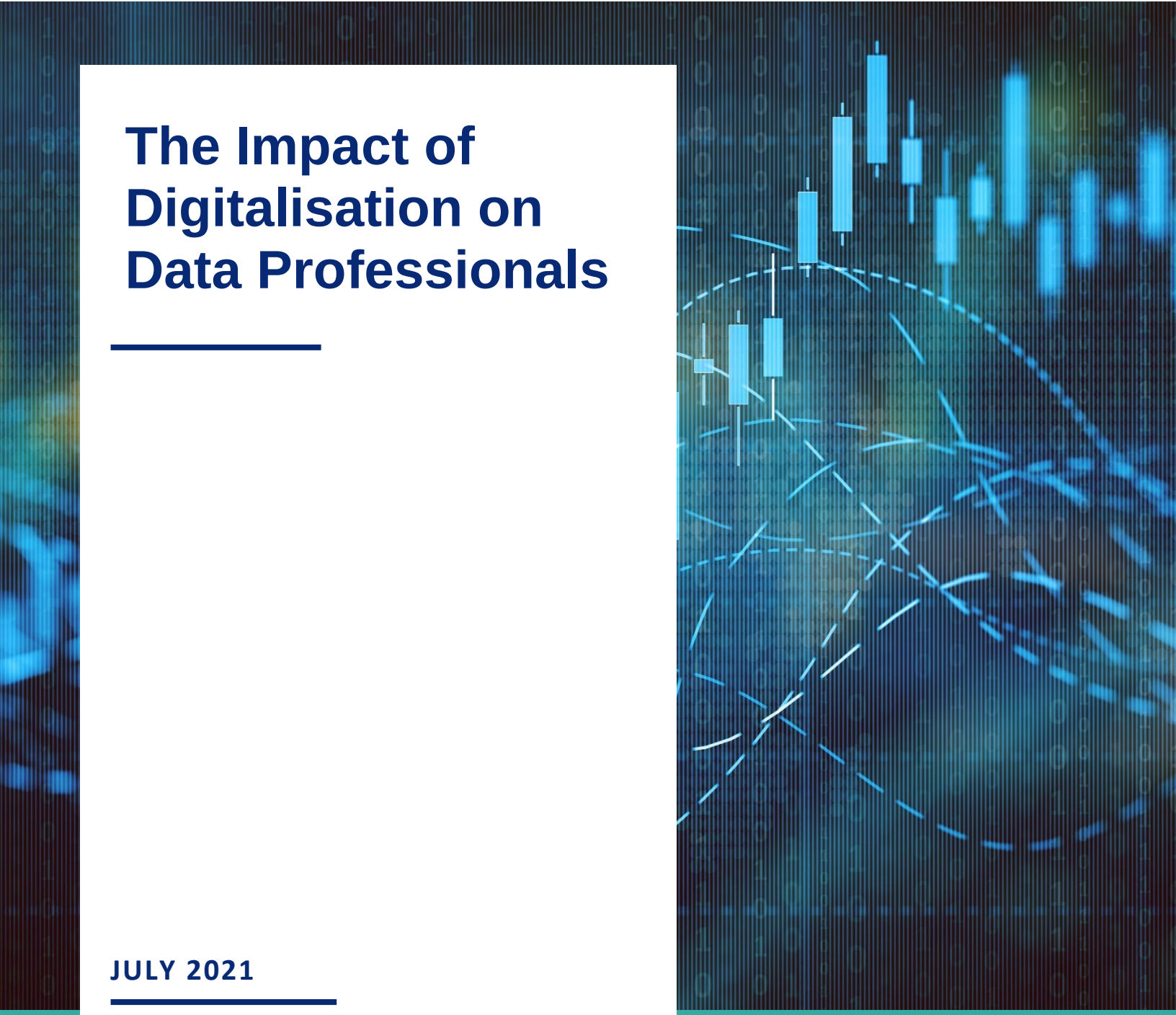

The Impact of Digitalisation on Data Professionals

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ROBERT GORDON UNIVERSITY ABERDEEN

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Foreword

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Data is changing us all. It's changing our working lives, and our private lives in ways we could not imagine just five years ago. And it is helping – from providing a foundation to guide us through the COVID pandemic, to enable more autonomous, data driven decision making, our use of data is changing how we work, and enabling us to work in new and better ways than before.

> *"Decision ready data doesn't come for free. It exists only through the work of data professionals, delivering critical work to ensure the right data is available in the right way when needed. But the rise of data has changed their roles as well."*

This important report – the first of its kind – highlights the ever growing range of skills required to work successfully in data in the oil and gas industry, and the challenge of finding all these skills in one individual. This is a welcome first step towards a digital skills agenda for data professionals, a crucial enabler for the continued success and development of our industry.

Executive Summary

Data and digital skills are critical to the oil and gas industry, whether for efficient offshore operations or strategic decision making. Digitalisation and the fourth industrial revolution are redefining the data profession.

The study had two goals: to develop and present a representative model of the industry's current digital ecosystem; and to produce a digital skills roadmap for the future of the industry. Key learnings arising from the work are:

- Digitalisation is progressing in two modes – establishing a digitalised data lifecycle, and secondly, using that improved data capability to digitalise the broader business.
- The roles delivered by data professionals are complex and unclear – many perform a mix of many different roles in their daily lives, requiring an ever-increasing range of skills, and increasingly challenging expectations of delivery.
- The importance of data governance is growing as a key enabler to effective exploitation of an organisation's data.
- Increasing data fluency and data dependency within organisations is challenging established organisation and leadership models.
- Few data professionals are sure that the data and digital skills they have today will be necessary in three years' time.
- Half of the data professionals surveyed do not anticipate support from their employer to keep their skills up to date.

Current approaches to on-the-job learning do not appear enough to ensure the digital skills required by the data community stay current. This report demonstrates the importance of incorporating digitalisation as a fundamental element of training and skills development for all staff, rather than something that is delivered by a project team, or encountered on a piecemeal basis.

As data professionals are critical to delivering the foundations of a digitalised enterprise, their roles and activity must be incorporated directly into the work of broader business delivery, as part of an integrated, multi-disciplinary team.

To date, our industry has depended on data professionals to be jacks of all trades – as the complexity of our digital environment continues to grow, this model appears increasingly difficult to sustain. The digital skills roadmap presented in this report signposts the way forward for our industry as we embrace the challenges of the energy transition.

Contents

Introduction 5
Methodology 7
Review of Practice 8
Findings 14
Roadmap and Recommendations 35
Sources 39

Introduction

This report presents the findings of a research project examining the impact of digitalisation on data professionals in the UK upstream oil and gas industry. The project was conducted by the School of Creative and Cultural Business and the Energy Transition Institute at Robert Gordon University on behalf of OGUK.

The study design did not constraint participants to a particular definition of digitalisation but for the purposes of this report, it can be considered to be "data & technology to gain additional insight, support better decision making, reduce risk, improve efficiency, and ultimately drive improvement in business performance".[1] Digitalisation is impacting all industry sectors. Advances in information technologies (including developments in artificial intelligence, data mining and analytics which are discussed below in the Review of Practice) are enabling industries, including the upstream oil and gas industry to leverage data and information more effectively. The effective use of these technologies is reliant on the skills and knowledge of the data and information professionals. At present however, it is unclear if the training and education requirements of data professionals needed to complement these technological advances are also keeping pace.

In relation to the UK upstream oil and gas industry, this report contributes to understanding of the current impact, of digitalisation on data professionals, and the anticipated changes in training and educational requirements as digitalisation progresses. This work also builds upon the work conducted by Common Data Access (CDA, a subsidiary of OGUK) in determining the business case for, and value of data management to the industry[2], and on the findings of the UKCS Data & Digital Maturity Survey[3].

Throughout this report, the term 'data management' is assumed to include 'information management'.

The aims of this project were: to develop and present a representative model of the UK upstream oil and gas industry's current ***digital ecosystem***; and to produce a ***digital skills roadmap*** for the future of the industry.

The digital ecosystem model highlights:

- Current gaps in skills provision.
- Examples of good practice in the emergence of appropriate organisational cultures.

The digital skills roadmap highlights:

- Current existing and potential future gaps in skills and competencies provision.
- The development of digital cultural environments.
- Proposed routes to addressing current and potential future issues.

Methodology

This study utilised primary data collated during three stages, preceded by a desk-based review of current practice across energy and other industries. The three data collection methods used were a questionnaire, a series of interviews and a roundtable discussion. The target population for the project was data professionals working in the UK upstream oil and gas industry. Data was analysed quantitatively and qualitatively, as appropriate.

Review of Practice

- Energy Sectors (focus on UK Continental Shelf, UKCS)
- Other Industries (focus on heavy industry)

Questionnaire

- 76 respondents
- Open for two weeks

Interviews

- Nine interviewees
- Purposive sampling based on organisation type, career stage, expertise etc.

Roundtable

- Five participants
- Wider representation including European and renewable sectors

Review of Practice

Energy Sector

While a large body of academic and professional literature has emerged over the last decade, about digital transformation in the oil and gas and wider energy sector, very little relates specifically to the UKCS. Instead, it is dominated by discussions of the situation in Asia, the Middle East, and the Americas. On reviewing the literature, several broad themes emerge. Firstly, there is a perception that, in terms of digitalisation, energy lags behind other industries, such as aerospace, automotive, finance, healthcare, manufacturing, marine, and retail. This reluctance to embrace digitalisation is typically attributed to a cautious, conservative, risk-averse leadership culture, coupled with a lack of awareness of available digital technologies and the benefits these might bring to the sector.[4] [5]

There are some exceptions, and several authors have outlined their own company's digital strategy or transformation programme.[6] [7] Allied to this is a recognition by some commentators of a need for energy sector businesses to acknowledge the value of data (and data management), and to encourage and promote a *data-driven* culture within their own organisations. For example, Huff and Lee[8] present a 'systematic proven and effective nine-step data governance framework' that might help oil and gas companies to improve results by treating data as a strategic asset.

Some literature has focused on the types of digital technologies and techniques that are relevant to, or are currently being used by, the energy sector. Typically: cloud computing; artificial intelligence and machine learning; smart sensors; the 'Industrial Internet of Things'; robotics; blockchain technology; digital twins; and data visualisation dashboards. Lu *et al.*[9] and Temizel *et al.*[10] provide overviews of these technologies and their application in oil and gas.

Technical solutions for digitalisation

However, most attention in the literature has been devoted to very specific accounts of existing or proposed tools, systems, applications, and/or platforms, each of which has been designed to deal with the challenges of 'big data' emerging from digital transformation. These examples come from across the oil and gas, electricity, nuclear, and renewables industries. And while some are described distinctly as data management tools, many others indicate that the data management element is but one part of an integrated system architecture, that can also provide for: operational performance planning; continuous, real-time monitoring; predictive modelling and forecasting; fault detection and diagnosis; data analytics; and the visualisation of other performance metrics that will support decision making. While examples of these systems are many and varied in the literature, it should be emphasised that their potential transferability to the wider energy sector is rarely, if ever, discussed.

In presenting technological solutions, a number of authors discuss the storage and access issues associated with data 'silos', and highlight the means by which their own organisation's system helps to overcome these problems, through the creation of a central, corporate data 'warehouse', 'store', or 'lake' that is accessible to all relevant individuals across the organisation. Interestingly, Brulé[11] extends the water body analogy to suggest that, without good data management, the data lake can become an unreliable data 'swamp'. But if a data lake is built with data management and governance in mind — including traceability, cleansing and integration capabilities — then it can become a more desirable data 'reservoir'.

Digital skills and competencies

The focus of this present research is on the digital skills and competencies required by data professionals in the oil and gas industry. Here, though, the discussion in the literature is somewhat patchwork. For example, several commentators speak only very broadly of a need for 'digitally savvy' or 'digitally minded' employees across the wider energy workforce.[12] Other observers, also discussing the workforce, forecast a need for more specific skills. Most prominent here is a perceived need for data analysis skills,[13] but other competencies, such as in basic coding and data visualisation, are also discussed.[14] Interestingly, the International Energy Agency[15] argues that complementary 'soft' skills, such as leadership, communication and teamwork skills, will be required, as a result of the increased collaborative work that is typically necessitated by digitalisation initiatives. On this last point, several authors, when discussing specific digitalisation projects within their own organisations, have highlighted the importance of multidisciplinary collaborations, including, in some cases, essential input from individuals or departments responsible for data management.[16] Though they are not specific to any one sector, Skills Development Scotland's (SDS) 'meta-skills' are notable for their focus on non-technical skills.[17] SDS also emphasises the importance of combining technical and meta-skills in the Climate Emergency Skills Action Plan, underlining the wider employability of data professionals.[18]

Future skills

Meanwhile, some authors,[19] rather than explicitly identifying future skills needs, instead *imply* what these might be by noting the emergence of new job titles across the sector, such as 'cloud architecture analysts', 'cyber security specialists', and 'data scientists'. Indeed, the emergence of data science (and the data scientist) in the energy industry is discussed extensively in the literature. However, precise definitions of these terms are rarely offered; thus, authors often simply express a sector-wide need for 'data science skills development', 'expertise related to data science', or 'competency in data science', without, apparently, considering the more specific skills and competencies that this encompasses.

There is also a body of work that explores the digital skills required by specific occupations in the energy sector. The roles discussed here are largely petroleum, drilling or system engineers,

geophysicists, or geoscientists.[20] [21] [22] In terms of the skills that might be required in these roles, some authors again talk broadly about a need to be 'technology savvy' or to develop 'machine intelligence'.

Where more specific skills *are* discussed, however, there is again an emphasis on data analytics and data mining, with some authors also suggesting that a basic understanding of programming (for example in Python or R) or technologies (e.g., augmented/virtual reality robotics, sensors, visualisation software) is required.

Project management competencies, and 'softer' skills such as critical thinking, are also suggested here. Interestingly, a very small number of authors advise engineers and geoscientists to become better acquainted with data/information management tools and techniques, so that they may become, as Holdaway[23] puts it, 'wardens of an oil and gas company's vital asset: data'.

Regarding the information professional, however, the potential acquisition of new or additional *digital* skills, to support digital transformation, has not really been discussed in the literature. Instead, a small number of authors have focused on the fundamental skills, techniques and processes that lie at the heart of 'good' data or information management, and have argued that these are key to the success of digitalisation projects.[24] Here, then, the suggestion is that the challenge for data managers lies less in acquiring new skills, but more in applying traditional skills and good practice (e.g., ensuring data quality, integrity, security, etc.) to 'more data, more types of data, and more data available in real-time'.[25]

Other Industries

This part of the review of practice sought discussion of the role of data professionals in Industry 4.0 and their required future skills and competencies in other industries. However, most white papers, think pieces, and journal articles on these topics focussed on specific tools or technologies and on data science and scientists, rather than data professionals and their current and future skills. Many industries are dealing with similar challenges related to digitalisation but most have not considered the role of the data management professional in relation to this.

Material which discussed industrial data management in heavy industry particularly was sought, as was material on organisations and sectors with complex supply chain as the route to digitalisation and the challenges of managing data in these contexts were perceived to be comparable with the oil and gas sector. Digitalisation in these industries must overcome legacy data and systems, complex supply chain, and vast array of interdependent physical and digital systems, in comparison to other industries which are undertaking digitalisation projects to leverage newer data from modern technology or from customers. The heavy industries covered were: Automotive, Utilities, Manufacturing, Construction, Agriculture, Chemical, Aerospace, and Shipping and Maritime. The other industries covered included:

Urban Planning, Clinical/Healthcare, Public Sector (particularly management of open data), Technology, and Finance.

Digital maturity and common challenges

As reported in Deloitte's Digital Maturity Index[26], oil and gas digital maturity is at a lower level than most other industries. Many of the heavier industries are clustered near the bottom end of this scale, except for the Automotive Industry. Similarly, the UKCS Workforce Dynamics Review[27] places the digitalisation of oil and gas, ahead of Agriculture, Mining/Metals, and Rail/Road Logistics, but behind Chemicals, Utilities, Automotive and much further behind Finance, Media and ICT. In fact, globally, only 14% of companies are considered to be 'digitally mature' and many organisations are in the initial stages of working towards 'digital fluency'.[28]

The Automotive Industry scores highly in these rankings, especially compared with other heavy industries. It is working towards the concept of the Smart Factory, which covers a range of stages from partial automation to an autonomous 'lights-out' factory.[29] Collaborative pilot projects and implementing digitalisation projects to improve the supply and value chain are also leading to transformative change.[30] Despite this success some organisations within the sector, particularly SMEs, struggle to move beyond the pilot projects stage of digital transformation, and the key challenges (other than simple lack of investment in digital) are overcoming lack of knowledge and poor digital capability.[31] The situation described is of pockets of digital expertise within functional areas, but people with digital skills are not sufficiently spread within these areas nor are these functional areas sufficiently integrated and working together harmoniously. This is a classic example of organisational silos causing roadblocks for digital transformation, which, combined with a lack of an overarching digital strategy and responsibility at Board level, hinders further development beyond the initial 'beginner' stages of digitalisation.

The Aerospace Industry is also ranked highly for digital maturity amongst the heavier industries, they are currently making use of cloud AI and digital twin technologies.[32] Alongside the rise in use of these technologies, Aerospace is seeing an increased need to focus on cyber security and resilience and a reimagining of the roles of those assigned to shepherd and protect these data.[33] Interestingly, the Aerospace Industry have a similar data management challenge to oil and gas, in that their assets/products can stay in production for many years and in operation for decades. Therefore, data connected to that product can end up in a patchwork of poorly integrated and hard to maintain systems and platforms. Solutions to this in the sector include resilient platforms and common standards for data,[34] and a move towards data-as-a-service as a business model for outsourcing technical knowledge to a specialist provider.[35] Further, the large amount of data produced by digital twin/visualisation means there is increasingly a need to consider how to manage, move and store that data.[36] Aerospace has an aging workforce which may be resistant to change and a skills gap caused by talent being pulled away into more digitally-advanced and high tech industries. While the age profile

of the overall oil and gas workforce is stable, it is possible that a similar gap may be emerging within its data-focused disciplines. [37]

The UKCS Data & Digital Maturity Survey report suggests that the oil and gas industry must understand the data they have, correct quality issues, develop governance before these data issues can be overcome and they can become more digitally mature. Of course, many other sectors are also grappling with this issue, and there is an added element of complexity where a high degree of collaboration is required or where the data are gathered from disparate sources (particularly in the Shipping and Maritime, Transport, and Public Sectors through their increased use of Open Data).[38] Further to this, oil and gas (alongside many organisations on the lower end of the digital maturity scale) is not investing enough - or is too risk averse to invest in - data processing technology and this could leave it behind once the data preparation phase is finished.

Digital skills and training

In most heavy industry sectors previously, the skills required of an employee may have included basic modern programming or software engineering, manufacturing, communication, innovation and traditional IT skills. There is now a noticeable shift towards digital skills for an Industry 4.0 employee, who may need to have a greater digital dexterity and be comfortable with tasks in the areas of data science and cybersecurity.[39] The UKCS Workforce Dynamics Review examined changing skills requirements in the industry for the next 20 years. With around 80% of the workforce still in the industry in 2025, the recommended focus was reskilling and upskilling, alongside recruiting for new (or augmented) tasks and roles. The report uses the term 'reskilling' to mean preparation for different roles and responsibilities, and 'upskilling' to enable workers to do their current job more efficiently. Many sectors called on both the Government and industry to consider future skills requirements for a digitally capable labour market.

Additionally, the Workforce Dynamics Review recognised that oil and gas work environments of the future will have to be far more adaptable and agile and teams will need to be flexible and nimble; something that most industries are also grappling with. Often, the issues with digital capabilities in these sectors are more about where the digital experts are placed within a company and the organisational structure and culture (as per the previous discussion of the digital expert silos in the Automotive Industry). Failing to align talent pools and technology assets will cause problems, as will lack of understanding of new digital technologies and capabilities by management. Without addressing the lack of skills and the poor organisational structure and culture, the result of any digitalisation project will be akin to putting 'digital lipstick' on legacy IT.[40]

The UKCS Data & Digital Maturity Survey revealed a focus on 'doing digital not developing digital' in those organisations with lower digital maturity scores. The recommendation for overcoming this is for training, support, particularly direction as to what digital training might be needed and a capability-specific digital programme. Skills and capabilities are often defined as a critical success factor for

digital transformation. In other sectors, solutions to the digital skills challenge are varied. An example from the aerospace sector that could be applied to oil and gas is that careful succession planning to ensure digital champions are in leadership positions and working together with the education sector, would help overcome the skills gap in the Aerospace sector.[41]

Roles and job descriptions

Much has been published about future requirements for workforces with an acknowledgement that there will be increased automation and augmentation of roles and tasks, more roles requiring use of data, and more roles shifting from labour intensive tasks to intellectual value adding positions.
There is very little information on the changing role of the data professional within this environment and a lack of clarity and consistency around job titles and responsibilities. An Automotive sector paper talks about the need for Digital Architects – a future role responsible for holding, sharing and managing data assets and supporting comparability of data formats within the organisation and its supply chain and this is seen as a distinct and 'new' future role.[42] In the Utilities sector, another white paper talks about the key role of Data Stewards in improving data quality by establishing definitions, structure and taxonomy, and as such are key to data governance tasks.[43] Most industry sources focus only on the technologies, discuss digital skills more generally across the workforce, or focus on Data Science or Analytics.

Given more workers in industry are dealing with data and their roles are becoming increasingly digital, it suggests that the domains of data management, IM and the associated professionals would be in high demand. However, there appears to be a lack of consensus about their role and function, with no clear definition as to the role and responsibility of such a person within a digitally mature organisation. There does not appear to be a professional body or institute for Data Managers across industries

Yet, when looking to the future workforce in industry, there is said to be a move away from thinking about creating cohorts with specialist skills or well-defined roles, instead pivoting towards reconfiguring positions as tasks evolve and developing more agile 'generalist' workers.[44] This suggests that the distinctions between the different types of data professionals may become fuzzy in the future as organisations adapt to a more flexible structure and agile workers working across traditional department or subject matter boundaries.

Findings

Digitalisation is considered to be a revision of existing workflows, and/or the development of new, transformative workflows.

Participants were spread evenly between those identifying as data *users* and data *providers*, though primarily from operator organisations and subsurface data disciplines.

Participants were generally confident in their current competence across the data lifecycle and understanding of data related issues.

Participants were less confident that their digital skillsets will be relevant in three years' time, and look to their employers to support digital skill development.

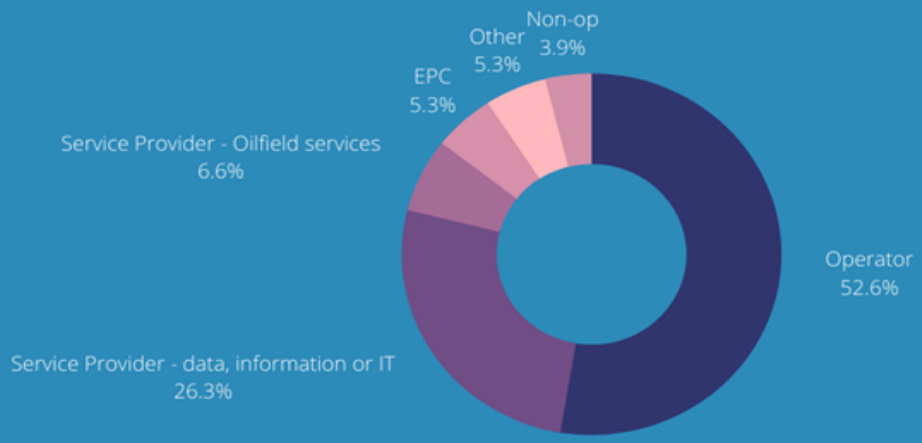
Data driven cultures within organisations are embryonic and need continued support.

There is growing awareness outside the data profession of the need for governance as a key element for success in digitalisation.

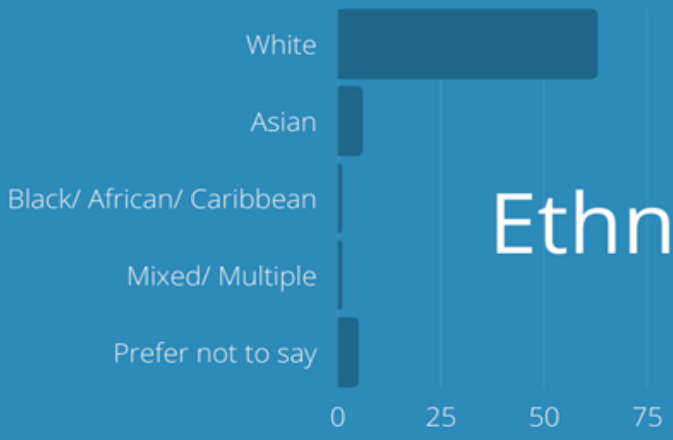
Note that in the following pages, unless percentage is indicated, units are counts of participants.

Demographics and Organisations

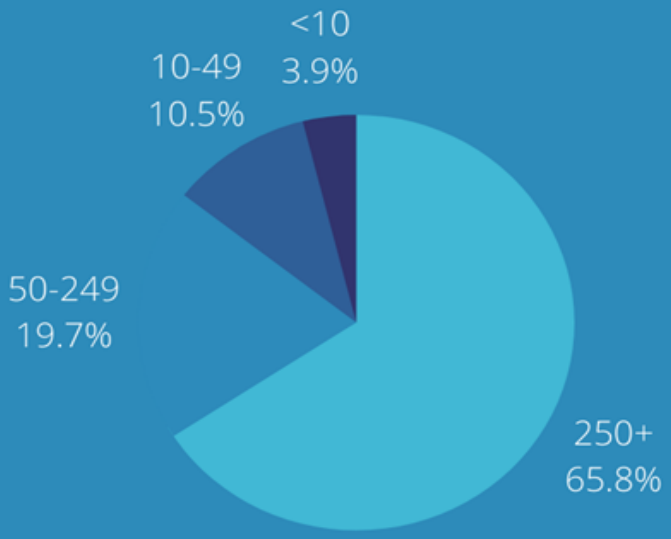
Company Type



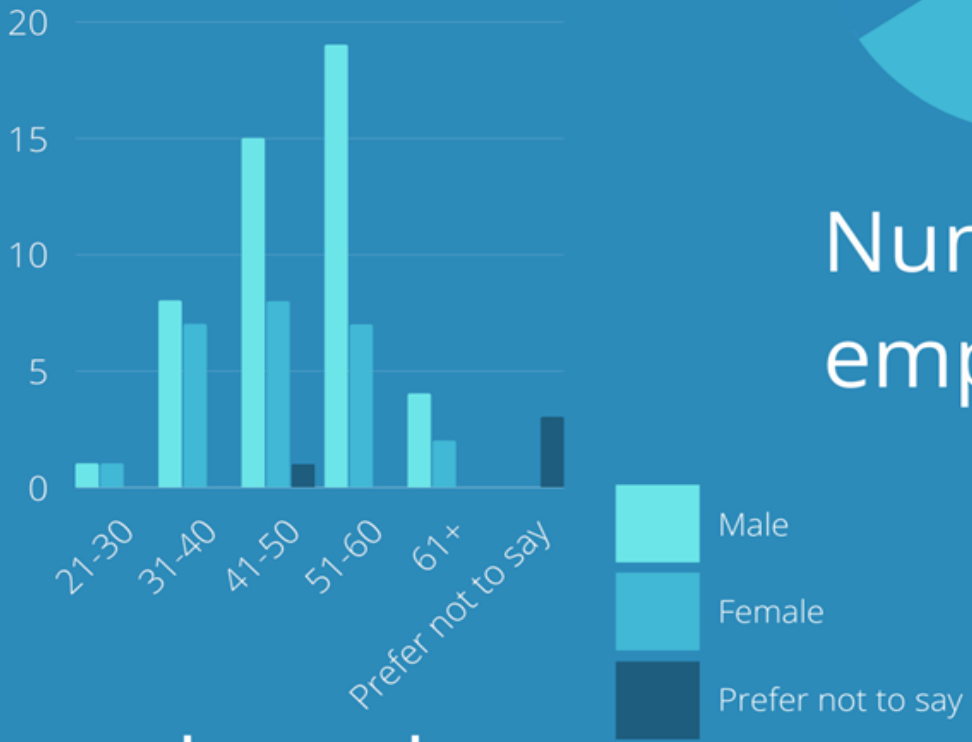
Ethnicity

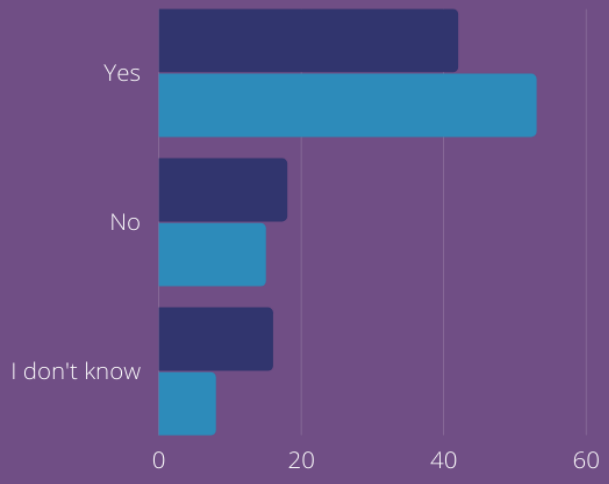


Number of employees



Age and gender





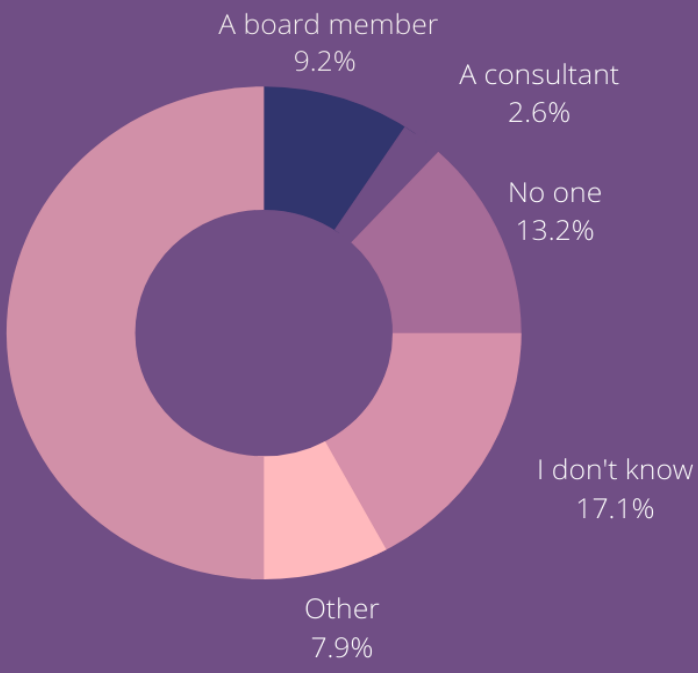
Does your organisation have these strategies or policies in place?

Digital Strategy

Data or Information Managment Strategy

Digitalisation Strategies and Leading Transformation

Who is leading the digital transformation of your discipline?

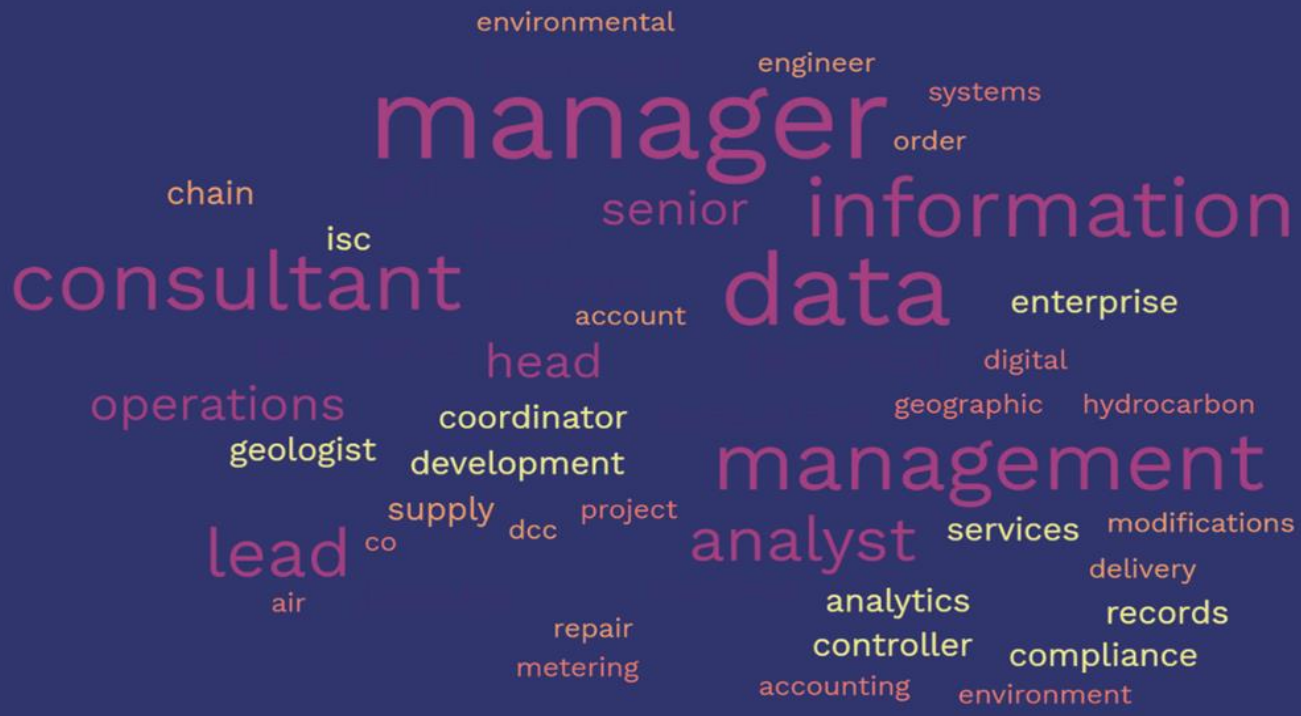


Roles and Responsibilities

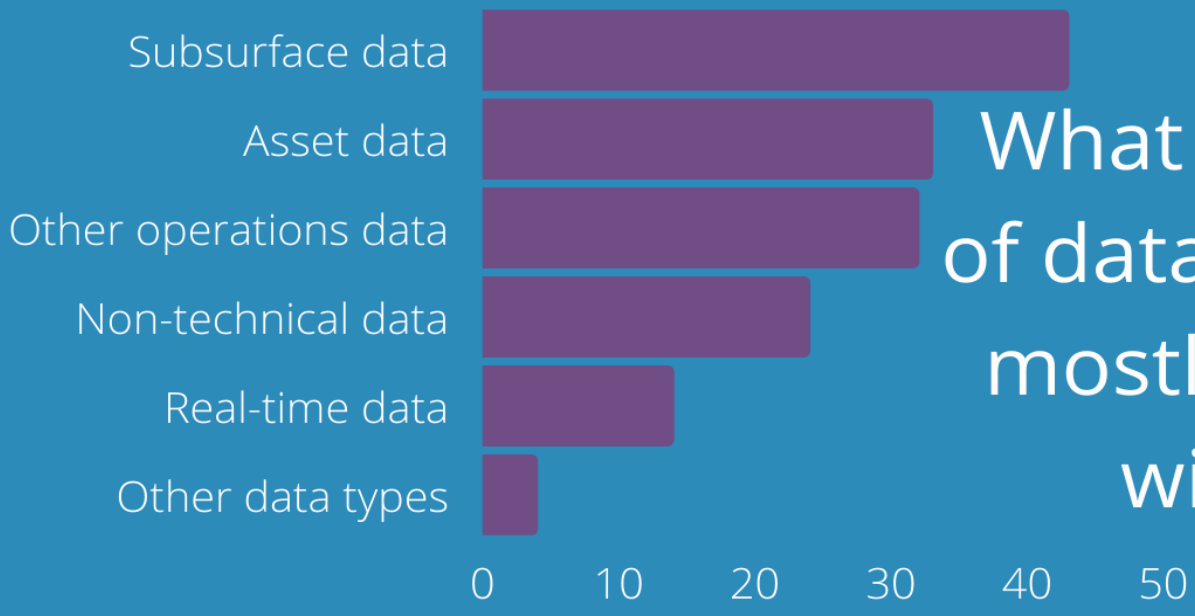
Do you have direct reports?

Where do you report to?

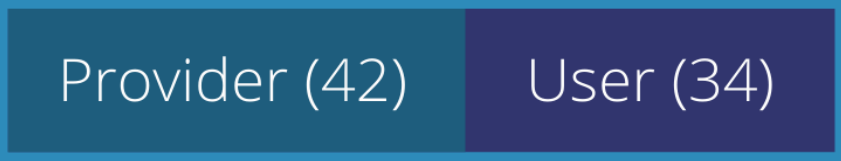
Job Title Terms



Data Types and Providers vs. Users

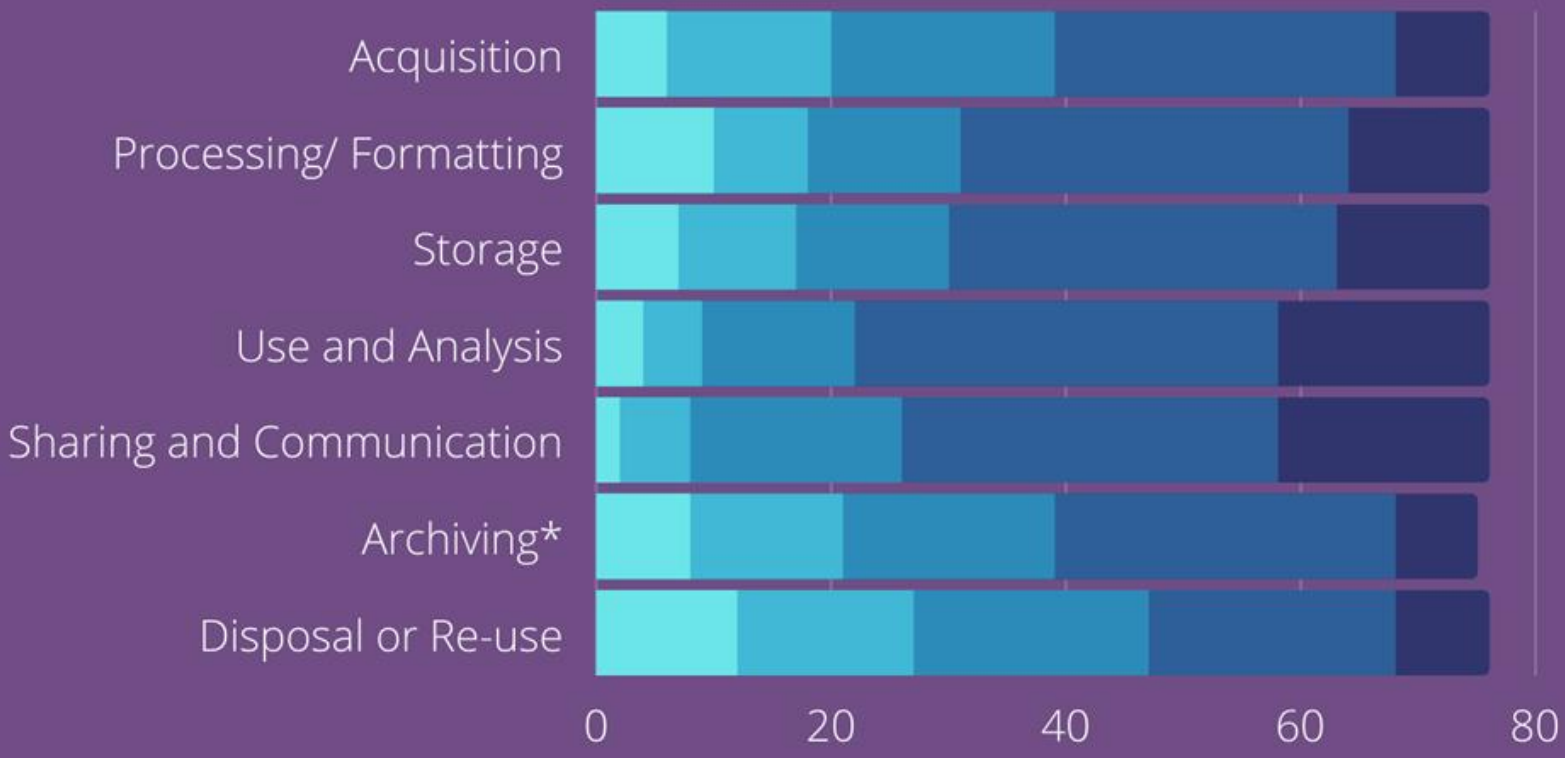


What type(s) of data do you mostly work with?



Are you primarily a data *provider* or a data *user*?

Self-reported competence along the Data Lifecycle



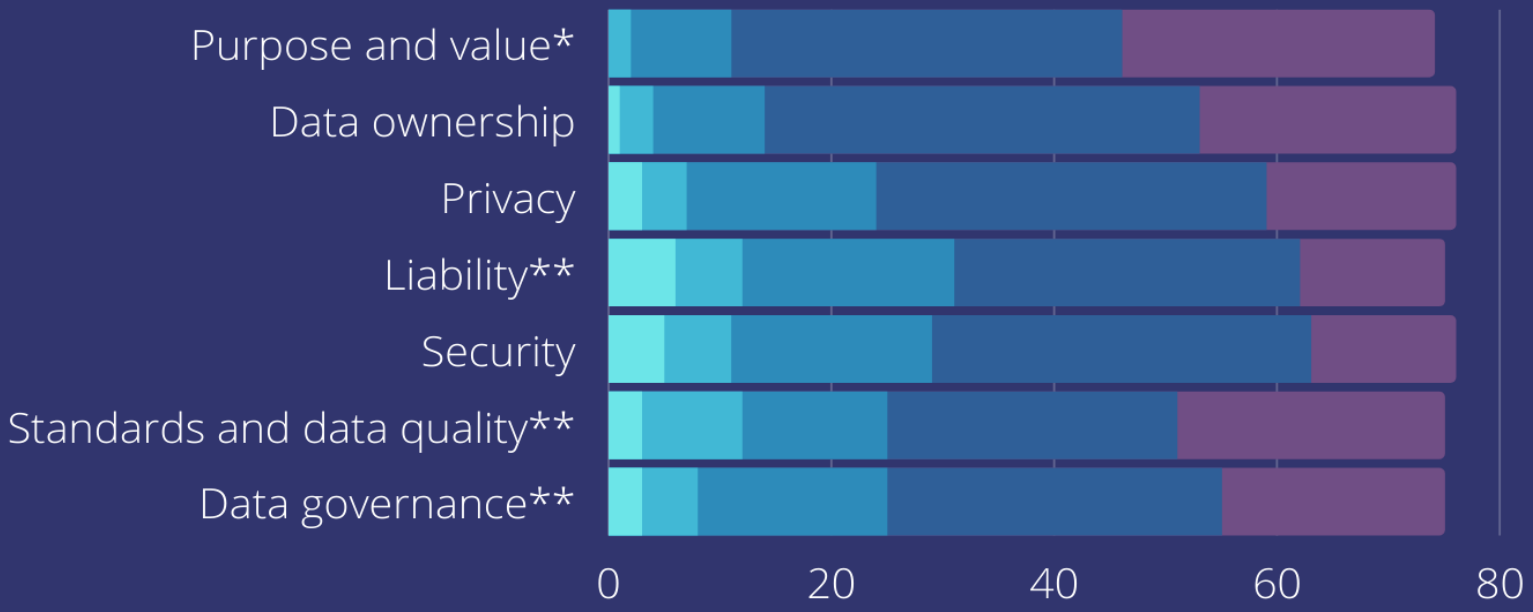
*One respondent did not answer this part of the question

Minimal | Some | Average | Good | Excellent

Significantly greater proportions of data ***providers*** regarded themselves as 'excellent' or 'good' in terms of data acquisition, storage, sharing, archiving, and disposal, compared with those who were primarily data ***users*** ($p<0.05$). However, in terms of data processing/formatting, and data use and analysis, no significant differences were found.

It was also found that those respondents who worked mostly with ***'other operations data'*** typically reported lower levels of competence in data acquisition, storage, sharing, archiving and disposal, than did those who worked more frequently with other data types.

Self-reported understanding of data related issues



*Two respondents did not answer this part of the question
**One respondent did not answer this part of the question

Minimal | Some | Average | Good | Excellent

Those who describe themselves primarily as data ***providers*** had significantly higher levels of understanding of data ownership, governance, and standards and data quality, than those respondents who were primarily data ***users***. In terms of line management responsibilities, however, only one significant relationship was observed; those respondents ***with direct reports*** had greater levels of understanding of liability issues than those with no such responsibilities.

Those respondents who work most frequently with ***non-technical data*** expressed greater levels of understanding of data privacy, liability and security, than those working primarily with other data types. Meanwhile, those who work most frequently with ***subsurface data*** reported greater levels of understanding of issues related to data governance, and to standards and data quality.

Themes

Two threads of digitalisation for data professionals

Interpretations of the concept of digitalisation were broad but two threads were evident: first, digitalisation is the revision of existing workflows to utilise emerging tools that enable faster, more comprehensive and higher quality outputs, often using automation. Most digitalisation in the context of the Data Lifecycle (see p19) comes under this thread (i.e., digitalisation not associated with business decision-making processes, but instead, a foundation for those processes). Most examples of digitalisation projects provided in the questionnaire also come under this thread. The second thread of digitalisation encompasses complete transformation of old workflows where the emerging tools offer such a different way of reaching goals that the new workflows are fundamentally different. This thread overlaps with the cyber-physical systems of Industry 4.0 and most high-profile Digital Business efforts come under this thread. Both of these interpretations of digitalisation from the perspective of data professionals are compatible with previously used definitions, such as that of the UKCS Data and Digital Maturity Survey 2020[45]. The same survey corroborates the concept of Digitalised Data Lifecycle efforts being prerequisites for Digital Business. In the questionnaire's 'any other comments' question, three respondents emphasised that digitalisation must be built upon a foundation of good data management; and that providing inaccurate digital content, or analysing 'bad' data, will be of little benefit.

Digitalised Data Lifecycle

- Using emerging tools to revise existing Data Lifecycle workflows for the purposes of speed, efficiency, comprehensiveness and quality of outputs.
- Workflows still recognisably analagous to pre-digital workflows.
- Undertaken in most or all Data Lifecycle stages.
- Enabler of normal business workflows and of Digital Business, but does not constitute steps in those workflows.
- May overlap with Digitalised Business on matters of data use.
- Possibly the 'comfort zone' for data professionals from data management backgrounds.
- Examples include capturing data straight to the cloud, metadata mining, AI-developed taxonomies.

Digitalised Business

- Using emerging tools for the complete transformation of business workflows, workflows may no longer be recognisable analogs of pre-digital workflows.
- Constitutes steps in business workflows.
- Overlaps with the cyber-physical systems of Industry 4.0.
- May overlap with the Digitalised Data Lifecycle on matters of data use.
- Possibly the 'comfort zone' for data professionals from advanced data science backgrounds.
- Examples include predictive maintenance, technical sentiment analysis, inspection robots.

An issue emerges where data professionals from data management backgrounds are expected to immediately identify with digitalisation when the only examples presented are from the relatively far-removed Digital Business side. An interviewee recounted a telling example which illustrates the divide between these two threads of digitalisation; a practitioner was working in a data management role and simultaneously studying Data Science. As their study progressed, they hit a ceiling; while their scope of work was confined to the Digitalised Data Lifecycle, the projects were not sufficiently challenging. To gain access to more advanced data science opportunities necessary to their studies they had to leave their role and work in a Digital Business vendor. This example shows that the depth of data science competence required in the Digitalised Data Lifecycle may simply be less than that required for Digital Business, meaning that some kind of 'data science lite' persona is required. This does not mean, however, that Lifecycle specialists are lesser data professionals.

> *"[I]f you're in an organisation that's got document controllers and it's got subsurface data managers and it doesn't have any Information Managers or digital people, [you] can't be surprised that those people in those specific verticals will struggle to connect what they do to digital."*
>
> **Interview participant**

It is notable from the questionnaire that a statistically significant difference exists in the self-reported competence of data professionals in the Data Lifecycle stages that are further removed from data use stages; people who consider themselves to be data users rate their competence lower than those who consider themselves to be data providers. Further, when asked about the potential for digitalisation along the Data Lifecycle, the data providers were far more likely to identify the data storage benefits of digitalisation (among other benefits), when compared with the data users. Meanwhile, those respondents who formed part of a data/information management department were more likely to recognise the data sharing and communication benefits of digitalisation, than those respondents who worked in other organisational units.

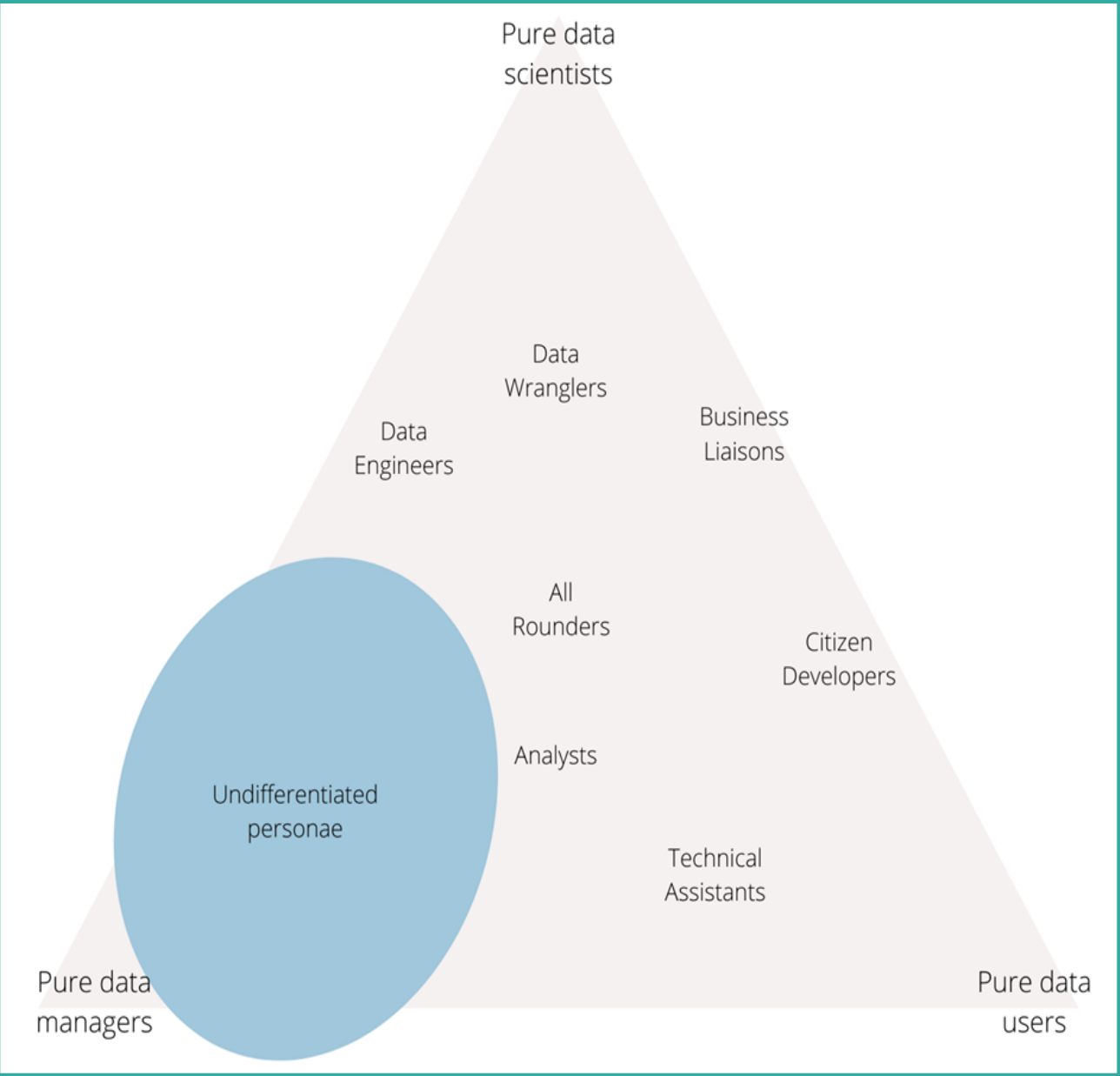
The Digital Ecosystem

This study allowed people to self-identify as data professionals, leading to three source groups emerging. Data professionals primarily come from data user, data science and data management backgrounds, though on the assumption that all underlying necessary IT is in place. Within the ecosystem, distinct personae are evident, illustrating that there is no one 'data professional'.

Instead, a variety of people are working together to generate value from data, whilst still identifying with their source group. Within the data science source group, data professionals can be pure, hard data scientists; data engineers or business liaisons, for example. Data users can be pure users, champions of new ways of working or even citizen developers. However, within data management there are typically no differentiated personae with respect to digitalisation. Instead, personae are defined by subject matter or data type, for example, roles such as geophysical data manager.

> *"[w]e're all going after the same thing as a sort of agile team and so therefore who does what and what the roles are, are not as important as the mix of everybody's skills. You've got a mix in the team and you need multiskilling for that to work."*
>
> **Roundtable participant**

This may contribute to a feeling of expectations being undefined and possibly even, unreasonable. The as-is ecosystem is illustrated below. Specific positions and wording matter less than simply appreciating the different skills and principles that can be observed.



As-is version of Data Professionals' Ecosystem.
Note that these are personae; they are not job titles and do not necessarily map to organisational structures

Data Governance is more important than ever

While it is not news to data professionals that data requires governance, it is evident that there is growing awareness beyond the data profession of the need for governance as an element of success in digitalisation. Existing data governance frameworks are designed to meet the needs of standard business processes, but data science is bringing large datasets together in novel ways.

> *"[historically] data governance has been seen as a good thing because it's the right thing to do because it reduces risk and because it manages compliance. All of which speaks to the costs that a company would bear... [but now] if you get this right, data can yield... positive impacts that make a difference to your organisation."*
>
> Roundtable participant

Further, data science projects use data in such volumes that governance issues are directly affecting project progress. Issues of quality; security; validation; personally identifiable data; duplication; redundant, obsolete and trivial (ROT) data; records management; integrity; ownership; archiving; preservation; obsolescence and integration were all raised by interviewees. As one interviewee observed, a problem is that people view data governance as tedious. While there have always been data professionals who would disagree, they can only act on this if roles exist. As another interviewee remarked, technical data roles often limit staff to specific technical domains, with organisations instead looking to consultants on broader management or strategic matters like governance. This is less likely to be the case in bigger, more mature companies, but the trend towards independent operators in the UKCS means that such companies are less present than they once were. The questionnaire also showed that self-reported understanding in different areas of data governance also varied depending on the type of data a person manages.

> *"Even though you might have had it prepared in a certain way for its current uses, it doesn't mean it's in the right shape for other uses."*
>
> Interview participant

People managing non-technical data reported higher understanding of privacy, liability and security issues and people managing subsurface data reported higher understanding of governance, standards and quality issues.

Leadership, strategy and change management

When discussing leadership and strategy, it was evident that there is a feeling that existing leadership structures are suboptimal because digitalisation is an opportunity that should transcend operational units. This also means that digitalisation should not be the responsibility of a single, central team.

There were suggestions that leaders may feel themselves to be still determining what digitalisation is, whilst simultaneously pursuing it, and that this may be contributing to structural issues, confusion, hype and wariness. As was evident in the questionnaire, staff are less informed about digital strategy than they might be about data or information management strategies.

Also in the questionnaire, responses to a final 'any other comments' question showed a theme of requiring good leadership and change management in achieving effective digital transformation (both within their own organisations and the UK oil and gas sector more broadly).

"[t]he domain is moving and it's not like anybody knows where it's going. We just know it's moving and the only constant thing is change."
Roundtable participant

"there is a bit of scepticism that people want to see the results because they've been involved in perhaps too many projects that have just been a bit overhyped and haven't delivered."
Interview participant

"[t]he field has to move at the same pace. You can't have somebody out sprinting miles ahead, trying to break new ground, when the rest of the industry isn't there yet. Because we are an integrated industry, very tightly dependent on our partners and our service providers. Everybody needs to be aligned. Otherwise, it's going to be a very difficult progression."
Interview participant

Some interviewees felt that collaboration should extend to the supply chain and peers to enable digital transformation.

On the topic of the supply chain, it was notable that the questionnaire response rate was low for participants from Engineering, Procurement and Construction (EPC) companies, and the cause of this merits further investigation.

A theme in the interviews was that until the scope of the digitalisation concept is agreed within a company, change cannot be optimally managed.

However, some tips for reducing potential negative perceptions of digital change were offered.

These include fostering open-mindedness, retaining familiar project structures to ease transitions, encouraging communication beyond the confines of existing workflows, and emphasising the ongoing value of core disciplines.

"we have this almost oxymoronic approach to data within the industry whereby the large Tier 1s are over here doing something very different over here while the rest of the industry is doing something completely different over there. Trying to have any degree of commonality over job roles, skills requirements, competency requirements is just really tricky because we haven't yet reached this point of standardisation."

Roundtable participant (outside oil and gas)

"[maintaining] a clear professional discipline within data and [IM] and that is organisationally replicated, then people don't feel that worry about retraining because they're not losing important skills they've got, they're actually enhancing it. And they are becoming very marketable individuals. Because they do understand both those disciplines."

Interview participant

Appealing business cases

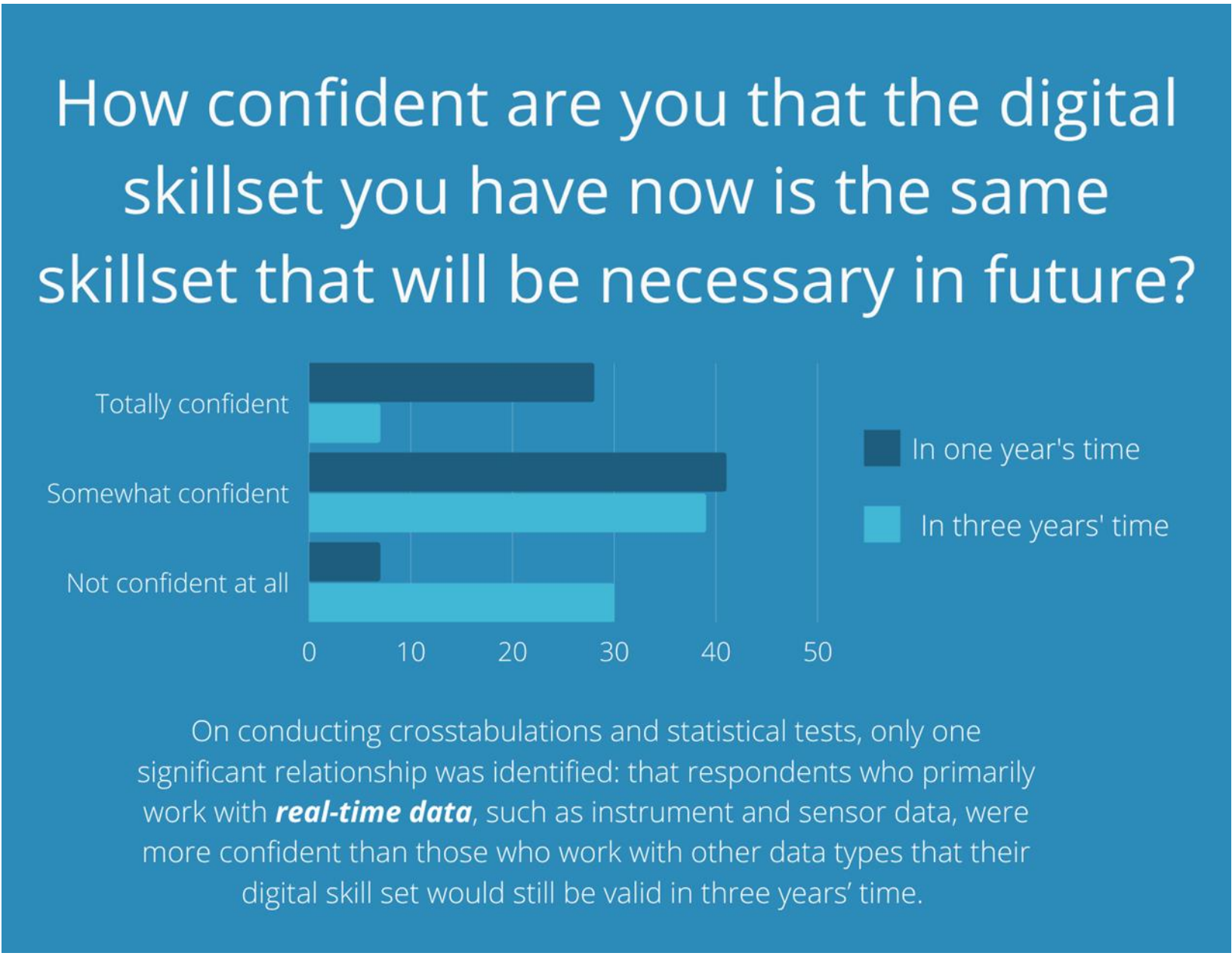
While the overall business case for digitalisation is not in doubt, interviewees felt a lack of relevant reference projects or case studies. This is because unnecessary proofs of concept, prestige projects and excitement over using novel tools sometimes have pulled focus from the task of identifying ordinary problem-solving opportunities. Working to identify, exploit and share lessons from such projects may also be a means of engaging and empowering staff at all levels and across the ecosystem.

> *"[t]here are problems out there that need more than one discipline to solve [them]. And we need to pull those disciplines together in a forum... we need to break down the silos. But I think actually having, also, something to get our teeth into. A problem to solve."*
>
> Interview participant

In the questionnaire's 'any other comments' question, three respondents spoke about a need for more 'best practice' evidence, which might demonstrate the potential value and benefits of digitalisation to the UK sector.

Skills

When asked about their current skillset, a large majority of 78.9% (60) questionnaire respondents indicated that, yes, their digital skillset was currently at an appropriate level. However, 16 respondents said they did not feel that their skillset was appropriate, citing concerns and uncertainty about the precise meaning of the term 'digitalisation' and its implications for their own role. Other respondents indicated that the sector's digitalisation agenda had left them 'continually playing catch-up', or 'outwith their comfort zone'.



How confident are you that you know what the digital skills required in your role will be in three years?

Specific skills were mentioned more by questionnaire respondents than by interviewees, with the exception of coding which was mentioned by multiple interviewees. Various other needs mentioned are listed here in decreasing order or frequency:

- better understanding of cloud computing and storage
- basic 'working knowledge' of AI, machine learning, and/or natural language processing
- basic programming or scripting skills
- data analysis skills, and/or a knowledge of dashboards and other visualisation tools
- 'basic data science' skills

Do you know how to gain these skills?

Where specific skills were not mentioned in the questionnaire responses, respondents spoke broadly of a need to acquire better awareness and understanding of 'new technologies and solutions', 'software developments and improvements', and 'what is possible' in the digital sphere. Amongst those respondents with line-management responsibilities, there was a sense that only a high-level understanding of digitalisation was necessary in their own roles; and that it is their employees, or those that they line manage, that will require the more detailed and practical digital skillset.

The interviewees' comments focused more frequently on behaviours and attitudes, though with the implication that getting these right will lead individuals into developing specific digitalisation skills. Higher level behaviours also correlate with what Skills Development Scotland calls Meta-skills[46]. The strongest human factor theme evident in the data was the importance of openness and willingness towards new skills, scopes and collaborations[47]. Interviewees clarified that they see fostering this openness to be the responsibility of managers and leaders, as much as they see displaying it to be the responsibility of individuals.

"it's important that the person leading the project... if that person is this kind of person who believes in collaboration, then they pass it on down... because that's the way they work and they want their team to work"

Interview Participant

"[we] need to change our whole attitude and approach and kick ourselves out of our comfort zone of: "it's nice and safe having my nice niche groups that I can manage and I can understand what the career development is." From a qualification, from a work perspective. And it's hard work looking at multi disciplines, but we have to do it. We have to do it"

Interview Participant

Culture

There were some concerns that digitalisation may be leaving some people behind, perhaps due to persisting silos, where "there's a much more traditionalist set of ideas about what they do and they can focus very much on their area and don't think about the wider [Information Management]". One interviewee compared the possible fate of data managers to that of corporate librarians:

"[t]hey were the original information scientists. In my own view, maybe they didn't have the skills or didn't really have a desire to then obtain the skills, but they got left behind because all of the smart stuff that you can do with text was being done by other people."

Interview Participant

Building on this, a roundtable participant suggested that the most traditional data managers may not just be suffering an identity crisis but an existential crisis, given that transactional tasks are suitable for automation, as has already been recognised in previous research[48]. Another participant shared that in their position outside the UKCS:

"[p]eople with an information background, they can adapt to that new way of working, but I understand that for some of them it can be a chaos, and it can be scary... we are actually lacking data stewards and data managers and we are actively trying to train them, upskill is wrong word, but to develop people in that direction... we are going to need more of them. Many more."

Roundtable participant

For people who do not already feel open to new skills, scopes and collaborations, the interviewees felt that personal motivation should derive from a professional sense of duty and from recognising a need to maintain employability; "they owe it to themselves to learn the skills and learn the language so that they can interact with that wider team."

One interviewee stressed the importance of “not the skills to code or to write algorithms, but the skills to understand what the machine is doing... any sort of AI that you employ cannot be black box to everybody... because otherwise no one will spot when the results are wrong or suspect and that would be really quite dangerous.” This logic may appeal to people from data management backgrounds, as they tend to have more understanding of the data itself than do strict data scientists. Data managers may also feel more comfortable developing digitalisation skills if and when more case studies in the context of the Digitalised Data Lifecycle are shared.

Summary of findings

The findings show that much of the current focus on digitalisation in industry contexts has been on specific applications of digital tools, and that across all industries there has been a general lack of recognition of the significance and potential impact of the human dimensions of digitalisation, including training and education requirements.

Like many other industry sectors, particularly heavy industries, the UK oil and gas industry is lacking in digital maturity. This is evident from the lack of holistic approaches to data management and the relative immaturity of data management processes from data acquisition to disposal. Concomitantly, the industry needs to increase financial support and investment in data processing technologies, and the requisite skills development programmes needed to utilise these new technologies effectively. There is a clear appetite for the improvement of digitalisation skills across the industry, and while its development is still embryonic, the Future Digitalisation Skills Development Roadmap in the next section provides a sustainable outline for areas of ongoing improvement.

While the need to develop and enhance existing digitalisation skills is identified from both the review of practice and the primary data sets, there is a clear need to articulate both the range of specific skills required (such as data analytics) and the industry sub-sectors and disciplines which are in need of these skills. Data professionals have been shown to be open to developing deeper digital skills, but when strategic plans are immature, the message becomes reductive, lacking healthy constraints to guide the development of any one data professional.

High quality data management skills are in evidence across the industry, and those skills are still very much in demand. However, this project highlights the needs for the identification of additional data management skills sets, which are themselves embryonic. As such, there is an ongoing need to understand what those skill sets are, how they can be developed, and their potential impact on the industry.

Roadmap and Recommendations

Derived from the review of current practice and the findings specified above, the roadmap identifies the current position and issues associated with the industry's engagement with digitalisation and its impact on data professionals. Key enablers to specific challenges are identified, and three inclusive maturity levels are presented. Current engagement with digitalisation in the upstream oil and gas industry is characterised by five main issues:

Technological focus

The current focus on digitalisation is largely technological, emphasising the development and application of specific tools for data processing and management.

Embryonic data-driven cultures

Data-driven cultures within organisations are embryonic and need continued support.

Variable understanding of data processes

Understanding of the range of data-driven processes is variable.

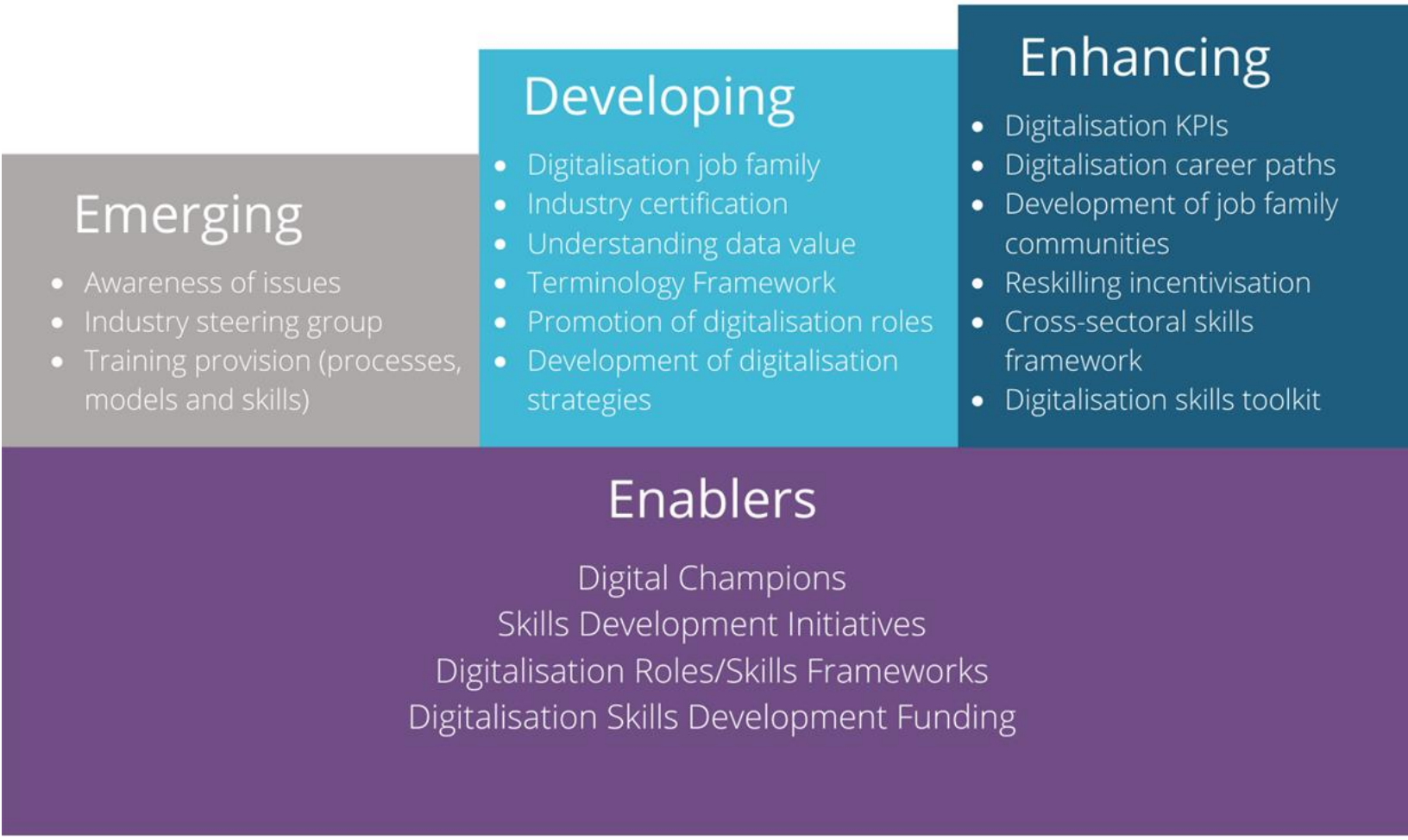
Variable data-related roles

Given the range of data related initiatives across the industry, the variety of data-related roles requires ongoing clarification.

Undefined digitalisation skills requirements

There is a clear need to understand the types of digitalisation skills, and the need for those skills within the industry.

Future digitalisation skills development roadmap

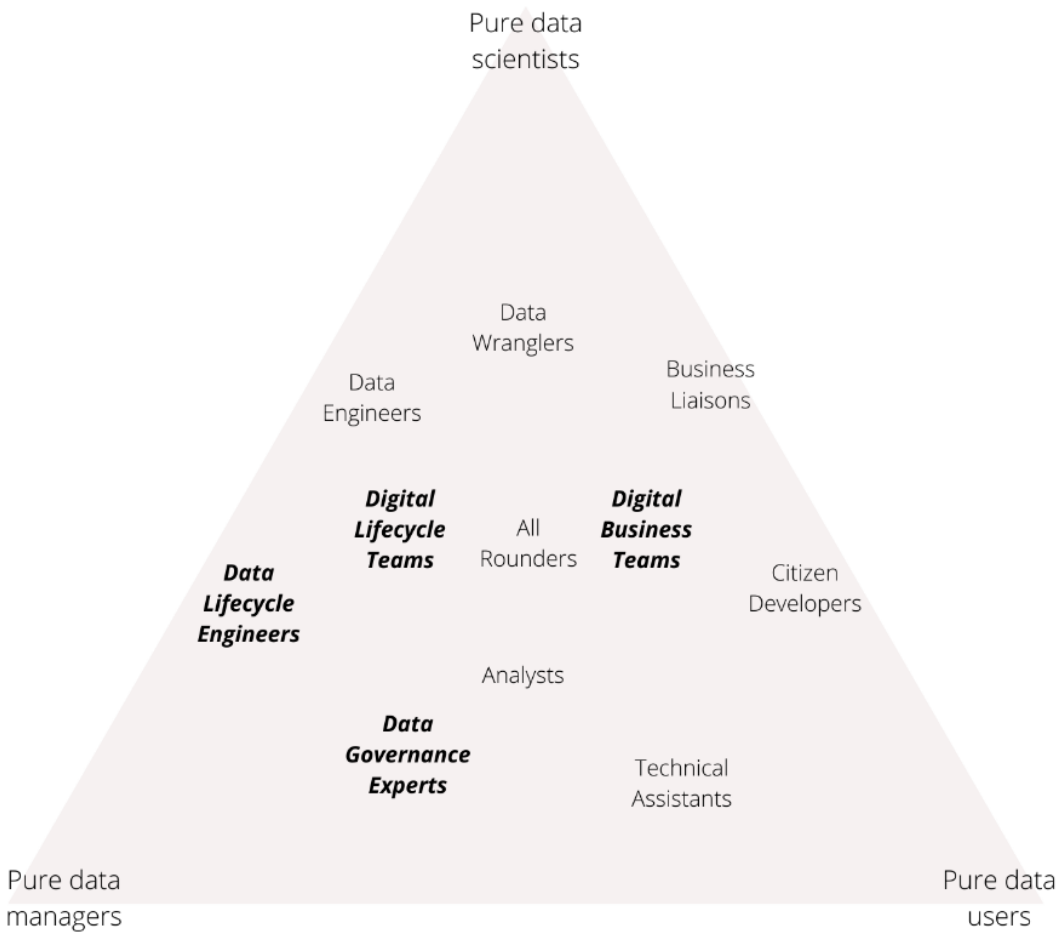


More broadly, we recommend a general ***move away from treating digitalisation as a homogenous activity*** that can be passively layered over existing staff and staff structures. ***Staff need structures that encourage them to engage for the purposes of learning*** (internally and externally), rather than limiting them to workflow engagement. Further, they need ***case studies and business cases that acknowledge and appeal to their personae***.

The two threads of digitalisation that have been identified in this study are compatible with each other and with previous research. Indeed, it has already been presented that Digitalised Data Lifecycle improvements are pre-requisites for Digital Business projects.[49] What this study adds is that **data professionals should also be regarded under this distinction, and therefore not all data professionals can or should be expected to equally contribute to both threads, at least not before consciously choosing such a persona.** Focusing on high profile Digital Business projects as reasons

to embrace digitalisation may not be as compelling across the data profession as previously expected.

The core skillset of all three source groups of data professionals (data scientists, users and managers) is still required so digitalisation should not be allowed to overshadow core discipline principles. Overall, digitalisation should be presented as a massive advance in the data professionals' problem solving and value-adding resource kit. Crucially, neither of these goals is new or unique to digitalisation, meaning that this framing offers an advance towards familiar goals, without downplaying the revolution that digitalisation can enable.



A possible future ecosystem with additional personae differentiated in bold italics. The exact position of any one persona matters less than recognition of the value of ensuring the range is covered.

Scope for further work

Two interviewees and one round table participant (later, by email) commented that the Norwegian sector is ahead of the UK sector in its digitalisation journey. As the scope of this study was the UKCS, comparative studies could be undertaken in future.

Despite attempts to elicit responses from EPC companies, their engagement with the project remained low. Future research should recognise and prioritise this gap in the data. The supply chain perspective is particularly important as there can be several intermediaries between an Original Equipment Manufacturer and the asset Operator, with data passing through all of them. From the digitalisation perspective, the criticality of equipment data in the digital twin warrants a supply chain focus in future work.

The study's demographic data shows a gender balance that is slightly more skewed towards men and older age bands when compared with the wider industry.[50] However, when cross-tabulated, the age skew is shown to be *specific* to men, with women's age distribution being symmetrical. Ethnicity is heavily skewed to white data professionals, as is ethnicity across the industry.[51] Diversity and inclusion (D&I) efforts are ongoing in the industry but the depth of studies does not typically extend to differentiating the data profession; we recommend ongoing D&I monitoring for the profession.

We do not know of any reason why the insights generated in this project might not be applicable in other heavy and process industries, where data is sufficiently technical that its care and utilisation has always required contextual understanding. Thus, future work could extend into construction, power generation and distribution, water treatment, transport, pharma, defence and aerospace and so on. This would also benefit data professionals as they participate in the energy transition and contribute towards achieving a net zero energy sector, which may include diversification into other technical areas[52].

Finally, in the age of industry 4.0, all professionals are data professionals. Future work could explore the impact of digitalisation on professionals across the workforce, maintaining the human focus identified within this report. Digitalisation will continue to shape the future of work. Given this, it is imperative that the UK oil and gas industry continues its journey to digital maturity.

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