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Defining Digital Excellence: Requisite Skills and Policy Implications for Digital Transformation

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ABSTRACT The skills required to realise the potential of technological transformation to preserve humanity and our fragile world ecosystem in the next decade will centre on the development of digital solutions. This paper discusses the issue of characterising these competencies, since a definition is needed in order to ensure an adequate supply of cutting-edge scholars and a highly educated and agile technological workforce. The paper takes a mixed methods approach combining insights distilled from a rapid literature review, with interviews with leading practitioners and industry leaders. The validity and reliability of the results have been ensured through expert workshops and focus groups. The outcome is a robust definition of what digital excellence entails as well as a road map guiding educational policy and the future supply of digital excellence in national workforces.

INDEX TERMS Digital excellence, human capital development, educational policy, competence supply.

I. INTRODUCTION

Cutting edge competency in digitalisation and the development of future technological systems and solutions is vital to the sustainable development of a high-technology society. Digital excellence empowers citizens to create and navigate future digital systems, providing them with the agency and ability to consume and create digital content. [14], of Manpower Group, emphasise this when they conclude that digital transformation is less about technology and more about people, and the importance of focus on soft rather than hard skills. Focus on equipping citizens for a future technological world is one thing, however, developing the national and global competence needed to fuel worldwide transformation has received limited attention.

Despite a long-standing discussion of digital excellence the term has no existing agreed upon definition. Developing a definition of digital excellence requires analyses of relevant underlying components and assessing the profiles and roles of those working in positions requiring such competence. In this paper we propose a definition of digital excellence that builds upon a review of the international research literature, European policy documents, and semi-structured interviews

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with industry leaders. The definition that emerges has been reviewed and refined through workshops with representatives from government agencies and the private sector in Sweden. Sweden is second only to Silicon Valley in the number of unicorns-per-capita (defined as a privately held start up company with a current valuation of more than US\$1 billion), across technology centers throughout the world, and scores high in Europe in the Digital Economy and Society Index (DESI) [10]. Moreover, [29] show in Coursera's Global Skills Index that Sweden ranks eighth globally in business skills and tech skills, and number five in data skills. Thus Sweden can be seen as a representative of the global tech scene and the resulting definition could be valid and relevant in a broader geographic setting.

A. DEFINING DIGITAL EXCELLENCE AND DIGITAL COMPETENCE

To provide a solid definition of *digital excellence* we first need to clearly outline in what way digital excellence is different to more commonly used concepts such as *digital skills* or *digital competence*. The following section discuss these different concepts. The overall goal of Sweden's digitalisation policy is to become "*the best in the world in exploiting the opportunities of digitalisation.*" In the Government's

digitalisation strategy [23], the goal has been devolved into five sub-goals, of which Digital Competence is one. The Digitalisation Commission's interim report [28], "*Makes Sweden in the future: Digital competence*," analysed the concept of digital competence and its impact on the public, in terms of general digital competence:

Digital competence is the extent to which one is familiar with digital tools and services, and is able to monitor digital development and its impact on one's life. Digital competence includes: knowledge of seeking information, communicating, interacting and producing digitally, skills in using digital tools and services, understanding the transformation that digitalisation entails in society with its opportunities and risks, and motivation to participate in development [28].

In most of the policy documents digital skills and digital competence is used interchangeably. Digital skills or digital competence should not be confused with digital excellence, which is not defined in the above report.

B. DIGITAL COMPETENCE VERSUS DIGITAL EXCELLENCE

There is a risk of a polarisation between digital excellence and digital competence. Digital competence, as defined by the Digitalisation Commission, is about how we provide all citizens with sufficient digital capabilities to be part of the digital society. It is about the ability of all people to use digital technology to facilitate everyday life, to be able to seek information and communicate, to be able to identify and implement various digital services, to understand what happens in the digital space, and to know how to protect yourself from intrusion or security risks. Raising digital general competence broadly is an important area of action that requires more efforts from society, but not germane to this report. General digital competence is quite different from digital excellence, which (as we will see later on in the paper) concerns a specialist expertise that few people in society can be expected to possess.

C. INTERNATIONAL RANKING OF COUNTRIES BASED ON DIGITALIZATION AND DIGITAL COMPETENCE/EXCELLENCE

The European Commission's Digital Economy and Society Index [10] ranks Europe's countries based on many areas essential for digitalisation. In aggregate, Sweden most often places among the top countries in all areas. In 2021 Sweden emerged third, just behind Denmark and Finland (in 2018 and 2019 Sweden ranked number 1). However, one area of concern is "Percentage of ICT graduates," where Sweden in 2021 scored 4.3%, slightly above the EU average of 3.9%, and number 14 in the EU rankings. For female ICT specialists Sweden is number 10 in the EU rankings. This is not in line with Sweden's self-image, where we aim to be the best in the world at exploiting the opportunities of digitalisation. Anecdotally this figure is said to be due to the fact that the labour market in Sweden is so strong that students are

attracted into working life before they have completed their degree. There are no real incentives to return and complete degrees. Many of these people are currently working in areas that can be classified as 'digital excellence'.

Another, often referred to, international ranking is the Networked Readiness Index [5], developed together with INSEAD and the World Economic Forum (WEF) up until 2016, which ranks countries based on their abilities in several areas related to Innovation, Digitalisation, Connectivity and Access to skills. Sweden consistently ranked high in these surveys, but fails to reach the same level as countries such as Singapore or Korea. The Nordic countries are consistently ranked high, and Sweden usually comes after Finland, for example. In the latest published survey from 2016 [1], Sweden is ranked 3rd after Singapore and Finland in the weighted ranking. However, when it comes to the 5th pillar in the index, called "skills," Sweden ranks 25th globally, and if you look at one of the subcategories 5.02, the quality of teaching in mathematics and science, Sweden has an unflattering 43rd place globally. However, statistics should be taken with a pinch of salt, as the ranking is based on the countries' own reported data. Many countries report using very different collection methods and sometimes even with specific agendas. After 2018 the ranking [2] was taken over by the Portulans Institute which is an independent non-profit, nonpartisan research and educational institute based in Washington DC., in collaboration with STL, which is an industry-leading integrator of digital networks. In the 2021 ranking Sweden ranks 2nd after the Netherlands. The detailed ranking is very different from when it was done by INSEAD and WEF, however, two troubling indicators remain. In the indicator ICT skills, Sweden scores number 12 and in SDG 4 – Quality education Sweden scores 14.

In 2018, the OECD commissioned the Government of Sweden to review Sweden's position [24] on digitalisation and digital transformation. The report highlights several different areas where Sweden has the opportunity to strengthen its position as the world's foremost digitalisation country, including increasing connectivity, increasing the uptake and use of digital technologies, upgrading digital transformation skills, promoting digital innovation, strengthening labour market institutions, improving digital security, and translating digital strategy into concrete policy changes. The OECD notes that digital specialists and digital excellence are a bottleneck for innovation and growth in Sweden. Demand is expected to increase in years to come, as digitalisation and new technologies, such as AI, develop [17].

In summary, we can say that Sweden is far ahead in terms of digitalisation, and is a country with many opportunities, but that Sweden's lack of digital excellence is perhaps the main obstacle to becoming best in the world at exploiting the opportunities digitalisation represents.

D. PROJECT DEFINITION

Against this background, the Swedish Government charged the Swedish Higher Education Authority (UKÄ), and

the Swedish Agency for Economic and Regional Growth (Tillväxtverket), with a “Mission to collaborate on the provision of skills of digital excellence.” This resulted in a request for tenders for proposals to provide a definition of digital excellence. The authors submitted the winning bid to this request, and this research paper is one result of that assignment.

II. PREVIOUS WORK

Various sources of information about aspects of digital excellence have been used to develop the definition of digital excellence presented here. As a starting point the state of the art in research pertinent to the concept has been elicited through a scientific literature study. Relevant authorities and stakeholder organisations were requested to provide documentary input in terms of their responses to the concept. Data collection took the form of a questionnaire, interviews, and participation in expert workshops. The interview study targeted both experts and business representatives. Finally, a review of the possibilities of different data sources which might prove useful in terms of forecasting national availability of digital excellence (in terms of the definition) were evaluated.

A. RAPID LITERATURE REVIEW

The work began with a survey and literature study to create a broad understanding of previous work, and to focus on finding and comparing various existing definitions of digital excellence. The work on the literature study began with a workshop where the authors sought relevant literature and developed a common analysis framework for the work.

Relevant literature includes both research articles and overviews and so-called ‘grey’ literature, which may contain important material but has not undergone the same rigorous scientific scrutiny in formal terms. We have also integrated results and insights from government investigations, policy documents and strategic plans, which are considered in a special section below.

Policy and research literature is an essential anchoring point for the definition of digital excellence. By analysing the current scientific and policy literature, we address three questions about how digital excellence should be formulated in order for Sweden to take a leading position in the digitalisation of society, focusing on industry and education. To enable exploration of literature beyond the Swedish policy sphere we define three sub-goals relevant to the concept of digital excellence and its use:

- 1) Identify English words related to the concept of “digital excellence.”
- 2) Develop a competency profile for digital excellence.
- 3) Analyse statistics useful for Sweden as a benchmark against other world players.

Evaluation of how the scientific literature might contribute to formulating a definition, a literature survey was conducted according to the principles of rapid review [16].

The objective of the search was to extract potentially relevant articles to the Swedish term “digital spetskompetens.” The dilemma here is to capture the intent of the Swedish word “spets” in this context. The Swedish term “spetskompetens” has connotations of excellence, cutting-edge, and thought-leader, in combination with skill-sets associated with digitalisation, and cutting-edge technological development in computing and related fields. To be derive a relevant query, while still remaining as inclusive as possible we combined the term “digital*” (to capture all variants of digitalisation and other related terms), with English terms we deemed pertinent to the Swedish term “spets” and “kompetens” resulting in the query terms “excellen*”, “competen*” and “capab*.” Our interest was in Higher Education and so we also filtered on that term.

A search was conducted on the Clarivate Analytics database “Web of Knowledge,” extracting scientific and review articles in journals published in English between January 1, 2016, and March 13, 2020 using the query formulation given below.

```
(TS=(digital*) AND
TS=(excellen* OR competenc* OR
capab*) AND
TS=(higher educat*)) AND
LANGUAGE: (English) AND
DOCUMENT TYPES:
(Article OR Data Paper OR Review)
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List. 1. Structure of the literature search.

The process of producing relevant literature is visualized as “PRISMA flow” [22], see Figure 1.

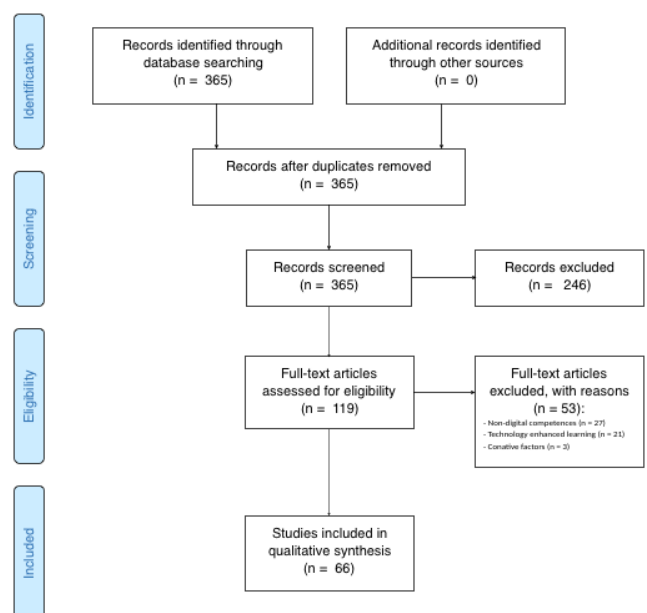


FIGURE 1. The implementation of the literature study is reported as PRISMA flow set up in accordance with [22].

Additional material identified as relevant included DigComp 1.0 [13] and 2.0 [34], and DigCompEdu [27], as well as an overview article that highlights the use of the concepts of “digital literacy” and “digital competency” [32]. It should be noted that a large part of the literature is aimed at the education system and skills falling under the responsibility of the education system.

The resulting article list contained 365 articles after duplicates were eliminated. Screening of title and abstract were then conducted to determine articles with potential relevance to the project objectives. In this process 246 articles were excluded, leaving 119 articles for more rigorous review. Criteria for excluding the first 246 items were twofold, either the article did not relate directly to education, and/or it did not address competences in student populations.

The 119 remaining articles were then assessed in detail for final eligibility. Those excluded during this process include: works addressing non-digital competencies ($n = 27$), works on technology enhanced learning ($n = 21$), articles dealing with conative factors such as self-efficacy or related factors such as confidence in the use of digital equipment ($n = 3$), articles dealing with specific technologies in educational settings ($n=1$), no full text available ($n=1$).

The remaining 66 papers were analysed in depth in terms of their approach and content. The approaches represented in this literature can be condensed into three main themes, or thematic areas. Content analysis focusses on key aspects (or dimensions) of digital excellence, as defined in the literature.

1) RESULTS OF THE LITERATURE REVIEW

In higher education, the following three themes relevant to the definition and production of statistics about education to prepare for digital excellence are identified:

- 1) Personal characteristics concerning how and when digital systems are integrated into society.
- 2) Issues and competencies (“dispositions”) considered to contribute to the development of easily accessible system environments, services, and technical systems.
- 3) “Skill-sets” with relevance for a person to exercise competence in the digital excellence domain and relevant areas.

Theme 1 concerns how persons possessing excellence in the digitisation of processes and systems prepares and works with the solution’s design, anchoring and implementation. It is about what personal characteristics contribute to excellence, grant work a high value, and are considered attractive in the field of application. The theme has a direct link to education and statistics that exist in established sources, and can be used both to track the education of people who have the potential to develop towards digital excellence, and to understand the implications, opportunities, and limitations of cutting-edge technology.

Theme 2 integrates the knowledge and characteristics of a digitally competent individual who integrates

technical knowledge with a broader background in behavioural science and social science subjects, which may include the cognitive load that a system or solution entails.

Theme 3 is about identifying areas of digitalisation where there is a close connection between businesses and other players, and where applied research has a major impact on the development of new services and systems. Examples of such areas at present are machine learning, Big Data, and artificial intelligence (AI).

Dimensions of digital excellence resulting from our literature analysis are:

- The level of information science and information technology competence (information literacy)
- The ability to communicate and collaborate in complex environments
- The ability to analyse create high-quality digital products such as designs, systems, and processes.
- The insight into and ability to handle issues of security and trust concerning the digitalisation of society
- The ability to solve complex problems (“wicked problems”).

III. METHOD

Four different empirical sources were combined to obtain a broad background with which to underpin the definition we propose.

First, the literature review described above was conducted. Analysis of the documents resulting from that review contributed to an understanding of the research field’s state-of-the-art discussions on the subject.

Secondly, materials in connection with the concept of digital excellence were collected from authorities and organisations and analysed.

Thirdly, interviews were conducted in order to capture a range of perspectives regarding digital excellence and cutting-edge skills. These include representatives of industry, the academy, and public authorities, who contributed perspectives and concerns.

Fourthly, a workshop with an external group of experts was conducted to confirm the viability of a prototype of the proposed definition. This workshop provided an opportunity to explore multiple stakeholder perspectives and invite additional external input to the definition process. ‘Design Thinking’ methods were applied to generate innovative personae which characterise how the definition might play out in practice.

Finally, conclusions and recommendations were made in order to emphasise the effects of the definition created.

Continuous dialogue with experts from the agencies procuring this research ensured the relevance of the result, and iterative refinement contributed to a higher-quality final outcome.

The outline of our methodological approach can be found in Figure 2. Each method is then described in detail below.

A. MATERIALS FROM AUTHORITIES AND ORGANISATIONS RELEVANT TO DEFINING DIGITAL EXCELLENCE

In the assignment, compilation and collection has been carried out of analyses/compilations potentially relevant to the assignment of the need for digital excellence in Sweden. An analysis of the impact these have on the understanding of how digital excellence can be defined has then been carried out.

To capture the available sources outside the research literature concerning digital excellence, three different methods have been used.

The first set of data was collected by compiling sources already known to the investigators for review. These have been read through in the relevant sections, and relevant material has been used in the process of investigating the definition.

The second set of data was collected by requesting sources that the investigators were advised about in interviews, workshops, and other meetings. The sources were analysed and relevant parts have been used in the process of formulating the definition.

The third collection was in the form of a questionnaire concerning digital cutting-edge competence, sent to authorities, trade organizations, and other interest groups ($n = 77$). Responses ($n_1 = 36$) were analysed to identify relevant material, parts of which have also been used in the process of exploring possible formulations the definition.

A summary of the material received can be found in the Appendix “Compilation of collected government and organizational reports.”

B. INTERVIEW STUDY

The interview study consisted of a series of semi-structured interviews conducted in accordance with an interview template produced during a workshop early in the project. The workshop had been facilitated by the authors, and drew on the research group’s prior understanding of the digital excellence. The goal of the workshop was to explore concepts linked to digital excellence and develop a survey in co-design with the workshop participants. A total of 19 people were interviewed for 30 to 90 minutes each. The majority of the interviews being of approximately 30 minutes duration. The interviews were conducted remotely by the third author. Participants were purposely sampled with the intent of capturing input from a breadth of stakeholders including business, government, and higher education [7].

The interviews were transcribed and analysed thematically [6]. Some quotes have been redacted in the process of translating them to English in order to eliminate grammatical anomalies and render them more readable. Participants were informed in writing about the interview’s purpose, what the interview would be used for, and how data storage compliance

with GDPR was to be achieved. They were also informed that participation was voluntary and that they had the right to withdraw without explanation, terminate their participation at any time, or refrain from answering specific questions. The people interviewed had very long experience, and all held the key positions in their organisations. Eight were women, and 11 were men. All of those interviewed had a long and broad professional backgrounds, and most worked with IT or digital transformation throughout their careers. Their undergraduate degrees varied from technical studies to other subjects such as political science, business administration to pedagogy. Many also describe how they developed their skills through education later in life, and some describe themselves as self-taught. The distribution between current employment within different types of organisations is described in table 1.

C. EXPERT WORKSHOP

An expert group associated with the project included representatives from industry, academia, the public sector, and interest groups. Participating individuals from the expert group are shown in the Appendix. Based on the literature study and the interview study, we produced an early version of a definition for discussion in a second workshop. The following draft definition was presented:

Digital excellence consists of the extent to which you have:

- Knowledge of theory and practice from software development
 - breadth of knowledge - computer science thinking and understanding
 - in-depth knowledge - unique specialist competence in an area of digital development
- Skills to be able to use and create digital products
- Practical experience with digital development
- Attitudes, gender awareness, 21st-century skills, ethical compass, understanding of the social impact of technology, motivation to participate in digital development
- Mobility to be able to quickly adapt knowledge, keep up with developments, and learn new things

The workshop was conducted in digital form using the meeting platform Zoom.¹ The workshop began with a short introduction from the Swedish authorities commissioning the work, a short introduction from the project leader, a quick presentation of all participants, a short presentation of the results of the interview study, and a short presentation of the literature study. This was followed by four breakout-group discussions. The participants were also informed about the purpose of, and use of, collected data. The data management procedure were presented. All experts participating accepted that the results could be used in the final reporting. All group discussion was documented by the groups themselves using the tool Padlet.² The issues discussed are presented in table 2.

¹www.zoom.com

²www.padlet.com

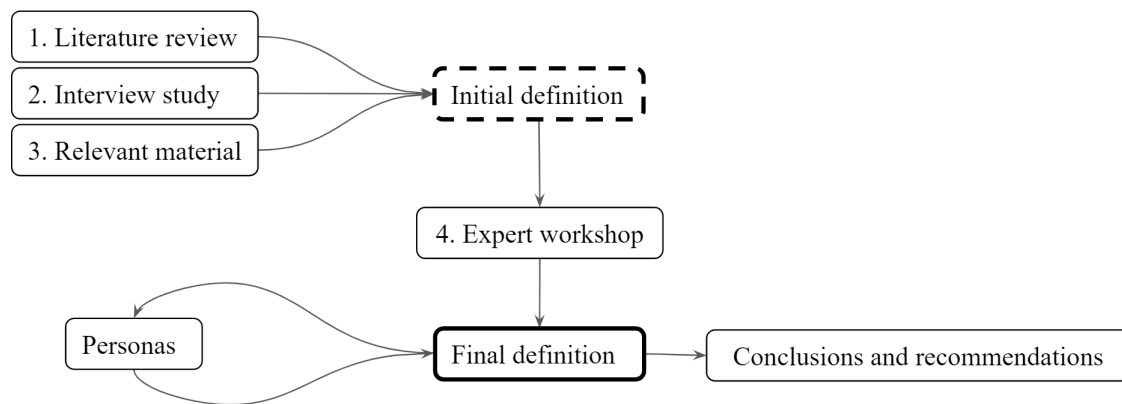


FIGURE 2. Overview of research design, where 1-4 denotes empirics.

TABLE 1. Interviewee's occupation and distribution of interviewees.

Interviewee's occupation	Number of interviewees
IT companies of various sizes and business orientations	7
Government	2
Independent organizations or employers' organizations	5
Universities and colleges of various sizes	4
Training companies in the private sector	1

TABLE 2. Issues discussed during the expert workshop.

Number	Issue
1	What are the meanings of the concepts: competence, knowledge, skills, experience, and education, for the concept of digital excellence?
2	In what way do attitudes, ethics, gender, mobility, and what are called 21st-century skills affect the concept of digital excellence?
3	Measurability: what can be measured and how?
4	How should we define digital excellence based on the proposed definition?

IV. FINDINGS

Findings from the collected empirical sources are extensive. A summary of each source's most important part is presented below. The full display of findings can be seen in appendix B.

A. IMPLICATIONS FROM THE REVIEW

In the screening that has been carried out, results from literature studies, materials from the authorities and organisations in connection with digital excellence, interview studies, and expert workshops have been compiled. In later sections, the parts of the result used to develop a definition of digital excellence will be presented and analysed. The results from the screening of data sources for the forecasting tool are discussed in connection with the development of the forecasting tool below.

1) LITERATURE STUDY

Our synthesis of literature from the last five years in the field of digital excellence identified important components related to digital excellence. The literature is more

relevant for a definition of the aspects of digital competence that are important for the citizens of the future, than a competent person in one of the areas where digitalisation requires excellence. However, the scientific literature shows that the following areas in relation to which personal development and education/training are particularly important.

- **Personal characteristics** are considered important in relation to how and when digital systems are integrated into society, where the importance of a breadth of knowledge that includes philosophy, ethics, and the social sciences is also indicated.
- **Skill-sets** relevant for an ability to exercise competence in the domain where digitalisation takes place (e.g., healthcare, sustainable product development, automotive industry), and in relevant application areas, develop and change with a high level of understanding for information flows and systems thinking.
- **Problem-solving ability** to solve complex problems ("wicked problems"), as well as the ability to analyse

and describe the problem area in order to accelerate digitalisation through design, systems, and processes.

- **Dispositions (from English)** includes demonstrated ability, personal suitability, commitment, and skills to be able to collaborate and communicate in complex work environments with different target groups and cultures, which together are considered to contribute to excellence.
- Some sources discuss the importance of the state-of-the-art person having insight into and the ability to handle issues of **security and trust** in relation to the digitalisation of society, but we have integrated this into the definition as a subset of **technical skill**.

2) MATERIAL FROM AUTHORITIES AND ORGANISATIONS IN CONNECTION WITH THE CONCEPT OF DIGITAL EXCELLENCE

The IT & Telecom companies emphasize that the digital sector spans almost every traditional professional category. The use of SSK (Swedish Standard Classification of Occupations) is no longer seen as meaningful for capturing those who work with IT solutions. At the same time, the IT & Telecom companies point out that cutting-edge competence (which is interpreted as situated in the digital sector) is somewhat broader than just possessing technical competence and having a solid education background. *UNESCO* [9] aims to establish collaboration and harmonization among different ways of assessing and evaluating what employees in different industries contribute within their profession at different levels. The relevance to the work here consists in endorsing the importance of describing competencies, instead of the content and amounts of knowledge that a person has been exposed to through education. *Swedsoft* reports a definition of digital excellence that contains two tracks: the ability to develop and manage digital tools, and the ability to follow digital development in order to identify, develop, and apply technologies and combinations of technologies. *Swedsoft* thus emphasises both the ability to operate in existing technology, and the ability to see and follow developments, at the same time as combinations of different technologies can be used for appropriate solutions. *The European framework for e-skills (e-CF)* defines e-skills as directly linked to a computer science education. However, the analysis is interesting in that the need for digital excellence is expected to increase faster than other needs for e-competence, and that the definition will be expanded with overarching aspects, such as ethics, inclusion, and security. The framework is relevant. It can inspire recommendations for clearer responsibility for validation, certification, and coordination, with international competence frameworks to certify competence relevant for developing validation routines in relation to Sweden's higher education system. The *Digital competence wheel* presents a definition of digital competence that involves many different dimensions and focuses on abilities. It is unclear how substantiated the definition is. The way in which the definition is presented creates clarity, something that this investigation can also benefit from. *The Institute for Electrical and Electronics*

Engineers (IEEE) / Association for Computing Machinery (ACM) are major international players in the standardisation of technical solutions as well as the range of higher education training and curricula. Their ongoing project *Computing Curriculum 2020* [8] also focuses on competencies considered to characterise various educations in the fast-growing data area. Since the curriculum report *IT2017*, the focus has been on competencies relevant to the discipline as a way of describing the objectives of different areas' curricula. *The Digitalisation Commission's* thematic report [3] raises several proposals for universities, governments, businesses, and individuals, to be able to promote a change to enable an increased degree of digital excellence in society. This is in order to create a better competence matching of supply and demand in the business sector, to meet the needs of an updated competence bank that is constantly changing, and to meet the country's needs for competence and competence development in the future. *The Digitalisation Council* [4] both raises convincing arguments for the transformation of industry and the public sector that require an increased degree of digital excellence, and provides a wide range of concrete policy proposals that could be implemented to increase the proportion of people with digital excellence and meet the needs of business and the public sector. The *Digital Skills and Jobs Coalition* highlights four different types of digital competence, of which digital skills for ICT professionals is one area. In the next Multi-annual Financial Framework, the long-term budget for 2021-2027, the European Commission will set aside extensive initiatives for increased digital competence both for the citizenry as a whole and for working life. It is therefore important to consider their definition of digital excellence.

B. INTERVIEW STUDY

It is clear from the interview study that there is no accepted definition of digital excellence. The people interviewed in different key positions do not have a consensus on what the concept consists of. It is clear that a definition needs to be developed and marketed so that the ongoing discussion in society is based on a consensus. A large majority of the interviewees believe that digital excellence includes knowledge, skills, and an attitude that is not equivalent to mere technical knowledge. A combination of technical knowledge and other knowledge is required, which depends a lot on context and the organization in which one works. If you work in health care, for example, some knowledge of medicine, the market, complexity, and the legal space is required. Some believe that the word 'excellence' is not well chosen to describe the knowledge and skills needed, and that the word excellence excludes the form of general knowledge needed if one is to work with digitalisation. Many believe that training in digital excellence needs to be broader than just dealing with technology, even if technology is an important and central part. Depending on the context in which one is to work, education in digital excellence can include opportunities for studies in subjects such as leadership, psychology, philosophy, and business administration. It is also important that Sweden

invests in enabling further education in the area of digital excellence, given the rapid technological development. It is also a gender-equality issue, as many women who today work in areas that require digital excellence trained later in life, and have not had a traditionally straightforward career. The majority of the interviewees believe that the number of women and men in the field of digital excellence needs to be more balanced. Here, some believe that a broad definition of the term will create new opportunities for women to become interested.

C. EXPERT WORKSHOP

The expert workshop highlighted several factors that have had a major impact on the definition of digital excellence, and which factors and conditions have needed to be taken into account. The following were the main conclusions:

- The definition of digital excellence must consist of many different factors that together give the full picture of digital excellence (knowledge, skills, disposition, etc.)
- Aspects that relate to the attitudes and values of the people who possess digital excellence have been highlighted as especially important. Ethical competence and gender awareness, as well as *phronesis* (action wisdom) are highlighted as important competencies.
- Despite the importance of being able to measure supply and demand for digital excellence, one warns of the dangers of measuring, and the risk of taking into account the aspects that are easily measurable while ignoring other aspects important for digital excellence.
- The importance of a definition to highlight the variability in competence and the needs for further development opportunities and lifelong learning is emphasised by several in the discussion.

Finally, the importance of not only seeing the need for digital excellence at the individual level, but also being able to assess whether a group of individuals possesses digital excellence at a level required by a particular project or organisation, is emphasized.

V. RESULT: DIGITAL EXCELLENCE

The approach we have taken to arrive at an operationalisation of the concept of digital excellence has been in relation to the following issues:

- What knowledge is the required foundation (related to existing curricula in higher education and various types of advanced education from private education intermediaries)?
- The importance and assessment of technical excellence (areas for expert knowledge, e.g., data security, AI, etc.).
- What skills are included in the definition (ability to design, program, test, ethical approach, awareness of norms, gender mainstreaming, etc.)?
- The importance of business experience for the competence level (if you need to present documented experience of successfully completed business projects) Based

on our synthesis of the results from the literature study and the interview study, we developed a first draft of a definition, and opened this up for discussion in a workshop with the expert group. In addition to the classic aspects of knowledge, skills and disposition, we have, after our analysis and studies, chosen to highlight some aspects that we have judged to be particularly important for precisely digital excellence.

The following proposed definition is the synthesis we have now made based on these background studies:

Digital excellence is characterised by the extent to which a person demonstrates

- **Knowledge** of relevant theory and practice associated with the digitalisation of society and related phenomena. Of which the constituents are:
 - *general knowledge* - possessing a breadth of knowledge including awareness of philosophy, ethics, gender mainstreaming, and aspects of the humanities.
 - *digital breadth* - well-developed awareness of computing and systems development concepts and processes (ICT literacy).
 - *specialisation* - unique mastery of a specialist area in one or more emerging cutting-edge domains (e.g., quantum computing, AI, expert systems, cybersecurity, etc.).
 - *domain-specific knowledge* - in an area where digitalisation is taking place (e.g., healthcare, power generation, transport industries, gaming, etc.).
- **Capacity and capability** to apply and develop digital products, and assess their advantages and limitations.
- **21st-century skills** including critical thinking, creativity, collaborative capacity, communication skills, information literacy, media literacy, technological literacy, flexibility, leadership, capacity to take initiatives, productivity, and social skills.
- **Disposition** meaning attitudes and value systems, commitment to gender equality, professional ethics, and an understanding of the impact of technology on society.
- **Mobility** meaning acquiring new knowledge rapidly and tracking change in conjunction with a motivation to contribute to digital development of society.
- **Reflective insight** resulting from active participation in digital transformation.

The definition above means that digital excellence is a measurable quantity (at least in part). The different types of knowledge can be measured by the courses that have been completed and their different types. Skills and abilities are best measured through various forms of proficiency tests. Future skills, disposition, and mobility require qualitative methods to be measured and assessed. Experience can be measured by the number of years or projects participated in, within the framework of what can be classified as digital excellence.

In addition to the above paragraphs, there is also often a requirement to follow an accepted ethical framework, such as the IEEE Code of Ethics.

A. KNOWLEDGE

We distinguish here between theoretical and practical knowledge on four different levels. The first level describes some form of general education level that is needed to demonstrate a sufficient breadth to be able to absorb and be top-notch within an area. It can be about philosophy, psychology, ethical knowledge, gender knowledge, sustainability knowledge, etc. The second level is called breadth knowledge and refers to a broad computer science and systems science, general understanding of concepts, processes and working methods, which in the literature is referred to as ICT literacy. It includes an understanding of basic system development methods, basic IT architecture, an understanding of basic computer science concepts such as operating systems, compiler technology, algorithm building, object orientation, basic artificial intelligence, and an ability to translate a real problem into an algorithm that can be solved, to give a few examples. In-depth knowledge, on the other hand, lies in an expert understanding of one or more delimited areas of the digital field so far as to master the methods and theories used in the specific field, a unique specialist knowledge in one or more digital sub-areas (e.g., quantum computing, AI, machine learning, data security, etc.) Two aspects of in-depth knowledge emerge:

- 1) The area is important for the definition, i.e., one may have general digital excellence as a professional developer or programmer or specific digital excellence in machine learning, data security, database management, or user experiences. Specific digital competence is sometimes classified as expert competence
- 2) Uniqueness: Several have suggested that the concept of digital excellence is a competence unique in the country, unique in a field of operations, or unique in their operations. Uniqueness has been highlighted by many as an indicator of excellence, i.e., top competence is limited to those in the top X% of an area of expertise. The value of X becomes strongly dependent on domain, business area, or organization.

In addition, domain knowledge, an understanding of the context in which the system is to be used and the possibilities and restrictions that lie within an area of application (e.g., healthcare, energy system, automotive industry, computer games, etc.), is also needed.

B. SKILL

Digital excellence does not only involve theoretical knowledge. One may be profoundly theoretically knowledgeable but not directly possess the skills required to cope with the craft to contribute to the development of digital systems. Skills and abilities enable use and creation of digital products, as well as determining their possibilities and limitations. As an example, you can be theoretically knowledgeable of

how to write a computer program in a particular programming language, but to be a good programmer you have to master the craft of writing the code, getting it to execute, and being bug-free. The skills try to capture this ability to, for example, be able to write executable, bug-free, and well-documented code.

C. FUTURE SKILLS / 21ST-CENTURY SKILLS

Future skills (referred to as 21st-century skills) [15] are becoming increasingly important skills in order to function at a digital excellence level. They are often referred to as the social and cognitive abilities that today's students are expected to need in the labour market, but which schools and universities find it difficult to cater for: creativity, communication, problem-solving, initiative, collaboration, and more. Future skills can be grouped into three different main groups: Learning abilities that teach people the mental processes needed to adapt and improve a modern work environment (critical thinking, creativity, collaboration and communication). Literacy skills that focus on how people can discern the facts, places of publication, and the technology behind them (information media and technology literacy). There is a strong focus on identifying reliable sources and factual information to distinguish them from the misinformation that floods the Internet. Life skills look at intangible parts of a person's everyday life (flexibility, leadership, initiative, productivity and social skills). These intangible assets focus on both personal and professional characteristics.

The 12 main future skills are often referred to as:

- 1) **Critical Thinking** - Describes the person's critical problem-solving ability.
- 2) **Creativity** - Describes the person's ability to think in new ways.
- 3) **Collaborative ability** - Describes the person's ability to collaborate and collaborate with others.
- 4) **Communication** - Ability to discuss, communicate, and transmit messages.
- 5) **Information literacy** - Understanding of facts, statistics, and data.
- 6) **Media literacy** - Understanding how information has been collected and processed.
- 7) **Technology Literacy** - Understanding the basic IT architecture of information and the technical aspects required.
- 8) **Flexibility** - Ability to deviate from planned arrangements.
- 9) **Leadership** - How to motivate a team to achieve a goal.
- 10) **Initiative ability** - How to start projects, establish strategies, and plan work on your own.
- 11) **Productivity** - How to maintain a level of efficiency amidst an abundance of information and competing awareness.
- 12) **Social skills** - To meet and network with others for mutual exchange.

D. DISPOSITION AND RESPONSIBILITY

Disposition is a concept that seeks to capture all the personal qualities and abilities that are important to possess in order to carry out a mission at the top level. They may include:

- **Attitudes and values** - Concerns what personal approach you have to your ability and what role you can play in development work, responsiveness to the target group (users), attitude and ability to collaborate, etc.
- **Ethical compass** - The societal impact of technology is extensive and, as involved in the development of technology, there is a great responsibility to ensure that technology contributes to building a free, open, and democratic society. As a holder of digital excellence, it is therefore necessary to have a deep understanding of the importance of technology and what it does to the individual, and to work for the development of technology to be responsible, i.e., that it contributes to the good of society, the environment, and users.
- **Gender awareness** - The ICT area is strongly gendered. Despite years of efforts to improve equality, less than 20% of professionals and students in digital excellence are women. A specific approach is required make the area more equitable and invite wider participation. Gender awareness also includes knowledge and understanding of technology's impact on individuals and society from a gender perspective.
- **Understanding of technology's social impact** - We have today seen how the development of several digital artifacts has contributed to far-reaching societal effects. Products such as mobile technology, social networks, artificial intelligence, or public digital services can transform society far beyond what individual technology contributes to. You have an obligation to show an understanding of this and take responsibility for making impact assessments beyond the individual product's use possibilities.
- **Motivation to participate in digital development** - New technology has a much greater potential to change than you may initially recognise. Digital excellence requires that you are motivated to take advantage of cutting-edge development, to stretch the boundary for what the technology can be used for, and to learn. Motivation builds an interest and drive that are prerequisites for development.

But responsibility also falls under this heading. The requirement that engineers be responsible for what they create, how it is created, its social impact, and any effect of the artifact on what is developed.

E. MOBILITY

The digital area of expertise is constantly evolving and changing, and new products, software languages, hardware, and systems are being launched at an ever faster pace. The area requires continuous skill development at a level completely different from any other area. Mobility therefore indicates the

ability to develop their skills, acquire new knowledge, and change ways of working. Digital excellence is characterised by a special ability to embark on new areas, explore the possibilities of new technology, and create digital systems without having any previous experience with the program language, program library, or software/hardware to be developed. It also includes the person's motivation to participate in digital development. Mobility characterises the ability of a person to readily orientate themselves as they enter a new field, allowing them to rapidly contribute cutting edge insights into processes, the implementation of systems and solutions that:

- are adapted to the nature and culture of the business,
- can optimise flows that were not previously digital
- add something new by integrating deep technical insight into the possibilities and limitations of digitalisation with an empathic understanding of the domain where the solution will work.

F. EXPERIENCE

Experience entails practically reflected experience of actively participating in digital transformation. One may have theoretical knowledge and skills in the digital field but little experience in applying these skills. Many companies and organisations claim emphatically that new graduates employed in the field of digital excellence need to be internally trained to achieve a level that enables them to deliver any business benefit within the framework of the company's operations, or to the customer. Many organisations also claim that digital excellence requires demonstrable experience with tough projects where you have had to demonstrate your experiences.

VI. DISCUSSION

Since digital excellence is, by our definition, a consideration of a variety of qualifications and competences, we need a mechanism to visualise this. We therefore propose a visualisation in the form of a spider diagram illustrating weighted digital excellence (see figure 3).

With this way of describing digital excellence, one might propose that a measure of digital excellence is the extent of surface area the diagram covers. You might also think that a level of excellence is required within one, or some, of the illustrated areas in order to be able to classify as digitally excellent.

Some areas of competence could be said to require a minimum competence, to the extent that one could not be judged to have digital excellence if one has only the highest competence in one area and very low competence in the others. Further work on the definition and its consequences may show whether it is feasible to specify low levels within parts of the definition.

The definition of digital excellence is based on an international literature review, and an international review of gray literature together with an interview study with both

Dimensions of digital excellence

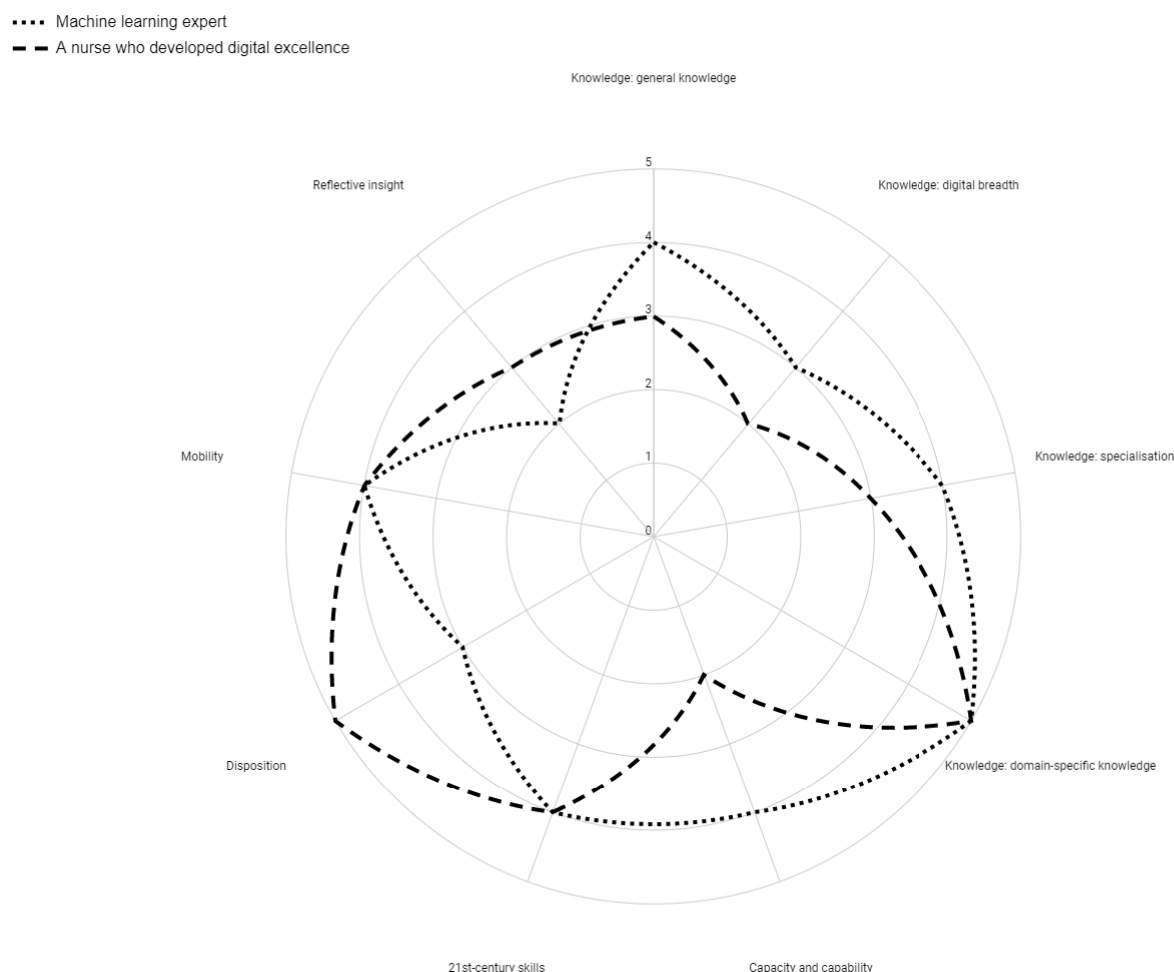


FIGURE 3. A spider diagram illustrating the digital excellence of two individuals (personas).

international and Swedish companies. Hence, the definition of digital excellence is international and applicable globally.

Finally, it is worth highlighting proposals to describe digital excellence not at the individual level, but as the accumulated digital excellence of a group working together for a specific purpose. Since digital excellence, as defined in this report, can almost be described as a “renaissance person,” it is no more than reasonable to consider whether or not to build digital excellence based on a group.

A. PERSONAE TO ILLUSTRATE THE DEFINITION

In order to come up with new suggestions for how to solve the question of providing digital excellence, we have worked with creative-design thinking methodology. Design thinking is an iterative process where we try to understand, challenge assumptions, and redefine the concept of digital excellence to identify alternative strategies and solutions around the definition that may not be immediately apparent. Below we have made personae to illustrate our definition of digital

excellence. The persona method was originally introduced by [11], who argued for hypothetical archetypes of real users. According to [11], personae should be based on actual users and should be accurate and specific, as it is more difficult to ignore a detailed persona than aggregated user data. The most common way of producing personae is to collect qualitative data through, for example, interviews and observations of real users [11], [26]. From the five different personae that derived from the design process, two are presented below. Our personae illustrates our definition of digital excellence and is created based on the literature study, discussions in workshops, and the interview study conducted within the framework of the project.

1) PERSONA 1: ELENA SANCHEZ, MACHINE LEARNING EXPERT, 38, STOCKHOLM

Elena Sanchez has a master’s degree in engineering and graduated from the Technical Physics program in 2010. She has since worked as a systems architect and programmer in

a large international consulting company. In recent years, she has become interested in machine learning, and by reading online courses and participating in discussion forums, she has become one of the company's experts in machine learning. Elena is very interested in the latest technology, and likes to spend the weekend reading up and trying something new. Her knowledge in machine learning has been further deepened by her participation in major international EU projects. Elena Sanchez is not so interested in business ideas or societal challenges, but her great interest lies in creating stylish code and cool programs. Nor is she particularly interested in ethical issues, gender issues, or equality issues. These are important issues for society, she thinks, but nothing that interests her personally. The persona's visualised digital excellence profile can be seen as the dotted line in 3.

2) PERSONA 2: DAVID NOEGA, A NURSE WHO DEVELOPED DIGITAL TOP COMPETENCE, 35, SÄVSJÖ

David Noega, worked as a nurse for several years before receiving an offer to work with the introduction of digital hospital records. With two small children at home, it felt tempting to work during the day with something new, so he changed assignments in the service. He is motivated by the opportunity to influence care so that it becomes more patient-centred, and wants to contribute to solving the societal challenges of an aging population. With his new job, he sees greater opportunities to influence. David Noega's strength in the regional IT department is in combining his knowledge of healthcare with an interest in the possibilities of digitalisation. Today, he works as a project manager for major development projects in healthcare, and leads efforts to introduce new eServices for patients. In particular, he sees opportunities with AI and patient services in primary care, and he often travels to international conferences to stay up to date on how other countries are solving healthcare challenges. The persona's visualised digital excellence profile can be seen as the dashed line in figure 3.

VII. ADDRESSING THE DIGITAL COMPETENCE GAP

Drawing together our results and the synthesis of stakeholder input we have made a series of recommendations to the Swedish Agency for Economic and Regional Growth, and the Swedish Higher Education Authority. These recommendations lay the groundwork upon which policy, strategic investment, and extended oversight can be based. A thorough investigation of background data from a variety of sources has been combined with focus group meetings to discuss preliminary findings, which illuminates the situation from a wide range of industry, academic, and societal perspectives. Although these recommendations are addressed to a national authority, in many cases they can be seen as general extending beyond the national context.

Measures that can be taken to ensure a sufficient supply of digital excellence are many. An increased focus on education for digital excellence from an early age and throughout the education system will therefore be important. How do we

ensure that we have good, modern, university-level education to ensure digital excellence? How do we ensure that these programmes have sufficient applicants to ensure quality? How do we ensure that potential students do not lose interest in technology, IT, and other subjects that form the basis for digital excellence already early in the school system? How do we ensure sufficient vocational programmes to enable more practically or vocationally oriented digital advanced competence educations? Fast-track training has been carried out in pilot form and proven effective [18] in supplementing digital excellence in those who also have another academic background. By building up a small number of fast-track training courses in selected IT areas, we can increase the capacity to quickly convert already trained workforce to digital excellence. In particular, this exchange of skills would be effective by staff in occupations with a high risk of being automated. Two issues that border on the supply of skills are student support systems and labour immigration. How do we enable a student support system that provides an opportunity for retraining from another education to digital excellence? How should the public and private sectors contribute to life-long learning and help to establish a value proposition around the role of further education in maintaining Sweden's at the digital cutting edge in terms of technological development given the rate of development of the field, and that knowledge in the sector has such a short shelf life. Furthermore, how do we enable a migration process that allows us to give well-educated individuals an opportunity to stay in Sweden and work with their newly acquired digital cutting-edge skills training? Validation of work experience is highlighted by several sources as a very important part of the future framework for qualifications and mobility. Can one work with skill assessments to identify and develop individuals' abilities beyond what education provides? Can competence assessment and/or certification be carried out decoupled from the education?

3) RECOMMENDATION

- Examine the current state of competence regarding digital cutting-edge competence.
- Review the lifelong learning mission of higher education institutions.
- Increase the volume of short courses to increase the number of digitally skilled people.
- Increase flexibility in the design of educations to broaden the knowledge base.

4) MISSION

Assign higher education institutions to investigate how IT education can be developed to meet requirements of the definition of digital excellence. Investigate how efficiencies in the education flow can take place to more quickly fill skills needs that exist in society. The starting point for state-funded education should be that need for educated labour and delivery opportunities should be adapted accordingly. This means that long breaks in the training year, low intensity in training

programs, and other things that hinder the rapid delivery of labour should be subject to needs. Consider making a competency inventory to identify groups that have competencies that together with IT competence could have digital excellence. At the same time, an inventory of successful quick educations in IT at public universities can be carried out. Following these inventories, it should be considered whether there is any value in calling for the establishment of rapid training for specific groups.

A. ENSURE EQUAL CONDITIONS FOR ALL WITH POTENTIAL FOR DIGITAL EXCELLENCE

The project's goal is to create a definition of digital excellence that is both gender-conscious and inclusive. Professions in areas that require digital excellence will probably change in the future. AI will probably do parts of these jobs automatically, and professions today seen as less technical will include a lot of technology, such as nursing. The number of people employed within STEM will probably increase in the future, and occupations will also include higher demands on abstract thinking [19]. These changes can create opportunities from a gender-equality perspective [19]. Job-seekers may consider occupations traditionally dominated by the opposite sex, if the employment prospects are better in such occupations. For example, health care jobs may use more technology in the future, perhaps reducing barriers for men to enter these traditionally female-dominated occupations.

There is research in gender studies that indicates that women, to a greater extent than men, refrain from applying for employment if they do not satisfy all qualifications sought for IT positions, a theme which also emerged in several of the interviews. In addition, many studies show that women have a tendency to underestimate their digital skills [20]. We would also like to point out that fewer qualified women than men felt compelled to seek excellence when such announcements were made in research [30]. We therefore want to point out from a gender perspective the importance of allowing the definition of digital excellence to be broad and thus inclusive.

Clearly, the need for digital cutting-edge expertise in Sweden and in the rest of the world is great. Using gender loaded terms such as "excellence" or leadership can be highly problematic from the perspective of gender-neutral development of the area. In particular gender research identifies these types of terms as problematic in the context of supporting gender mainstreaming, and in many cases alternative terms should be considered.

Other aspects are also important to consider to define digital excellence in an inclusive way. The interviews showed examples of work situations where it was made possible for people with cognitive functional variations to be able to pursue digital excellence on the basis of special competence within certain parts of the definition of digital excellence, while completely or partially lacking other parts. Special targeted efforts are required to create conditions for people with functional variations to fill parts of the identified competence gaps. Another important target group to include in

the definition of digital excellence and subsequent policy proposals and initiatives, in order to achieve the goals of good supply of digital excellence, is foreign-born people who have acquired a digital excellence education in Sweden. It will be important to ensure that these people are not forced to leave the country after completing their education, but that they are provided with opportunities to become professionals in Sweden. A large part of the labour market for people with digital excellence does not require Swedish language skills to work professionally.

1) RECOMMENDATION

The equal opportunity perspective should be an integral and natural part of the work in the future, and should be seen as a very important aspect that must be allowed to take time and place.

2) MISSION

- Work with a special focus to define cross-sector digital excellence skills work that enables improved equality.
- Increase the understanding of problematic in the concept of "tip" because it has a clear gender marking.
- Investigate how a professional identity linked to digital excellence could be established.
- Investigate how brain drain can be avoided, so that digital excellence that otherwise risks leaving Sweden can be transformed into a national resource of digital excellence.
- Make it easier for people with special skills to develop their digital cutting-edge skills. Make these people visible and the need for their special skills clear.
- Ensure that good competence regarding equal conditions and gender studies is included in the Council for Digital Excellence
- Map and strengthen the work with equal conditions in the educations that lead to digital excellence. This partly applies to the perspective of who studies them, and how issues concerning equal conditions and gender are integrated into educations. Spread good examples from successful programmes.
- Clarify the equality and gender aspects of digital excellence programme evaluations. Investigate how these aspects can be given special weight, e.g. with financial incentives or certification.

B. VALIDATION AND CERTIFICATION OF DIGITAL EXCELLENCE

Labour immigration and the influx of skills to Sweden make it difficult to capture data on, for example, the education of parts of the possible workforce in this area. At the same time, it is important that the resources available are both visible and quality-assured. Being able to effectively validate knowledge and skills that included in the definition of digital excellence is therefore important. Through a validation process, a professional identity can also be created, which in the long run can increase quality and clarity

(cf. doctor, lawyer). The issue is intimately linked to the international development of the Qualification Frameworks [9]. This also enables the collection of statistics that complement the existing sources and allow the various aspects of the definition to be measured more comprehensively.

1) RECOMMENDATION

- Investigate how the responsibility for the issue of validation and certification of digital excellence will be placed within the Swedish education system.
- Develop competence frameworks and “Qualification frameworks” as well as a validation process to capture labour that cannot be easily identified via academic degrees or other sources.

2) MISSION

Assign UKÄ and the Swedish Agency for Economic and Regional Growth to create a working group within the framework of the work with digital excellence, in order to produce a basis for deciding who will be responsible for validation and certification of digital excellence in Sweden. Define an expert group that takes responsibility for both the development of the validation process and routines for how to document relevant competence, to facilitate the registration of competence, as well as for mapping, follow-up and forecasts.

C. ESTABLISH A COUNCIL FOR DIGITAL SUPPLY OF DIGITAL EXCELLENCE

The concept of digital excellence is complex and consists of several different incomparable dimensions. Each person has a unique combination of knowledge, skills, future competencies, etc. A high level in one area cannot directly replace a low skill level in another, as there are no interchangeable quantities. Therefore, profiles must be considered in their entirety. Some of the variables that make up digital cutting-edge expertise are relatively easy to measure. Others may defy any absolute measure. It is therefore important to understand and consider the limitations of what you measure. Focusing unilaterally on finding an absolute measure risks ignoring what is important, or beneficial to the individual, the employing company, or the forecast recipient. A one-sided focus on measurability risks measuring what can be easily measured instead of what was intended. This issue of validity risks leading to a situation where decisions are based on incorrect conclusions but have the semblance of credibility. Our commission was to explore means by which one can measure and assess the availability of digital excellence; what training, competence, etc. that people can be judged to have. But it is also interesting to make an analysis/inventory of stakeholder's requirements in the area of digital excellence. What do companies need in terms of knowledge, skills, experience, and special abilities? In which specific areas are skills lacking? The time perspective, the current situation and needs as well as the envisaged future need, complicates the outlook in a non-trivial manner. This has not been a focus in this study,

but it may be valuable to analyse the situation with the intent to form an holistic view.

As we have seen, the assessment of digital excellence is complex. Several factors contribute to the definition of the term. Area of application, stage of development, and external factors are important sources in order to capture characteristics and competencies necessary to assess digital excellence. The digitalisation area cuts through a number of industries and areas of society. A meaningful discussion of forecasts therefore also needs to include broad subject perspectives, especially if the conclusion is to have a meaningful edge. Growth analysis [12] notes this challenge: “When digitalisation policy spans an increased number of policy domains, the number of actors also increases. A question becomes whether there are interactions between different actors that are hindered today? If so, are there policies that address these barriers? For example, the number of actors in different ministries has increased. Today, digitalisation policy is at the Ministry of Trade and Industry, e-government policy at the Ministry of Finance, e-health policy at the Ministry of Social Affairs and security issues at the Ministry of Defence.” There is thus a value of coordination between several areas if correct forecasts are to be implemented. Static data sources, more elusive assessments, and solid analysis of the surrounding world are components that a forecasting tool needs to handle. The forecast tool will also change over time. Therefore, it is important to be able to select currently relevant data sources and make assessments situated in the current context.

1) RECOMMENDATION

To meet these needs, we proposed that a council be established, the Council for Digital Supply of Excellence, with the task of making labour market forecasts for the area.

2) MISSION

The Council for Digital Leading Competence Supply would be commissioned to make semi-annual analyses of the current competence situation, forecasts for future competence needs, and propose initiatives that can lead to the competence demand being satisfied. The goal is to be able to provide an overall picture of both the current and future demand for digital cutting-edge competence and to continuously assess and provide proposals for measures and planning to dimensions of the labour supply. In order to be able to make sound assessments, the Council should focus on analytical and subject knowledge before representatives of various actors and stakeholders. The Council needs to be able to obtain data and analysis from official data sources, industry organisations, and other actor-oriented data sources. The national federations on the employee and employer side are other avenues for data. With an increased global production of IT services, the perspective of the greater world is important. This is particularly central in relation to labour supply, which can be linked to the Swedish labour market via labour immigration. The approach is that the availability of digital excellence is not naturally a contentious issue between parties in the labour market, but a

competitive issue for the nation. The Council shall therefore not deal with wage setting, conditions issues, or anything else that belongs to the social partners' negotiations. Political considerations, as well as political influence, are handled by recipients of the Council's forecasts and do not constitute the Council's mandate. In order to easily access the best decision documents and the most relevant information about the state of the world, our assessment is that the following competencies should be included in the Council: forecasters from employers' and employees' organizations, experts in digital excellence from academia, forecasters from the ministries of business, infrastructure, education, and labour, or by these designated authorities, the authority for polytechnics, and finally an operative person grounded in business interests.

Before each forecast, the Council needs to create a number of analyses: national and international analyses of the surrounding world, forecasts for education, labour market analysis, research and innovation analysis. The competence to produce these does not necessarily have to be represented in the council, but orders can be made on an ongoing basis from the most initiated players. The Swedish Public Employment Service, the National Institute of Economic Research, and Statistics Sweden are some data sources. More forward-looking analysis from, for example, the OECD and the European Commission should also be considered. In addition to other data, the data sources in the appendix on statistical sources constitute important input to the analyses.

The Council's initial work includes building up an analysis model that brings together a basis for a quantifiable forecast. An extensive survey of educational actors and flows of participants/students must also be introduced initially. These products need to be maintained and adjusted on an ongoing basis.

The work of the Council can be advantageously initiated already during the execution of the government assignment. A prototype for the organisation can then be proposed when the government assignment is finally reported.

VIII. CONCLUSION

Addressing the global need for digital excellence in the workforce and society at large is central to solving many large-scale challenges. Distilling the essence of the prior discussion we conclude with a series of recommendations for achieving sufficient supplies of digital excellence based on our research and professional experience. We propose the following concrete actions to increase availability of digital excellence.

Establishing equal opportunity for those aspiring to digital cutting-edge competence is a central principle, and is attained by:

- ensuring that equal opportunity and gender mainstreaming are a natural and integrated aspect of future work in this initiative. It is important that this attitude permeates working practice and is given the time and consideration it demands.

Validation and certification of digital excellence provides a measure of human resource capacity, and is implemented through:

- determining who should be responsible for validation and certification of digital excellence within the Swedish educational system.
- developing competency frameworks and qualification frameworks to capture data related to relevant workforce human capital not readily identified through academic qualifications, transcripts of results, and other existing data sources.

Creation of a "Council for the Supply of Digital Excellence" is needed to provide structured oversight, and to meet the need for:

- identifying a clear supply and demand profile for the digital excellence workforce. This council should have responsibility for compiling prognoses and establishing human capital supply profiles.

IX. FINAL REMARKS

The project's goal in the long run is, of course, to ensure that Sweden has the digital excellence it needs to continue to develop. Sufficient access to digital excellence is ensured by:

- benchmarking the current situation.
- conducting an overview of life-long learning priorities for universities.
- increasing the volume of shorter diploma programmes to increase the availability of digital excellence in the general workforce.
- increasing the flexibility of educational offerings in order to create a broader knowledge base for the area.

APPENDIX A COMMISSION

The commission from the Swedish Higher Education Authority (UKÄ), and the Swedish Agency for Economic and Regional Growth (Tillväxtverket) to the authors provided the following framing for the project.

Part 1: Define the concept of "digital excellence."

- There is no accepted definition of the concept of digital excellence. The contractor should therefore describe and analyse the concept of digital excellence and propose a definition of the same. The assignment includes discussing the advantages and disadvantages of the various definitions that exist today.
- The definition of digital excellence must be used partly to analyse existing statistics and partly to improve the availability of statistics and forecasts in the future. That is, it should have a practical relevance for the production of statistics and projections for the competence needs of digital excellence.
- The definition will be developed in dialogue with both representatives of the education sector and working life representatives.

Part 2: A review of the state of knowledge and deficiencies in the knowledge base regarding the future competence needs of digital excellence

- A brief literature review of current research in the field.
- National external analysis: What analyses/compilations regarding the need for expertise in Sweden of digital excellence have been made that are relevant to the assignment?
- International external analysis: What analyses/compilations regarding the need for digital excellence are made or done internationally, both by international organizations (OECD, EU, *et al.*) and, for example, government agencies in other countries, which can be a benchmark for this assignment?

Part 3: Provide suggestions and recommendations for the project's continued operations and design in accordance with the assignment.

- Based on the conclusions of the report, make recommendations on which actors and networks The Swedish Agency for Economic and Regional Growth and UK Ä should include in the dialogue for collaboration on the provision of expertise in digital excellence.

APPENDIX B COMPLETE FINDINGS

A. MATERIALS FROM AUTHORITIES AND ORGANISATIONS WITH RELEVANCE TO THE CONCEPT OF DIGITAL EXCELLENCE

The collected material has been analysed with regard to discussions about digital competence and digital cutting-edge competence. Nine different sources have been judged to be relevant for the work with digital excellence.

A review of the sources is presented below, followed by a summary of the contributions they make in relation to the assignment.

Relevant sources for the task of defining digital excellence: *Swedish IT and Telecom Industries (IT&Telekomföretagen)* produces a report on the state of competence in the ICT sector every two to three years [33]. The report deals with driving forces for development and how these are believed to affect the need for competence. The report points out that the Standard for Swedish Occupational Classification (SSYK) does not capture many of the competencies of which the survey aims to calculate the deficit/surplus. In part, this has to do with the fact that the digital sector spans many different sectors and occupational categories:

- 1) *"The digital sector encompasses all businesses that in any form create, develop, deliver and operate systems, services and products with digital content in the form of hardware or software, including both pure suppliers of hardware and software and related services (what is called IT and telecom industry) and other activities where the end products are not IT products per se but, for example, vehicles, financial services or travel but where hardware and software are key components."* [33]

IT & Telecom Industries emphasises the importance of seeing the digital sector instead of different occupational categories or individual sectors.

Furthermore, competence is defined as "referring to [...] an individual's ability to perform a task by applying knowledge and skills." Excellence is not defined, but is related to the fact that those who have such naturally also have a solid educational background, a broader register than the purely technical. Being able to develop user-friendly, utility-driven, secure, and flexible solutions are also stated as characteristics important for digital excellence.

The report talks about cutting-edge expertise in relation to the digital sector. The report also notes that education is important, but far from definitive, in relation to work in the digital sector. Experience is seen as important, albeit of varying importance in different parts of the digital sector. Complementary competencies beyond IT are also considered of central importance in meeting competence needs.

The Global Inventory of Regional and National Qualifications Frameworks is an inventory of different frameworks for how to validate and evaluate the work profiles of individuals in Europe. An extensive screening of various national systems was carried out in 2017 with the aim of studying how these systems interact and also relate to the EU's sustainability goals. The report was updated in 2019 [9] and analyses different ways of assessing individuals' professional experience and education with a focus on increased consensus on qualifications and the labour market's need for increased mobility and the ability to assess skills. Of importance for the work with the definition of digital excellence is that the report states that competencies implemented as "learning outcomes" are now practiced in all education sectors to describe the value of education, experience, and lifelong learning.

It is also emphasised that validation of life experience is an important component in a future qualification system. Above all, it is stated that it is important to be able to describe competencies. The concept of digital excellence is not specifically addressed in the report.

For some years now, *Swedsoft* has been arranging an annual workshop called "Gathering of Software Sweden" (Samling av mjukvarusverige) for decision-makers in Swedish software development from companies, academia, authorities, and organisations. Swedsoft's compilation from the annual workshop "Samling mjukvarusverige 2020" is a survey of the association's needs. The report takes a look back at previous definitions of digital competence, including the association's own, and presents an updated version of the latter. Based on this, the workshop develops a definition of digital excellence. Based on the definitions, a forward look is made towards 2025 where the desired current situation is described. Based on a description of the current situation, ways forward are then presented, as well as what needs to be implemented to reach the desired situation.

The report is shared in various networks, and supported by about forty different individuals from business and the public sector.

The definition of digital excellence that has been developed is:

- 1) *“Digital excellence consists of an in-depth ability to develop, configure, and manage digital tools and services, as well as the ability to follow digital development in order to identify, develop, and apply technologies and combinations of technologies in solutions that are appropriate.” [21]*

As a consequence of the current situation, and the vision that “[...] Sweden belongs to the international top in attracting talent, with the largest proportion of residents with digital (cutting-edge) skills, with broad inclusion and a workforce that further education throughout life,” four measures are then proposed:

- 1) Competence inventory - what does the situation look like and what is needed?
- 2) Popularise and stimulate interest in digital competence and cutting-edge competence
- 3) Carry out a competence assurance:
 - Invest in lifelong learning.
 - Promote interest in digitalisation among young people.
 - Facilitate skills immigration for strengthened competitiveness.
- 4) Consider unbureaucratic innovation support.

The European e-Competence Framework (e-CF) is summarised by the researchers with the following quotation:

- 1) *“The aim of this study has been to monitor the demand and supply of e-competence in Europe, and to target national policy initiatives and multi-stakeholder partnerships within the EU. We have analysed the development of supply and demand over the past ten years.”*

We have taken part in the study in the work of formulating the definition of digital excellence, and we have concluded that their analysis is done with a focus on the use of new information and communication technology (ICT) in various industries. ICT in the analysis of access is based on statistics on the production of graduate computer scientists per year in Sweden. ICT is thus equated with e-competence and computer science education with access to relevant competence. The report predicts an increasing lack of access to skills. In the forecast for the demand for cutting-edge expertise, the increase is expected to be much higher in the future.

Digital Formation is an independent company from public support that has created the Digital Competence Wheel [31]. The tool is a way of mapping an individual's competence through about forty questions and then presenting it as a spider diagram. The tool deals with different areas: information, communication, production, and security. Within these themes, the resolution is then increased through sub-areas.

Digital Education also makes its own definition of digital competence:

- 1) *“Digital competence is a combination of knowledge, skills and attitudes with regards to the use of technology to perform tasks, solve problems, communicate,*

manage information, collaborate, as well as to create and share content effectively, appropriately, securely, critically, creatively, independently, and ethically.”

The definition thus emphasises the ability to use technology to solve problems with several boundary conditions around the execution of the problem solution.

The Institute for Electrical and Electronics Engineers (IEEE)/Association for Computing Machinery (ACM) have jointly defined a number of curricula in several IT-related areas.³ A new project, “Computing Curriculum 2020,” is underway, with the aim of developing new proposals for how the various disciplines in computer science, information technology, or informatics can be classified and described at international curriculum level.⁴ The change of focus to competencies began in the work on the IT2017 curriculum report, and now also includes specific curricula for “Cyber Security” and “Big data, data analytics.” “Computing Curriculum 2020 (CC2020) is a joint project launched by professional computing societies to examine the current state of curricular guidelines for academic programs granting degrees in computing and to provide a vision for the future of computing. The goal of the initiative is to produce a comprehensive report and interactive website that compares and contrasts these guidelines to situate and contextualise them in the landscape of computing education. Ultimately, the project strives to help programs to prepare graduates both academically and professionally to meet the challenges of the 2020s. The international project team represents organisations from academia, industry, and government.”

The project focuses on formulating competence profiles as a description of what a newly graduated person is expected to have achieved and be able to demonstrate in different professional situations. The IEEE/ACM curriculum changes, in line with the new norm in the education sector, from describing educations as subject content and hours in the classroom to describing ILOs (Intended Learning Outcomes) and competencies (defined as a combination of knowledge, skills, and attitudes practiced in problem-solving context). It has also been stated in the project that competence profiles for the same education in different parts of the world vary, and that a tool is needed to visualise and compare the expected competencies of different educations.

The effects of digitalisation on the individual and society - four thematic reports (Digitalisation Commission, 2016) deals with the implications of digitalisation for Sweden's development. The thematic report “The role of higher education in a digital age” describes the way in which society needs to change in order to better meet the future needs of digital competence, on the one hand, and digital excellence, on the other. It also highlights the importance of understanding that digital excellence is undergoing rapid change, which means that the ability to absorb new knowledge and learn new things is crucial for the future. The theme

³www.acm.org/education/curricula-recommendations

⁴www.cc2020.net

report was written with the overall goal that Sweden should be a leader in the digital transformation of higher education and impart high-quality digital competence for lifelong learning in all areas. It has been written as a manifesto for the development of higher education in a digital age. Here, the role of universities is formulated as to promote the development of digital competence in all educations, regardless of subject area, as all professions in the future will need to relate to and use digital artifacts and be affected by the changing conditions and opportunities that digitalisation provides. Universities should to a greater extent make their educational offer relevant and adaptable for both professionals and people outside the labour market, regardless of age or life situation.

Universities should pay more attention to the needs and opportunities of the labour market. The business community needs to be actively involved in the development of educational programs. Universities should be more present in pre-school, compulsory school, and upper secondary school in order to arouse early interest in digitalisation linked to higher education. This can be done through school visits, open houses, open lectures, science festivals, and so on. Universities should be good role models in the use of technology in their activities and in their educations. It should be possible to take advantage of digitalisation and technological development by creating a smarter organisation, working for higher quality, attracting more students, reducing the need for administrative resources, and so on. Thus, digital competence also needs to increase at all levels internally in the organisation.

Universities should be proactive in their work with the use of new forms of digitised education, digital exams, Massive Open Online Courses (MOOCs), and design content, pedagogy, and structure based on the possibilities of technology. The business community, on the other hand, should be more involved in the management and leadership of educational programs through active participation in program councils, faculty organizations, and the like. The business community should be involved in meeting the need to better match the education that universities provide with the needs of the labour market. The business community should to a greater extent offer their participation in educational programs through guest lectures, internships, company visits, workplace-based learning (APL), student employees, and degree projects. The business community should develop their work to ensure staff's lifelong learning, for example in the form of more active and systematic work with ordering commissioned training.

The business community should take a more active part in both research and higher education through an increased degree of collaboration. The state should create incentives for universities to begin their digitalisation of education, as well as to digitize the support activities for education and research at universities. This can be done with advantage through increased grants to universities and colleges, earmarked for digitalisation, or if this is not possible through redistribution and reprioritisation within the universities through the

regulatory letters. The system for financing higher education and student support should to a lesser extent focus on academic performance in the form of completed elements as the important measure of production, and instead focus on allocating resources based on the universities' abilities to teach and validate knowledge.

Through the digitalisation of higher education, the need to show and attain knowledge achievements is assessed differently than with the current system. Online courses such as MOOCs, which are not time- or place-dependent, should also be covered by the student finance system. Research and postgraduate education in the digital field should be expanded to meet the needs of business and public administration, with a special focus on sustainable growth and the needs of the labour market. Funding should be used as a tool to prioritise the expansion of education in areas that are crucial for the development of business, the public sector, and working life. For example, the digital area is, in a broad sense, one of the areas where the greatest future recruitment and development needs are located, and is an area with the potential to create new innovations and growth in jobs.

The universities' management and governance models should be investigated and, if necessary, changed to create a modern structure that supports and enables change. Tax breaks, incentive programs, or subsidies should be considered to create conditions for the individual to be able to take greater responsibility for their own skills development. A changed attitude should be encouraged and developed in all individuals in society around their responsibility for their own continuous competence development, so that everyone takes greater responsibility for lifelong learning. Individuals should have greater opportunities for risk diversification in terms of financing skill development, analogous to, for example, the pension system. Some form of skills insurance that provides financial assistance to individuals developing skills for new tasks later in life could have a major effect on lifelong learning.

The Digitalisation Council is the Digitalisation Minister's own advisory body for assisting with advice and policy proposals within the framework of Sweden's digitalisation policy with the aim of Sweden becoming the best in the world at utilising the possibilities of digitalisation. In 2018, the Digitalisation Council published "A situation picture of digital competence" [4] as one of the government's central sub-goals. The goal digital competence contains 4 sub-areas:

- Ability and opportunity to contribute to and participate in the digital society.
- Modernisation of the education system.
- Matching of competence.
- Digital competence in public operations and in state-owned companies.

All areas except the first deal with aspects of digital excellence. The report identifies forecasts that show a large labour shortage and lack of gender equality as one of the reasons for the lack of digital excellence. It is also emphasised that

the labour market is still changing and the need for life-long learning is increasing, without education and student support systems being able to switch to enable digital skill development towards increased digital cutting-edge skills. Structural transformation in the public sector requires new ways of working, and artificial intelligence requires radically changed ways of working and structures. The Digitalisation Council recommends, among other things, developing a vision for Sweden's digital higher education institutions, including polytechnics, to measure the digital development of higher education institutions, to allocate special funds for development initiatives to promote digital competence in higher education, to increase the number of educational places for digital specialists, as well as targeted efforts to design a special development package to increase women's skills in ICT, to make a special investment in research and research-related education in sustainable AI, to design a pilot project for the digitalisation of the future, and a number of labour market-related measures.

The *Digital Skills and Jobs Coalition* aims to unite European Union forces to promote digital skills. Each member state organises itself in the form of national coalitions, where stakeholders promoting digital competence gather and act together in national coalitions. In the next EU budget, the European Commission has proposed to invest billion in the new Digital Europe program, of which million is earmarked for advanced skills development with a particular focus on High Performance Computing, artificial intelligence, and cyber security.

In addition, the Connecting Europe Facility programme plans to fund a platform at EU level that supports innovative measures to increase digital skills in Europe. This platform will be linked to the activities and websites of the national coalitions. The overall purpose of coalition work in Sweden [25] is to highlight the good examples of various Swedish actors to promote digital competence. The network arranges and coordinates joint activities to highlight the national need for different types of digital competence in the following four areas:

- Digital competence throughout the education chain - Digital Skills in Education.
- Digital employee skills - Digital Skills for the Labour Force.
- Digital excellence - Digital Skills for ICT Professionals.
- Digital citizenship - Digital Skills for All.

B. INTERVIEW RESULTS

The interviewees had many different thoughts about what digital excellence is. Many had heard the expression before the interview: *"It is a Swedish word that I have not heard much"*. But there were some who had not come across it before: *"I have never heard the word before, digital excellence"*. The three parts of the word digital excellence many people, to approach the concept of "digital excellence" or "cutting-edge digital competence" we found it useful in our interviews

to decompose the phrase into its constituent components and consider the terms, *"digital"*, *"cutting-edge"* and *"competence"* both separately and in combination. Interviewees responses indicate that there are several meanings of the word digital, where some think of digitalisation from a technological perspective, such as *"transistors or circuit boards"*, *"control systems in microwave ovens"* or *"zeros and ones"*, where it is about converting from analogue to digital representation. Others see it as *"IT-based solutions that must be connected to the Internet in some way"* and some describe it as the broader digital transformation, and the transition to an information society. The word tip also signals to many that it is people with very specialised competence it is about: *"tip competence... is someone who has very specialised and deep knowledge that is also at the forefront in a specific area"*. Several point out that the word tip does not give a good picture of their entire interpretation of the word digital excellence, but that it excludes the breadth of knowledge that they see as necessary to successfully work with digitalisation. These people believe that a tip is not enough to be digitally cutting-edge competent, and that the word is not good: *"You need to be pointed in one area, but keep an eye on the others so that you have the whole picture"*. Some also have in their interviews reflections regarding what the word competence means, and believe that it is used synonymously with the word knowledge.

1) DEEP TECHNICAL COMPETENCE

Several who were interviewed believe that digital cutting-edge competence consists of deep technical competence or know-how in, e.g., machine learning, databases, or IT security. Those who are digitally cutting-edge, according to some people, are those who are *"very specialised and have deep knowledge that is also at the forefront in a specific area"*, or *"people who are hardcore digital people"*.

Many also emphasise that there is a difference between what you can do, and what competence you have, depending on which area you are knowledgeable in: *"Having cutting-edge competence in computer technology is something completely different than having it in interaction design or something like that, they are completely different things"*. Many people link digital cutting-edge competence to being knowledgeable in programming: *"Then it's probably the case that I see it as people who, for example, are advanced coders, Artificial Intelligence or data scientists or the like, who are doing some form of IT. And then I think programming first and foremost, Python programming and the like"*. A few point out in their interviews that this view that digital excellence consists of only deep technical competence in a specialist area is what has been the traditional approach in computer science. It coincides with the common image of the lone male computer nerd ('genius') who is only interested in technology and not surrounding aspects such as people, sustainability, or ethics. The people believe that this approach is problematic as it excludes many, and that it also requires more than just technical competence to create functional, innovative systems

that lead society forward: *“If you with digital excellence believe that you must know machine learning or Big Data query, etc., then you exclude a lot of other people who can influence the systems or influence society”*.

2) DIFFERENT GROUPS WITH SKILLS BEYOND THE ORDINARY

Some of those interviewed believe that the digitally leading competence is the group that has competence beyond the ordinary within different groups. These groups could be software developers, those who work with digitalisation in organizations, leaders, or users. The interviewees have different suggestions for what the groups consist of in areas, and many include the group with deep technical knowledge as described in the previous paragraph. What digital excellence is in these different areas would depend on what the group's focus is. Being digitally cutting-edge as a software developer is not the same as being digitally cutting-edge as a leader in digital transformations, or as a user of technology in everyday life. *“A cutting-edge competence in that context can be so much more, it can be that you are the best at to deal with people, or best at solving problems, or something completely different”*. Many also point out that the people who are digitally cutting-edge competent in the various groups also need to know related areas in addition to the technical, such as a knowledge and understanding of business. As a leader, you need to know HR issues and sustainability issues, in addition to digitalisation and change work.

3) A COMBINATION OF DIFFERENT SKILLS, MULTI-SKILLS

A common way of looking at digital excellence among the interviewees is that it consists of a combination of several different competencies or areas. These people believe that it is the combination that is the unique, or the tip, and not the depth within the different areas, and that you can be a generalist in several areas, and yet be seen as digitally excellent if you have a digital component in your knowledge. It is not enough to just have some technical competence, these people say, but it should be combined with other competence as well: *“So there can be a multi-competence that becomes top competence as well”*, or *“a digital top competence can also be somewhere to understand a whole, to be able to connect things so that it can become a multi-competence that becomes specialised because you are quite unique in perhaps having that kind of understanding of several areas and how they are connected.”*

In particular, many people believe that, as a digital cutting-edge expert, they need to know areas that are traditionally not computer science. Examples of areas mentioned in the interviews are the humanities, philosophy, leadership, law, and economics, depending on the area to be digitised.

Most people, however, believe that depth, or a tip, is required in a technical profession: *“You can take area by area and then you can stack a lot of knowledge and skills on top of each other, but there is an important principle for me and that is that special competence is required.”* A few people in the interviews go so far as to say that quite superficial

technical competence is enough: *“You may not need to know much at all about technology really”*.

Some people link this approach to how digitalisation will take place in the future, and believe that it will require very different knowledge of how that work should go, depending on which industry and sector is to be digitised. It is not enough to only have the technical competence, but other knowledge is also required to be able to successfully, e.g., automate tasks: *“When we have studied how the labour markets may change, we see that we all have tasks that can be automated, or digitised. It can then be between 30 and 60 percent of your work tasks that can do it. And then it is clear that the cutting-edge skills you need to develop the tools for the rest of the sectors are, depending on which industry or sector you work in, where there will be different things required, needed, or which are interesting.”*

4) DIGITAL CUTTING-EDGE COMPETENCE AND IN-DEMAND COMPETENCE

Some emphasise that the definition of digital excellence depends on what competence is in-demand in society: *“In-depth understanding in a specific area, unique and in-demand competence”*. A definition of digital excellence linked to demand would mean that one cannot become digitally cutting-edge competence in areas that are in poor demand in the market.

5) TO BE FIRST, NEW AREAS AND DIGITAL EXCELLENCE

Many people also believe that digital excellence has connections with being first to know an area in computer science such as AI, or bitcoin. *“It is enough to quickly learn an area.”*

At the same time, there are several who believe that it is rarely people without previous digital excellence who learn new areas, but often knowledgeable people who learn the new. If the new digital area is close to what you already have competence in, you can quickly become digitally cutting-edge competent: *“In general, you can think that in many new areas it is difficult to have 10 or 20 years of experience. You can have other relevant experience”*.

Some believe that when an area is new, there is often a great focus on purely technical skills, and not on the broader skills. On the other hand, people with the broader skills are needed when it comes to making technology work in a business.

6) EDUCATION AND DIGITAL EXCELLENCE

The view of how digital excellence connects to education varied among the people we interviewed, and much depends on what view one has of digital excellence. Some, including representatives of universities and colleges, believe that you need a university or college education in IT or technology to be seen as digitally cutting-edge. This group of interviewees believe that there is a depth in the knowledge gained through post-secondary education that cannot be obtained in any other way, as here: *“No, it is not just experience. When I say education, I mean formal education, i.e., having gone to university. It is not possible to fix this knowledge in other ways, through*

field studies and such". Some point out that this knowledge from universities or colleges needs to be within, e.g., science, technology, or mathematics. Some point out, however, that one may need to look beyond those who have completed an academic education, given that many who have studied may have failed to complete their degree: *"that you need to go wider than just those who may have an actual degree in the field"*. Some say that some companies also like to hire students before they graduate, so that the company can train people with additional knowledge and skills: *"They do not want the students when they graduate, they say, because they want to be able to shape them, the last the part"*.

Many people believe that you can get the skills needed in many different ways without having an education in the field: *"you may only be able to use it, and be involved and work with it in different ways"* or *"there are actually self-taught people who can have digital excellence"*, or, *"So, you need to have learned things. If by education you mean formal education, university-based where you have received grades, then I'm not sure you need it, but you need to have learned things"*.

Some individuals believe that in the field of digital excellence, one needs to ask oneself what competence is needed in society and then find the best people in that field to teach globally. World-leading training in digital excellence requires global collaboration between industry and academia to find teachers with the unique knowledge and skills.

Some also point out that many people are educated in areas relevant to digital excellence later in life, and that one must not forget that group. These educations may be internal educations within companies or consist of other competence development, e.g., via colleges and universities: *"Because there are also quite a few people who have been educated later in life in this"*. This includes people who study technical competence at a basic level, and those who have a broad technical competence but study in a certain area such as IT security, a certain type of programming skills, or AI. Many of those interviewed believe that you need to be able to read and learn various digital cutting-edge skills later in life, and that it is definitely not a matter of training once and then finishing. Further education is central to the field of digital excellence. Some see digital excellence as volatile and not constant over time: *"This excellence is also a current knowledge that can change all the time. You cannot learn top skills once and then believe that you are set for the rest of your life if you do not continue to develop"*.

Many agree that a good education in the field of digital excellence requires breadth, and does not just contain technical parts. However, what is meant by breadth varies, and some mean breadth in sub-areas in computer science, while others mean breadth in relation to completely different subject areas. Examples of such areas mentioned in the interviews are behavioural science, psychology, economics, and political science: *"So today, unlike when I started 30 years ago, you need a little of each. You need to know a little about behavioural science, psychology. You can benefit from*

technology and you need to know a little about business management and risk management. It's a smorgasbord!"

7) WIDTH COMPETENCE AND TOP COMPETENCE

Most of those interviewed believe that you can be both broad and narrow in your area of expertise and are seen as digitally cutting-edge competent:

"It is a very complex network in digital cutting-edge expertise, so you should not only be good with a special area of technology. You should also not be good at a specific process or automation, but if you have a digital cutting-edge competence, you will understand the big context, but can also immerse yourself in various specific areas or technologies. So to really have digital cutting-edge competence today requires these somewhat unique people who have both the will and the ability to be very much at the same time: both breadth and depth".

Many believe that those people who have highly specialised expertise in a narrow (pointed) technical field are digitally state-of-the-art. However, the vast majority also believe that breadth is required to be seen as digitally cutting-edge competent. Many agree that you need a broad base with classic areas such as technology, mathematics, and science and also knowledge of wholes and how things are connected: *"But when you talk about digitalisation and something that is digital, it is about that it is connected. Combining several things connects several things in different ways. And if you do not have the breadth so that you can understand the whole, then you cannot call it digital excellence."*

Defections of width differ. Some mean a breadth in the technical areas and some related skills, while others think of breadth as ability in completely different areas such as economics or behavioural science.

8) DIGITAL COMPETENCE AND ETHICAL COMPETENCE

Many people see ethical competence as part of digital excellence, and one person states this: *"So ethical competence is a super important issue, and it is clear that if you have excellence, you also need to think about how you ethically use it"*, and *"ethical competence is fundamental"*.

Some people interviewed see ethical competence as different things, and say that *"You can be unethical and have excellence"* and *"Absolutely! You can make landmines that are incredibly effective at blowing up children"*.

Several point out that ethics can limit the power of technological innovation and development, and that *"It can be like a wet blanket over development that too much ethical consideration is given to everyone"*.

Some believe that the ethical responsibility in an organisation may lie with people other than themselves, who are digitally cutting-edge competent in a team, or that the responsibility may lie with the management of the organisation. It is about having a team or organisation that works well together, and that each individual does not need to have ethical competence.

9) GENDER, DIVERSITY AND DIGITAL EXCELLENCE

Almost all interviewees believe that diversity is generally a problem in the field of digital excellence: *“It is a huge problem!”*, and that there are few women, and *“that you feel alone”* as a woman. Some individuals believe that gender ratios, as well as the gender perspective in innovation and development, are interesting, but not included in what they are involved in, or what they think is included in the area of digital excellence.

Several point out that the issue of diversity needs to be formulated based on the area of digital excellence’s problems to attract different people: *“How come we do not succeed in attracting more women to our area, what do we need to do better?”*.

One reason why we need great variety of people among those who are digitally cutting-edge is that the users of the systems and products are a very diverse group: *“If you think about the products you develop, they must be equally useful for women and men. So it is clear that in many industries and other types of industries, e.g., the automotive industry that I was in before. The auto industry was very male-dominated, but even there there was a very strong movement towards everyone understanding the gender perspective, partly because occupational categories are not gendered as they were before, partly because the market and buyers are not gender segmented as they were before, and partly because in order to have sufficient competence in your company to be able to meet other users and other markets, you must have a sufficiently diversified workforce”*.

Some have thought a lot about the area’s definition and believe that it is important to have a definition that is flexible and that covers many different types of skills, and that it must not be too narrow. It needs to be a definition that attracts different types of people, some say: *“Is the top competence this that you have breadth in your competence, and can combine business parts with more technical parts of? I think it is a definition that may appeal to more women”*.

Digital excellence must be independent of gender, ethnicity, etc. many claim, and the definition must be written with care. Some people think that given the different grounds for discrimination, you need to think through the definition and the words that are used so that they do not exclude people by saying *“read”*, but use *“assimilate”* e.g.

One person points out that you can use the same knowledge that you have when recruiting when defining digital excellence and reasoning like this: *“How do you write ads for people to apply for jobs? Then you see that if you write in one way, only men apply and if you write in another way, perhaps a more varied group is looking for the job”*. Another important issue, some say, is to help people who do not traditionally see themselves as digitally state-of-the-art to understand their own competence, especially in relation to digital state-of-the-art competence. Here, some point out that men generally overestimate their ability, and perhaps especially in technical areas: *“Even if we try to write the ad differently and try to reach as many women as men for certain positions, it may still*

be the case that men to a greater extent say”I can interview for that job“, no matter their qualifications”. If the definition is too narrow, many will find it difficult to feel that they meet the criteria: *“Being able to help a person understand how their skills and competencies can be used in new contexts”*.

C. EXPERT WORKSHOP FINDINGS

Question 1: What is the meaning of the concepts that constitute competence, knowledge, skills, experience, and education for the concept of digital excellence?

The use of a definition has been discussed. For a specific development assignment, one could weight the four variables and show the needs of them in relation to it, one spider diagram per assignment. It was emphasised that a definition is important in order to be able to make forecasts and statistics to show what competence is needed. In order to be able to operationalise the definition, we should start from already existing knowledge.

Here it was discussed whether there is any difference between knowledge, skills, experience, and education, and whether the educations of today deliver all parts of the competence. It was stated that education provides knowledge, but that competence is applied knowledge that creates skills. Experiences are skills that are almost intuitive. In this way, it can be said that these four quantities relate to each other. Education with focus on producing a narrow type of cutting-edge skillset may run the risk of failing to impart the types of transformational competence that a fast moving high-tech sector requires. It is crucial to retain a level of adaptability and breadth, in order to be capable of analysing, and subsequently, implementing processes and systems that reorganise the production flows of a business or industry sector. It was emphasised that contextual understanding is important. Emphasis is placed on the ability to quickly become acquainted with and understand contexts and opportunities in order to have an effect on the whole. It was discussed whether digital excellence is only about the digital professions. Cutting-edge competencies are characterised by agility and adaptability combined with a personal drive and ambition to remain in the forefront of a technological and digital transformation agenda. We touched on the IEEE’s definition, which speaks of knowledge, skills, and dispositions (attitude, adopted as personality). Using competence requires an attitude. It is also probably important that the model does not become too complex, otherwise it will not be possible to communicate to decision-makers, clients, or to a wider audience.

It was discussed what an education for general digital competence would look like not only for actual “IT” experts, but for use by a wider group, e.g., nurses. The importance of understanding the problems of others and that the system should naturally support our work and wishes was discussed. Interviewees also discussed how to include the holistic perspective, and not just excellence in education. They also touched on the polytechnic, because top educations are also there. It is important that there are complements between

different types of education. Lifelong learning is crucial for digital excellence.

It was concluded that it is difficult and challenging to define digital excellence. That digital excellence can be found in different professional areas.

Question 2: In what way do attitudes, ethics, gender, mobility, and what are called 21st-century skills affect the concept of digital excellence?

The need for interdisciplinary competence and composition of working groups over time is important (not just to supplement with competence at the end of the project). Since digitalisation is a process of change that involves developing digital artifacts and working methods, cross-competencies in the work chain are needed as success factors for success with implementation and innovation. The need to supplement with other competencies was emphasised, e.g., security, information management and accuracy, data quality, usability, digital dexterity, learning ability, etc. You can define what you consider to be “critical success factors” to be able to identify new skills.

Many are passionate about this area and consider it very important. Now more than ever, when AI, facial recognition, etc. are widely used, everyone who is involved in building must be aware of the ethical concerns, in order to avoid mistakes. Ethics must be included immediately. (‘Privacy by design’, developing technology with personal integrity as part of that technology). However, it is provocative to call it attitudes (gender, ethics, etc.); it is also knowledge and competence. Ethical competence creates a lot of discussion, as seen here:

- 1) A: *-What does it mean to be ethical? A well developed ethical compass or well developed prudential judgement provide an individual with a framework and ways of reasoning about what can, might, and should be done in different situations. It is this weighing of alternatives that is vital from the perspective of education, where societal perspectives, views of social justice, and wise and responsible development of technology, are considered to be central to a sustainable future.*
- 2) B: *-Ethics is conceptually, culturally, and contextually dependent. So it's pretty close to the cultural norms where we mean we know what's right and bad. Thus, something that is ethically “good” in one place can be ethically “bad” in another.*
- 3) A: *-Law is also culturally and contextually dependent. Also the view of who owns the data. Or the view of what is “common” in a society. Or what is “good AI” or the view of joint ownership. Much of the technical development will require responsibility for the development.*

One of the groups highlighted other areas of expertise that it believes could be important for digital excellence:

- Curiosity - To be creative in wanting to explore new solutions.
- Realisability - The desire to realise an effect.

- Inclusivity - The desire to find solutions that include all intended and potential affected users.
- Gender awareness - Gender aspects important for technology development. Develop technology adapted to the needs of both men and women. Ethics by design is crucial for the development of relevant solutions.
- Diversity - Intelligence in a group can not only be measured on the basis of the total intelligence, but also on the basis of synergies such as diversity. Diversity means that you can solve tasks better. However, diversification is important in itself, both as a goal and means.
- Social relevance - Education needs to show societal relevance to attract more women.
- Ethics and philosophy - Can refer to the degree objectives: ethical and socially beneficial consequences/effects/aspects must be taken into account.
- Phronesis - Includes good judgment or prudence as well as understanding or competence.

The discussion and reasoning concerned with attitude is of fundamental importance for digital excellence. Attitude applies to a complete overall approach/interface, so that you see all the parts and components involved. Valuation issues become increasingly important the more complex and broad solutions we implement, to strive for technical experts to have a broader perspective / context. In summary, attitudes play a very large role in the digitalisation of society. Technology entails major changes, such as the distribution of responsibilities, competencies, etc. It is important to be able to absorb new competencies.

The university is not equipped for lifelong learning, which requires major changes. It is difficult for higher education institutions to find forms of funding for professional development and to find teacher resources. Society has an educational system, but much responsibility lies with the individual. In order for the individual to be able to take responsibility for lifelong learning, there must be an opportunity for such learning with relevant education providers. It is important to have a discussion about who is responsible for learning, society or the individual.

It is very important to think about which skills you put at the centre and which you place at the periphery. It was pointed out that the definition of digital excellence is to help Sweden formulate what we need, that one should be careful in the balance between “competencies” and “attitudes.” It is important to have a discussion about responsibility. For example, how algorithms are designed affects outcomes; things can go really wrong in ways you did not think about when designing. Within IASA, there has been a discussion about whistling, but does that mean it should be included in the definition? It is a very complicated discussion. A code of conduct is a possible way to go.

Question 3: Measurability - what can be measured and how?

Much of the expert workshop's discussion was about understanding why one should measure at all. Should one measure whether one has assimilated a specific education,

or is it at all possible to measure whether one has really learned something, and been able to practice and show that one's competence has had effect? Is it the effect of the digital excellence that is important? Should it be included? Or is it important to be able to demonstrate that Sweden has gained more individuals with digital excellence? The question of why to measure was also asked. One problem is that one often starts from how one "measures" in other industries and sectors, which are much more stable and nationally based, where one can agree on professional groups (e.g., what is an electrician, plumber, etc.). This approach simply does not work when talking about digital excellence. If you are going to measure educations, you have to go down to the syllabus level, because it looks so different for each education program and competence profile area.

It is difficult to measure whether Sweden provides the skills needed, and to show what cutting-edge expertise is at different stages of digitalisation. Each step in the journey from need to service/service provided requires different skills that should be measured in different ways. If you do not have all the competencies, you also do not see which educations are needed within the academy, the polytechnic school, or from institutes/organisations that provide digital (cutting-edge) competence. Implicitly, it is about measuring a lack of access to skills.

Education of cutting-edge competence is difficult to measure, but the conditions for being able to develop cutting-edge competence can be measured on the basis of the knowledge dimensions of our definition, as well as ethics and partial gender awareness, responsibility, and future competence. LADOK data linked to courses that deal with relevant learning objectives can already be used today to identify individuals with a suitable background experience. Statistics from LADOK only apply to results obtained through higher education, and to a certain extent to validation of previous experience and education where training elements may have been carried out outside Sweden. It will then be important that a system is established around the validation of skills in labour immigration. It is also important to monitor developments in the education system where curricula, curricula for educational programs, relevant learning objectives, and technical skills in digital excellence will change over time.

What we have identified in the anchoring work around the definition is a need to measure in a more systematic way the dimensions of work experience and mobility, in that systematic validation and certification of cutting-edge competence is not carried out in the digitalisation area in Sweden today. There is a need to define methods for both validation of digital prior learning and work experience and mobility linked to certification of digital excellence. The latter could be assessed through an analysis of CV-like documentation of management experience in the field as well as systematic reference taking (i.e., enable assessment of skills linked to the mobility dimension in the definition). In order for this to be feasible with credibility, it needs to be done by an independent

body consisting of people who have the expertise to be able to assess digital excellence.

One should avoid inventing benchmarks without relying on international standards. Much has been done to build digital competence in connection with the development of the European Computer Driving License. However, this does not contain anything that links to, for example, ethical competence. The EU Science Hub offers, for example, a method for assessing digital competence. However, this does not measure the level of excellence. The measurement method itself needs to be agile.

Should one measure at the individual level or at the organizational level? When it comes to developing cutting-edge skills, it's about unique, individual skills. It becomes very difficult to measure, especially because it changes all the time. What is important for future measurements we may not even know today. It will therefore also be a challenge to assess whether courses *de facto* lead to results. Some highlighted the possibility of measuring an organisation's digital maturity, rather than focusing on the individual's competence level.

Swedsoft's surveys show that it is difficult to measure other than YH-related educations. The polytechnic has dialogues with employers. A special focus has been on providing professionals with short advanced training in digitalisation. However, companies find it difficult to assess the content of such courses. You want "the latest," but do not know what that means. Companies often have poor control over the type of skills they demand. The question is whether one should have general education and let individuals niche themselves.

A general consensus from the expert workshop was that it is important to be aware that what you can measure is not always relevant. If we are to develop new measurement methods, it is important to base these on what already exists and is measured, and if additional data is needed, it is most likely qualitative. There are self-assessment methods but these are cumbersome and rarely lead to comparable results. Question 4: How should we define digital excellence based on the proposed definition? Breaking up the draft definition into different parts becomes very interesting. How much of each part must you have? It is challenging with "excellence" when you think about when the excellence is needed. There is a difference between individual competence and group competence. Individuals can be very niche competent in their skills, but within a group, individuals can complement each other and form a good group. It is unrealistic to demand that these criteria be met by individuals. For example, there is a risk that people with niche technical skills will not be counted as "digital cutting-edge skills" if all criteria are to be met.

Knowledge: Broad knowledge, where it is probably relevant to include consequences and effects. In-depth knowledge may not list different technologies, but what area/effect, which discussion linked to skills. One group questioned what "computer science thinking" might be. Isn't it too "deep" a concept that looks more backwards than forward? It is also important to be able to collaborate across

different disciplines, e.g., technicians with lawyers. Mobility and adaptability are important, i.e., continuous learning.

Skills: Digital excellence requires the ability to “create” digital products, to create code, for example. Where is the connection to business benefit, or benefit for society/individual? It is very important to highlight the “benefits.”

Outline: Attitudes and attitudes. In international literature, attitudes are clearly indicated to take responsibility for the effects and consequences that are created. One of the groups raised a discussion about whether digital excellence includes the ability to lead a state-of-the-art team? The group agreed that excellence can also mean to lead, innovate, manage, or possess specialist competence in the legal field.

Consequences: It is obvious that Sweden needs to have the ability to retain real cutting-edge expertise in order to realise digitalisation and AI use in Sweden. It can be useful for the work in the future to focus on how Sweden retains well-educated workers.

Some members of the expert workshop recommended considering the dimension of competence that the five levels in the e-Competence Framework illustrate, i.e., five levels of competence’s impact, ranging from ability to use learned digital functionality to ability to change and further develop a technology, or scope.

D. CHALLENGES TO OPERATIONALISE THE DEFINITION STATISTICALLY

During work on the assignment, several aspects of the statistical situation were identified, the possibility of using statistics to capture relevant data points was investigated, and we have analysed how forecasting tools can look and be used. On the one hand, digital excellence cannot be easily placed in a professional group, and on the other hand, the SSYK standard⁵ captures the mapping of individuals towards specific professions, rather than identifying those who have digital excellence. The concept of profession therefore appears obsolete, in relation to capturing individuals with digital excellence and for creating forecasts.

The experiences and knowledge of different individuals are important for whether they can be classified as digitally state-of-the-art. The definition also includes a relationship between experiences. The different dimensions can also be combined in different ways to reach the level of digital excellence.

What is interpreted as digital excellence is judged to be different in different contexts. Although it is possible to make the thought experiment to gather relevant individuals and rank them, such a standardisation of the concept would override the goal of the definition. Those who constitute digital excellence in a sector far from the absolute development front could fall outside the definition, despite the fact that they are important agents of change for the sector’s development towards digitalisation and digital transformation.

⁵ www.scb.se/dokumentation/klassifikationer-och-standarder/standard-for-svensk-yrkesklassificering-ssyk/

Digitalisation efforts continue apace, and the rate of technological development is accelerating. Many of the skills and abilities identified as central in development of digital solutions a decade ago have been supplanted, or are of much diminished relevance today. Defining digital excellence in terms of ability to absorb new technological knowledge and skills is also problematic, as this does not necessarily equip the holder with the ability to put them into practice in meaningful ways. For instance a person might be extremely highly educated in the STEM area, but does not yet qualify as cutting-edge to so a lack of domain specific experience in the relevant application domain. While the potential of this person is undeniable, to realise this potential requires additional industry and life experience. This type of potential needs to be evaluated systematically at a national level in order to be able to make forecasts related to availability of cutting-edge competence in the future.

The situations where digital cutting-edge competence must respond to the need for competence are complex. It is not obvious that an individual has the opportunity to fulfil an organization’s skills supply needs alone. An individual with special technical competence in, for example, machine learning, who does something in common with an individual with competence in the financial sector, and develops a fintech solution, may contribute to the effect goal that a definition of digital excellence intends to capture, but not necessarily captured by each individual. There is a risk that people with niche technical competence will not be counted as digital cutting-edge competence if all criteria are to be met.

The proposed definition contains characteristics that define attitudes rather than real competence. An example is outlines. In summary, attitudes play a very large role in the digitalisation of society. Technology entails major changes, for example the distribution of responsibilities, competencies, etc. It then becomes important to be able to absorb new competencies. How these attitudes are captured in an operationalisation is not obvious.

Finally, measuring education can be problematised. The traceable education that an individual has undergone can, together with information about the results of the studies, form the basis for an assessment of certain parts of the proposed definition. Especially if the assessment is made in close connection with completed education. At longer distances to the education, the content of the education needs to be examined more closely to make the same assessment. The time aspect can also have an impact on which competence is still relevant and up to date. Here, variables with service history can also be decisive for the assessment.

The increased use of online courses in the STEM area is also difficult to capture with available statistics. Especially as the proportion of students who read the course without participating in the examination and completing the course, but who may well have acquired the knowledge, can be large.

1) THE CHOICE BETWEEN DESCRIBING WITH PRECISION OR CAPTURING STATISTICALLY

In other words, the challenges associated with capturing the different factors of the definition with different data sources are significant. Existing statistical data can to some extent be used as a basis for assessing the current situation regarding digital excellence. However, it is difficult to see how the whole of the definition can be captured through existing data. There are several ways to get around the problem of inadequate data sources and parts of definition that are not easily captured. Two can be considered the main candidates.

A first alternative is to increase the collected data through several direct and indirect variables. A significant effort needs to be made to identify and collect this new data and resources therefore need to be allocated. At the same time, a finer-mesh network of data will emerge. A second option is to create a narrower, possible, statistically useful definition that is a subset of the complete definition. Existing data sources, with some addition or some new combination of variables, can then be used. It will be possible to make forecasts and spread the method for this to several actors. However, there are several disadvantages to this. The statistical definition does not include key elements of the complexity of the concept. The description of the complexity and the consideration that needs to be taken into account also risks not following the spread of the statistical operationalisation. And even if it does, it is likely that forecasters will not be able to easily take it into account. Finally, we have a definition that is used to calculate current situations and forecasts as well as make efforts and investments, but which does not reflect the full breadth of the definition of digital excellence.

None of these paths appear to be attractive as a solution to the question of how we can create a good basis for decision-making in relation to digital excellence. A third way is possible, however, which we sketch in the results section.

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