes were composed to help interpret quantitative results. Quantitative analysis was done using IBM SPSS Statistics software. While multiple methods were used to gain insight into the data, the findings provided in the current article are based on means comparison through T-tests.

3.3 Conducting the Case Study

3.3.1 Analyzing the Context of the Case

Each Proekspert employee is provided with a training budget that is mostly used for professional training, but there have been cases where employees have taken courses not directly related to their professions. The philosophy of the human resources team regarding worker development is that promoting competences that the worker needs in non-professional life will go a long way to improve the person's contentment with both her/himself and the employer. Emotional intelligence development is promoted, to increase a person's ability to identify, assess and manage the emotions of one's self [20]. This will, in Proekspert's philosophy, result in a more motivated worker who is enthusiastic and willing to contribute to the company culture and community. Albeit Proekspert strives to be a company of engineering excellence, the "soft" competencies of workers are not neglected. The company

provides various trainings for social empowerment and emotional intelligence empowerment, encourages self-development and mentoring other workers. Employees are viewed as the most valuable resource of the company and thus they are included in the core processes of the company strategy.

For example, employees are encouraged to participate in long-term strategy planning. When planning the strategy for 2020, a series of workshops was held that focused on the strategic factors that would help towards the next level in company development, and employees were invited to nominate, prioritize and describe these factors.

Figure 2. The hierarchy of a manager-free team-centered organization. AM – account manager, HR – human resources, IT – IT support, QM – quality management. Source: Proekspert AS internal documentation

Another example of inclusion is the recruiting culture of Proekspert. When a team finds they need additional resources, they contact the human resources specialist who will find out whether there are any available employees in-house who could join the team. When there are no available resources, the HR specialist finds potential new recruits who are then interviewed with at least one team member present. Although there are many parties included in the process, it is usually the team that makes the final decision.

Proekspert has developed several internal tools to create transparency regarding employee competencies and the skill sets needed for existing and potential new projects. For technical competency mapping, Proekspert has developed the internal product Pulse that provides the functionality to enlist oneself for new challenges, and spread information about potential new projects. In a way, the tool acts as an in-house recruitment portal where users can specify their competencies and past experience. Project leads can then filter employees with the required skill-sets and invite them to participate in new projects. At the same time, employees can search through the projects and apply for the team if they find it interesting. The ultimate goal for developing internal HR tools is to provide a better overview of worker competencies, existing projects and resource allocation, which in turn improve the sales process, financial estimations, and provide a better basis for developing organization strategy [21]. If integrated with the proposed platform, Pulse could be used to collect data to visualize the real-time technical competency gap in Proekspert.

For "soft" competencies, Proekspert uses another internal tool HappyMe that allows users to assess their own and their team members' competencies, set goals and give feedback. These data are compared and visualized to users. This tool is also used to gather data about employee satisfaction towards the company and the overall values of the employees. This data is used to align the company strategy to the overall culture of its employees. Similarly to Pulse, HappyMe could be used to gather real-time competency data to the central competency management platform. Statistics of this information may prove valuable for companies who are actively recruiting as it gives a good insight into what workers mostly value in their employers. These are but a few examples of novel internal tools that are used in Proekspert to advance the competencies and overall work life of the organization. Thanks to its openness and interest in continuous improvement, Proekspert makes an engaging case for studying and propagating a new-age organization culture.

3.3.2 Application of the Competency mapping instrument

An interactive instrument based on Poll Everywhere software was created to map Proekspert's competency gap. The mapping takes place in a seminar format where participants are asked to bring their own devices: laptops, tablets or mobile phones. The questions are displayed on a large screen together with real-time results. Discussion is encouraged and in case of participant consent, sessions are recorded on audio.

There were 5 types of questions: multiple choice questions, Likert scale questions, freeform questions, rank order questions, and clickable image questions. The questions were divided into five logical categories. The first category of questions was used for warm-up. As the Poll Everywhere environment was new to all participants, it was decided to practice different question types. For example, to practice clickable image questions, the participants were asked to click the circle that represented their mood in the following Figure 3.

Figure 3. Example of a warm-up question to practice the data-collection instrument. Image source: Poll Everywhere

The second category comprised of personal questions. Participants were asked about their profession, gender, age and track record in the field of ICT. The third questions category focused on how participants perceived competency development. This included questions about the frequency of having to learn new competencies; different difficulty levels of developing "soft" and "hard" competencies; stakeholders of competency development; the competency gap of the organization and labour market. The questions from the last two categories were asked alternately: the first one was a freeform question where participants were asked to elaborate on what indicates that a person has the respective competency. Again, discussion was encouraged and in some cases the corresponding competency description from [3] was read to clarify the term. The second question was a clickable image question where participants were asked to map the importance and their self-assessed level of a competency. The image depicted a 3x3 grid matrix that can be seen in Figure 4.

Although there were nine distinct areas mapped onto the image, the location of clicks was tracked in pixels and percentages. This feature in the software was quite useful as the scale of the grid proved to be too small: in some cases, the click was deliberately made in a very extreme corner of the corresponding area to show strong conviction. This was taken into consideration when interpreting data. It is also important to point out that during quantitative analysis the scale of these types of questions was from "low" to "high" (1...3) and that there was no option for the respondents to mark that they lacked the competency entirely. This

was due to the belief of the researchers that everyone possesses some low-level proficiency in every competency.

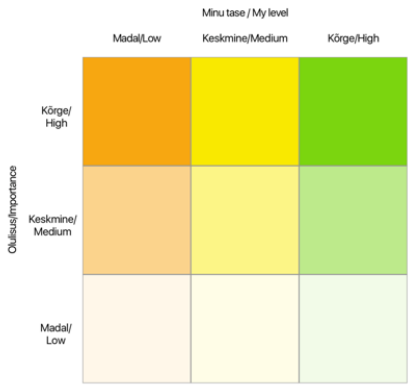

Figure 4. Competency importance and self-assessed level matrix

3.3.3 Results and feedback

The participants were asked whether they feel that their employer supports the development of their competencies. Out of 9 participants 4 agreed and 5 said that they agree in most part. When asked about the benefits that the employer gets from worker competency development, one of the main keywords was efficiency, but some softer aspects were also considered. For example, it was suggested that through competency development the employer will have a worker who is in a better place with her/his life and through this will be a stronger contributor to the company culture. According to participants, the additional entities that benefit from their competencies include themselves, their families, friends and colleagues, and hopefully the future. On a professional level the beneficiaries include the clients of the employer, the society, local municipalities and the government.

The highest competency priority for the participants was problem solving, which was unanimously evaluated to the highest importance level (3.0). It was also one of the cases where participants clicked in an extreme area of the grid: three participants had placed their markers in the high top border of the area. The interpretations followed four major themes: understanding the problem, finding suitable solutions, creativity and persistence.

While perceiving problem solving as the most important competency, the participants also evaluated their own problem solving level as the highest, along with teamwork skills – both competencies were evaluated to an average level of 2,6. Thus, the competency gap of problem solving is 0,5. The reasoning of such high prioritization and self-assessment of problem solving skills may lie in the nature of day-to-day work in ICT domain. The issues that ICT workers tackle on a daily basis are not limited to only coding and computer issues. As the company focuses mainly on client projects, the employees are working to solve problems inherent to the domains of their clients which in itself raises several other issues, for example finding a common language between business and technical people.

The high self-assessment of teamwork skills amongst participants can be explained with the company hierarchy described earlier: self-governing teams as central units of the company. When analysing the interpretations of teamwork skills, it became evident that most participants had their own unique understanding of teamwork, for example cooperation, understanding the objectives, motivating people, honesty, leadership, cooperation, knowledge sharing, taking responsibility, and empathy. These interpretations indicate that for the participants, teamwork skills incorporate several other competencies. The competency gap of teamwork was 0,2 as the average perceived importance was 2,8.

The lowest priority for the participants were intercultural skills with the importance assessment of 1.8. While the interpretations of this competency were unanimous with the themes being awareness and empathy, there are two explanations to this this low assessment. First, the sample only consisted of Estonians who have not met intercultural issues. On the other hand, the working language of the company is English, which helps avoid language and communication barriers. The self-assessed level of intercultural skills was 2.0, making the competency gap -0.2. It was one of the three competencies where the perceived level was higher than importance, the other two being process understanding and efficiency orientation.

The competency with the lowest self-assessed level was networking with an average level of 1.5, while its importance was deemed medium, with a score of 2.2. The highest competency gap between average importance and average level was understanding IT security with a gap of 1.1. Only one participant assessed her/his IT-security understanding skills to be high. The interpretations of understanding IT-security were closely tied to the three fundamental aspects of cyber security: availability, confidentiality of integrity. The average importance levels and self-assessments of competencies can be seen in the following radar chart (Figure 5).

As can be seen in the figure, all categories have competencies of different priority levels. The category with the highest average competency priorities is the methodological category that also has the highest cumulative competency gap. This kind of visualization could be beneficial for the organization when planning new trainings or deciding between potential recruits. Coming back to the competency management platform, these visualizations could be used for generic competency gap as was presented in the current study, but also to visualize the gap in very specific competency areas. If enough organizations would provide their data, it would be possible to visualize future trends and plan how to mitigate potential competency shortage issues. It would also give individuals good indications on which competencies to develop to be more valuable in the labor market.

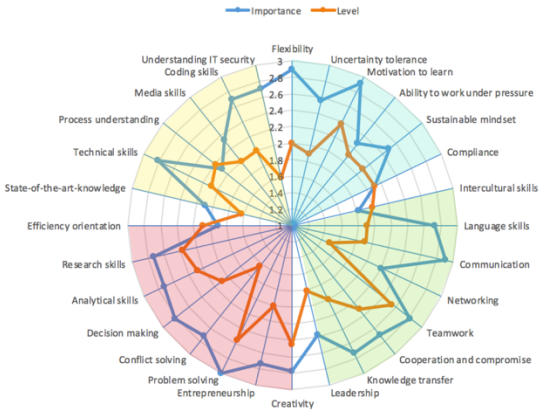

Figure 5. Compiled competency importance and self-assessment levels of participants. The different categories are visualized with colors: blue – personal, green – social, red – methodological, yellow – technical.

3.3.4 Results feedback

The participants and additional stakeholders from Proekspert were shown the compiled competency importance and self-assessment

levels diagram shown in Figure 5. The participants' feedback revolved mainly around recruiting and composing the teams: based on the competency priorities and levels it would be easier to determine whether a person is suitable for a team or not. It would also provide both the individual and the team with information of what is expected from them – in reality they may possess these competencies but it may very well be that they are not aware that they need to employ them in the new context. Another aspect that was suggested was to draw correlations between the competency priorities and levels, and personality types, for example the Myers-Briggs Types.

Participants also suggested integrating the functionality of the instrument with the existing internal tools, Pulse or HappyMe. A concern was brought up in regard to automating the data collection: it is important to ensure that the data is frequently updated, and therefore the data collection process must be as convenient as possible. To fully employ these data, role profiles should be created that reflect, which competencies are important in which context. These requirements may differ across professions and are different, for example, for designers and developers. At the same time, it also depends on the context of the project. For example, it may not be necessary to be very innovative in a maintenance project whereas in an R&D project innovative mindset is crucial.

The board members that were provided with the results focused on the company strategy. They deemed it helpful if it were possible to similarly visualize the competencies derived from strategic objectives and compare them against the importance, self-assessed level, and also the competency aspirations of employees. This would help in several ways. First, employees would have a clear visualization of the company's competency need concerning existing and potential projects. This is valuable information when planning self-development and aligning one's interests with the ones of the company. It would also help prepare for future sales and deciding on which leads to follow. Finally, the board would have a better understanding on how the importance of competencies is seen by the board itself, employees specifically working on strategic planning, and all other employees. In order for the company strategy to work, its values must be aligned with those of the employees. Based on this visualization, Proekspert could align its strategy to conform more to the common values of the employees, or recruit new people that already share the values derived from the strategy.

3.4 Results and Implications from the Case

Two concerns were found regarding the instrument. First, the competency list based on [3] proved to be too exhausting for the participants. Due to a large number of questions, the seminars lasted over three hours and the participants felt tired at the end. To alleviate this, similar future seminars could be divided between multiple sessions. The seminars were held at the end of work days, so another solution would be to ask the employer to allow employees to participate during working hours. The second concern is related to the interpretations of competencies. While most competencies were interpreted very similarly, some competencies struck a different note in the participants. To help overcome these "translation" issues, similar instruments in the future should include some pre-written indicators or guidelines to explain the competency. One option would be to provide some examples of activities carried out by proficient employees, before asking for participants to provide their interpretations.

The resulting data and visualizations were mostly deemed helpful by the participants and other stakeholders of competency development. First, this information would help compose well-balanced teams where members know which competencies are needed from them. Secondly, it would help the company plan the competency development strategy to be aligned with the needs of current projects and future leads, while considering the competency aspirations of employees. This would simultaneously mean that individuals can plan their competency development to be more valuable for the company. Finally, all competency development stakeholders would have an overview of the overlap of the strategic and actual competency priorities and levels, to ensure that the same values are shared by those responsible for company strategy, and other employees. It was pointed out by many people that the instrument could be integrated with one or several of the existing internal tools of Proekspert.

4. FUTURE WORK

While the findings of this study may prove a good basis for developing an instrument to help Proekspert implement a competency framework, many additional aspects still need to be considered. The instrument created for the study will be improved based feedback from participants and other stakeholders, and the study will be repeated on a larger scale with the improved instrument. For the large-scale study, a more detailed Proekspert-specific competency model needs to be developed based on the current study, to describe the competencies on a far more specific level.

Future work will also include similar case studies in other ICT or Industry 4.0 companies. As every company has their own nuances, competency modelling is different in the context of each company. This means that the instruments created for this purpose need to be adaptable to different circumstances. After establishing the foundational base for implementing a competency modelling framework in ICT companies, the research will shift to the design and development of the common competency management platform.

5. CONCLUSION

Industry 4.0 is bringing along a shift in the core competencies needed in workers. To prevent a labor force crisis, all stakeholders must participate in the retraining and upskilling of the workforce. To promote cooperation and fast movement of competency-related information, the development of a common, data-driven competency management platform was proposed. The platform would serve as a communication layer between stakeholder competency management systems while including several existing systems that provide functionalities for data-driven competency management.

To conceptualize it as a "central" platform that all stakeholders agree to use, the stakeholders have to be provided with instruments to properly initialize the competency framework in their specific context. A series of studies will be carried out to understand the different nuances of stakeholders' perception and assessment of the importance of these competencies in their own contexts. As the first study, we have conducted a case study in the context of Proekspert, a software design and development company. The study focused on an instrument to map the perceived competency gap in Proekspert by mapping the major themes that become evident when workers are asked to explain the indicators of a person's proficiency in a competency. These themes were used to interpret the numerical importance and self-assessed level of the corresponding competencies which in turn were be aggregated into the perceived competency gap in the context of the organization.

Some weaknesses were discovered when testing the instrument developed for Proekspert. For example, the competency list, although chosen for its small size, proved to be too exhausting for one session. Another issue arose when interpreting competencies – while some competencies were understood unanimously, some were seen very differently by participants.

When combined with data collected from internal tools, such as the aforementioned Pulse and HappyMe, the visualized competency gap can be used to plan future trainings across all employees or different profession groups. Integrating the tools with the proposed competency management platform and collecting similar data from other ICT companies would help provide insight into the current state of the labor market. This could be done through visualization of the overall competency gap across profession groups, overview of the existing and aspired competencies of workers, and information about future trends regarding competency needs. To continue implementing a competency framework in Proekspert, a subsequent study using an improved version of the developed instrument needs to be carried out to include more employees.

Similar case studies will be carried out in other ICT companies to study how to adapt the developed instruments in different contexts, such as different managerial hierarches. When the base for implementing a competency modelling framework in an ICT company is established, the research will continue towards the design and development of the common competency management platform.

WORKS CITED

[1] World Economic Forum, "The Future of Jobs: Employment, Skills and Workforce Strategy for the Fourth Industrial Revolution," World Economic Forum, Geneva, 2016.

[2] World Bank, "World Development Report 2016: Digital Dividends," Washington, 2016.

[3] F. Hecklau, M. Galeitzke, S. Flachs and H. Kohl, "Holistic approach for human resource management in Industry 4.0," in *6th CLF - 6th CIRP Conference on Learning Factories*, 2016.

[4] J. Smit, S. Kreutzer, C. Moeller and M. Carlberg, "Industry 4.0," 15 02 2016. [Online]. Available: http://www.europarl.europa.eu/RegData/etudes/STUD/2016/570007/IPOL_STU(2016)570007_EN.pdf.

[5] S. Sackey and A. Bester, "Industrial Engineering Curriculum in Industry 4.0 in a South African Context," *South African Journal of Industrial Engineering,* vol. 27, no. 4, pp. 101-114, 2016.

[6] B. De Waal, F. van Outvorst and P. Ravesteyn, "Digital Leadership: The Objective-Subjective Dichotomy of Technology Revisited," in *Proceedings of the 12th European Conference on Management, Leadership and Governance ECMLG*, Bucharest, 2015.

[7] S. L. Müller, F. Willicks, S. Stiehm and S. Jeschke, "Demography Management in Industry 4.0: First Results of a Qualitative Study," in *Proceedings of the 12th European Conference on Management, Leadership and Governance ECMLG*, Bucharest, 2016.

[8] D. Buhr, "Social Innovation Policy for Industry 4.0," Division for Social and Economic Policies, Friedrich-Ebert-Stiftung, Bonn, 2015.

[9] L. Ilie and I. Bondrea, "Changing Labour Market Needs and the Challenges for Academic Leadership," in *Proceedings of the 12th European Conference on Management, Leadership and Governance ECMLG*, Bucharest, 2016.

[10] L. Prifti, M. Knigge, H. Kienegger and H. Krcmar, "A Competency Model for "Industrie 4.0" Employees," in *Wirtschaftsinformatik (WI)*, St. Gallen, 2017.

[11] European Commission, "The European e-Competence Framework 3.0," 2014. [Online]. Available: http://www.ecompetences.eu/.

[12] IntelLEO Consortium, "IntelLEO," 2009. [Online]. Available: https://intelleo.eu.

[13] B. Kieslinger, K. Pata and C. M. Fabian, "Participatory design methods for learning and knowledge sharing activities in networked organizations," in *ICELW*, New York, 2009.

[14] eDidaktikum, "eDidaktikum," 2016. [Online]. Available: http://edidaktikum.ee/.

[15] T. Ley, J. Cook, S. Dennerlein, M. Kravcik, C. Kunzmann, K. Pata, J. Purma, J. Sandars, P. Santos, A. Schmidt, M. Al-Smadi and C. Trattner, "Scaling informal learning at the workplace: a model and four designs from a large-scale design-based research effort," *British Journal of Educational Technology,* 2014.

[16] Learning Layers Project, "Learning Layers," 2012. [Online]. Available: http://learning-layers.eu/. [Accessed 2016].

[17] S. Lindstaedt, B. Kump, G. Beham, V. Pammer, T. Ley, A. Dotan and R. de Hoog, "Providing Varying Degrees of Guidance for Work-Integrated Learning," in *Sustaining TEL: From Innovation to Learning and Practice - 5th European Conference on Technology Enhanced Learning, EC-TEL 2010*, Barcelona, 2010.

[18] T. Ley, A. Ulbrich, P. Scheir, S. N. Lindstaedt, B. Kump and D. Albert, "Modeling competencies for supporting work-integrated learning in knowledge work," *Journal of Knowledge Management,* vol. 12, no. 6, pp. 31-47, 2008.

[19] S. Shamim, S. Cang, Y. Hongnian and L. Yun, "Management approaches for Industry 4.0: A human resource management perspective," in *2016 IEEE Congress on Evolutionary Computation (CEC)*, Vancouver, 2016.

[20] O. Serrat, "Understanding and Developing Emotional Intelligence," in *Knowledge Solutions*, Springer Singapore, 2017, pp. 329-339.

[21] S. Anijago, *Analysis and Prototyping of a Central Information System for a Manager-Free Software Development Company,* Tallinn: Eesti Infotehnoloogia Kolledž, 2017.