Towards digital economy through data literate workforce

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ABSTRACT
In today's digital economy, data are part of everyone's work. Not only decision-makers but also average workers are invited to conduct data-based experiments, interpret data, and create innovative data-based products and services. In this endeavor, the entire workforce needs additional skills to thrive in this world. This type of competence is united by the name data literacy, and as such, it becomes one of the most valuable skills in the labor market. This paper aims to highlight the needs and shortcomings in terms of competencies for working with data as a critical factor in the business of modern companies striving for digital transformation. Through systematic desk research spanning over 15 European countries, this paper sheds light on how data literacy is addressed in European Higher Education and professional training. In addition, our analysis uses results from an online survey conducted in 20 countries in Europe and North Africa. The results show that the most valuable data literacy competence of an employee is the ability to evaluate or reflect data and the skills related to reading or creating data classification.

CCS CONCEPTS
• Applied computing → Education

KEYWORDS
Data Literacy, digital transformation, higher education, digital competencies, data skills

1 INTRODUCTION
Digital competence and digital literacy are concepts that are increasingly used in public discourse [1]. The rapid progress of new information and communication technologies has created new conditions for the knowledge society. Since the 1990s, many countries have gradually entered the age of knowledge from industrial times and through the information age. The acquisition, production, processing, and use of knowledge play an increasingly important role in stimulating the country's economic growth and has gradually become essential. The knowledge society has also contributed to changes in human epistemology and structure. When it comes to the knowledge society, digital competence is one of the most important factors that distinguish it from the information society. The knowledge society transforms information into resources that enable an organization to take effective action, while the information society creates and disseminates raw data [2]. Today, people are surrounded by the internet and various digital technologies that require data literacy competencies. The development of the social structure and the trends in the use of technology have already changed the way we live and the way we acquire knowledge. Due to the outbreak of the Covid-19 pandemic, regular traditional teaching activities have been suspended. Many institutions and organizations are changing their teaching methods and striving to provide a convenient, safe and flexible educational environment for their students [3]. Universities are starting point for the labor force to acquire data literacy. The development of students’ data literacy levels and their digital competence is crucial for improving the effectiveness and efficiency of the learning process, as well as for adapting students to the dynamically changing labor market, which increasingly requires digital competencies [4]. This paper aims to highlight the needs and shortcomings in terms of competencies for working with data as a critical factor in the business of modern companies striving for digital transformation.
Drawing on the competence-based view of industry evolution [5], this article theorizes and provides evidence on how data literacy is addressed in European Higher Education and professional training. In addition, our analysis uses results from an online survey conducted in 20 countries in Europe and North Africa. Our findings show that an employee’s most valuable data literacy competence is the ability to evaluate or reflect data and the skills related to reading or creating data classification.

2 LITERATURE REVIEW

Data literacy includes skills in reading and interpreting data, critical thinking, and understanding the implications of datafication through mediatisation [6]. It is a cornerstone of digital media literacy, a tool of empowerment, and shapes social practices. It is an important factor for retaining agency and enabling inclusion as well as resistance in the digital society [7]. New data literacy behaviors such as correlation estimation, anomaly detection, and high-frequency data processing are evolving as people adapt to the different types of data flows enabled by digital transformation and its elements [8], [9]. Access, use, and management of data are increasingly recognized as an essential learning outcome in higher education. Data literacy approaches are usually based on information literacy. New approaches to information literacy have emerged that address the way information is used in different disciplinary contexts in which people learn and work. Successful data literacy approaches will also need to address contextual issues. Informed learning is an approach to information literacy that deliberately addresses contextual problems by proposing pedagogical strategies to enable students to use information in ways that support discipline-oriented learning outcomes [10].

Leahy [11] argued that technology can be used to transform business processes, to "do things better," or it can be used for innovation - "doing new things." Digital transformation can help an organization gain a competitive advantage, simplify business processes, enable cooperation and motivate employees. It is generally believed that investing in information and communication technologies brings valuable returns, but this is not only a case of investing in technology but there must also be an understanding of innovation and the benefits of using new approaches to business [11]. Reynolds [12] found that "information and communication technologies as the main driver of economic growth" lead to the development of new products and services and the improvement of productivity in existing tasks and processes. However, the study notes that there are concerns at all levels of government about the lack of qualified people with the necessary level of competence to work with data. Thus, data literacy competencies are strategic in nature and are skills needed to take advantage of business opportunities [12].

Working on data literacy competencies must be linked to business and industry culture changes to create an environment where opportunities are considered. Thus, the staff is encouraged to suggest improvements, and organizations are ready to innovate [13]. A study conducted by Wang, Wu, and Huang [14] found that decision-makers with digital competencies must think critically about data to make informed decisions. More specifically, competencies for working with data as part of digital competencies are becoming an increasingly important skill whose research should be given additional attention. In addition, the subject of the study should be the observed mismatch in supply and demand for these competencies.

Occupations that require conditions related to data literacy, i.e., data competencies, are shown in Table 1. This information was provided by the online tool for analyzing job vacancies for Europe (OVATE), which is mapped to European Skills/competencies, qualifications, and occupations (ESCOs) [15].

<table>
<thead>
<tr>
<th>Data literacy-related skill</th>
<th>Occupation (4 digits ESCO)</th>
<th>% Online advertisements for careers containing the selected skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perform data analysis</td>
<td>Financial analysts</td>
<td>50.5</td>
</tr>
<tr>
<td></td>
<td>Life science technicians</td>
<td>43.7</td>
</tr>
<tr>
<td></td>
<td>Database and network</td>
<td>39.9</td>
</tr>
<tr>
<td></td>
<td>professionals</td>
<td></td>
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<tr>
<td></td>
<td>Mathematicians,</td>
<td></td>
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<tr>
<td></td>
<td>actuaries, and</td>
<td></td>
</tr>
<tr>
<td></td>
<td>statisticians</td>
<td></td>
</tr>
<tr>
<td>Manage data,</td>
<td>Pawnbrokers and</td>
<td>82.2</td>
</tr>
<tr>
<td>information and</td>
<td>money-lenders</td>
<td></td>
</tr>
<tr>
<td>digital content</td>
<td>Credit and loans</td>
<td>63.9</td>
</tr>
<tr>
<td></td>
<td>officers</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Advertising and</td>
<td>53.7</td>
</tr>
<tr>
<td></td>
<td>marketing professionals</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Management and</td>
<td>50.2</td>
</tr>
<tr>
<td></td>
<td>organization analysts</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Announcers on radio</td>
<td></td>
</tr>
<tr>
<td></td>
<td>television and other</td>
<td>48.8</td>
</tr>
<tr>
<td></td>
<td>media</td>
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</tr>
</tbody>
</table>
3 METHODOLOGY
The results presented in the article are obtained through two studies that show how essential data skills really are. The research was conducted within the DEDALUS1 and DATALIT2 projects.

The first study used desk research. The data literacy domain was investigated in fourteen countries: the Netherlands, Ireland, the United Kingdom, Spain, France, Germany, Portugal, Austria, Italy, Croatia, Serbia, Latvia, and Romania. Each country was investigated by a local expert. Each expert searched according to their abilities and according to their habits, although there was a common order of research. The desk research was conducted through the following three steps:

1. Search for an educational institution to find modules of competencies for working with data or modules that cover these competencies. Search at all levels (graduate, master's, doctoral studies). To achieve homogeneity, the search terms were as follows: Data Literacy, Information Literacy, Data Literacy in Higher Education, Data Skills, Data Competences, Data Framework, Data Awareness, Data Literacy Competencies, Data in within critical thinking, data journalism / communication / storytelling, data interpretation.
2. Inclusion of competencies frameworks and related documents (roadmaps, strategic documents) at all levels: institutional, regional, national, etc.
3. Emphasis on learning objectives and competencies developed in the curriculum of the module.

The second study used a questionnaire on data literacy designed by the DATALIT project. Data were collected through an online survey. The final sample compromises 704 responses from 20 European and North African countries. The focus was on employees who have a good understanding of data skills. Approximately 59% of the respondents were men. The distribution by year was as follows: below 30 (41.2%), between 31 and 40 (32.9%), between 41 and 50 (15.9%), between 51 and 60 (7.3%) and over 61 (2.7%). About 55.4% of respondents work in private companies, 20.2% work in higher education institutions (HEIs), and the remaining 24.3% work in other fields. Figure 1 depicts the sample.

As for the level of data literacy competencies, 26.7% of respondents said they have high knowledge of data literacy competencies, 54.2% intermediate, 12.2% low level. In comparison, 6.9% admitted that they do not have any knowledge of data literacy.

4 RESULTS

4.1 Desk research on data literacy
Despite the homogeneity of the methods used, the results of this study were very different. Definitions of data literacy competencies vary from country to country, and linguistic diversity in Europe carries in some cases the absence of direct translation. This was the case with Spain, Serbia, and Lithuania. There were also significant differences in the maturity of public initiatives across the country-specific to data competencies. For example, in Ireland and the UK, a national data skills management group produces documents advising how data literacy can be addressed in all disciplines at British universities. Ireland also has documents at the national level that deal with aspects of competencies for working with data in the Irish higher education system, again in various disciplines that are not necessarily related to mathematics and computer science.

In other countries, such as Serbia and Lithuania, no such documents have been found focusing on data processing skills at the national level, using the same search terms. Instead, in these countries, data literacy competencies are embedded in digital skills and competencies, often translated and adapted from wider European Commission documents. In fact, the DigiComp3 document was the most common search result in all the countries observed. Its framework is widely used throughout Europe to determine digital skills and competencies and has been found to be very influential in shaping curricula for schools, universities, and professional development programs in the observed countries. Area 1 of this document places special emphasis on competencies for working with data in three main areas:

1. View, search, and filter data, information, and digital content

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1 https://dedalus.pa.itd.cnr.it/en/
2 https://datalit.pa.itd.cnr.it/en/
3 https://joint-research-centre.ec.europa.eu/digcomp_en
With regard to the observed university curricula, a great diversity was also found in the approach to competencies for working with data. However, a common trend has been observed: different faculties of different academic disciplines have included computer science topics in their modules, addressing aspects of data skills, as can be seen in Figure 2.

For example, business schools at most of the observed universities included modules with topics such as Big Data, data structures, cloud computing, data analysis and visualization, and so on. The faculties of applied sciences also offered modules with a large number of topics related to computing.

### 4.2 Online survey on data literacy

Given the learning objectives and competencies of the observed programs, these programs aimed to develop a wide range of competencies. After reviewing all these competencies, the consortium made a list of five groups of competencies:

- **Data protection and security**: Protect devices, content, personal data, and privacy in the digital environment following existing laws, ethical standards, and best practices.
- **Data selection and critical assessment**: Identify and select relevant data for identified needs to extract value from them.
- **Data processing**: To identify and select the most efficient data processing methods using the most modern tools and data formats.
- **Data analysis**: Use both quantitative and qualitative methods to extract insights from data in different formats from different sources.
- **Data Visualization**: Apply best data visualization practices in specific contexts (business, science, academia) using appropriate tools and methods.

According to the ranking of respondents, competencies related to soft skills that respondents consider to be the most important for a person with competencies for working with data are described in Figure 3. Evaluation of data or their evaluation was found as the most important soft competence related to competencies for working with data, followed by critical thinking, problem-solving, communication, and learning. In other words, from an industry perspective, an employee’s most valuable soft skill is the ability to evaluate or reflect on data. For example, a person with data skills can evaluate and use data according to specific goals and needs of management [16].

Also, the key competence of data literacy is critical thinking. Critical thinking allows employees to critically select, evaluate, and analyze data. Previous studies have also found that decision-makers with data competencies must be able to think critically about data in order to make informed decisions [14].
governments host open government platforms for the data they generate [17].

Figure 4. Ranking of the importance of functional competencies related to data literacy

In terms of functional competencies, respondents believe that reading / creating a classification of data or rules (56.2%) is the most important competence, while reading / creating weather trends and forecasts (38.9%) is the least important. From a business perspective, their employees must have skills related to reading or creating a data classification. It is of particular importance when it comes to risk management, compliance, and data security. The second most important functional skill is the ability to search and retrieve data that has already been published. Many sources often publish datasets for public use. For example, many governments host open government platforms for the data they generate [16].

5 DISCUSSION
The first study provides an overview of the ways in which competencies for working with data are processed in European higher education and professional development. Through desk research of more than 15 European countries, formal curricula and educational documents were examined to identify the strengths and challenges of increasing the need for data skills and to identify needs and opportunities for training programs specific to these skills that promote culture within the ecosystem of European industry.

Unlike the first study, the second includes soft skills. Bridging the gap between academia and industry in terms of key competencies for working with data is becoming critical as it is considered to be the most important issue of the 21st century. This study showed that the most valuable competence for working with employee data is the ability to evaluate or consider data, as well as skills related to reading or creating a classification of data. These results will support universities and industry to offer innovative, competency-based, cross-data courses for all students interested in developing or fine-tuning their competencies in relation to the data needed for a successful digital labor market transformation process [9].

Good proposals for improving competencies for working with data are offered by the DATALIT project itself, within whose consortium one of the previously described research was conducted. The goal of the DATALIT project is to provide opportunities for university students from different faculties to reach the appropriate level of knowledge about data that they can use and apply in an appropriate and diverse way during their personal and professional life, and perhaps to use it as a healthy basis for further and specialized training on competencies in data handling as well as data science. In addition, the goal is to narrow the gap between business and academia and to put European companies in direct contact with potential future employees or business partners who are properly trained to effectively understand and use data. To achieve these goals, the project seeks to lay the groundwork for integrating data skills as cross-cutting themes into potentially all university courses, identifying and developing a common curriculum, and innovative approaches to teaching and learning.

Higher education needs to keep pace with the rapid pace of the digital revolution, which is significantly changing the labor market and shaping the skills of successful future workers in all fields [18]. Introducing education for data skills is not an easy task for universities, primarily due to the lack of a common understanding of what data education means in all disciplines and what elements are necessary for the basic higher education curriculum [19]. This is clear by looking at the Data Literacy courses that some European higher education institutions already offer. They include very different topics and lead to different levels of competence. Creating a shared understanding of data education is something that universities alone cannot achieve [20]. They need to work closely with businesses and understand the needs of this essential partner.

6 CONCLUSION
Within the paper, two studies are presented that clearly speak about the importance of data literacy competencies and indicate their insufficient level of development. The needs of different jobs for these competencies are given, which are becoming more and more obligatory and unavoidable, instead of desirable by the candidates. The need for skilled employees in data management stems from the fact that the digital economy and digital transformation, and the mass transition to a digital business, require companies to achieve and maintain their competitive advantage, which could otherwise be significantly impaired. Transforming traditional ways of doing business into a digital business creates an increasing amount of data every day. It is necessary to extract real and purposeful information that makes the decision-making process faster and more efficient. Without the right competencies, huge amounts of data are a big, or even insurmountable, challenge. Filtering large amounts of data, analyzing, critical
thinking, evaluating, and interpreting appropriately is essential for the modern, digital business.

The presented studies have singled out the soft and functional skills necessary for a person who has the competencies to work with data. Thus, the evaluation of data, or their proper evaluation and consideration, proved to be the most critical soft skill. Immediately after this competence for working with data, critical thinking is of great importance. On the other hand, the most crucial functional skill is reading i.e., creating different classifications of data and rules for working with them. The second most important functional competence is the ability to create open data sets.

As the importance of competencies for working with data for the digital economy, and for business in general, has been proven, it is very important to notice the mismatch between the industry's needs for staff with these competencies and people with those competencies created by different universities. Most faculties do not offer the appropriate level of education required to develop the required data skills. The importance and necessity of these competencies have not yet been properly recognized and are not integrated into the regular courses offered to students at the faculties.

In order to bridge this gap between what the economy demands and what the academic community offers, it is necessary to achieve close cooperation between these parties. It would be ideal for creating appropriate study programs in accordance with the requirements of the economy, but such a change will require significantly more time. During that time, it is necessary to include competencies for working with data in other courses and work on spreading awareness of how crucial they are for the conditions of modern, electronic business.

Although competencies for working with data are still not a sufficiently close and valued concept, their importance should not be neglected or overlooked. The economy, on the one hand, and higher education institutions, on the other, must adapt their work to the new conditions of the digital economy and life in general and keep pace with their changing nature. The described studies show the real need for data literacy competencies, emphasizing their importance for digital business, as well as certain inconsistencies that leave room for improvement and should be the subject of future research.

This study has limitations that need to be considered. The results are based on a table survey conducted in 15 European countries. Future studies should focus on all countries in Europe to allow for greater generalization of results. In addition, the scope of the research was only about functional skills. Future studies should also include soft skills as they could be a valuable basis for courses that provide competencies for working with data at higher education institutions in Europe [15]. Interestingly, only one research instrument was used. It is assumed that the questionnaire together with the desk research, can shed light on all competencies related to working with data.

Future studies should focus on various methods, such as interviews with experts and focus groups, to confirm or discover new competencies [16].

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