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Bridging the Divide: Reflections on University-Industry collaboration for the development of the Graduate Certificate in Petroleum Data Management

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Structured Abstract

Purpose

This paper presents an analysis of the development of a new graduate certificate course in Petroleum Data Management. The course was developed in response to an identified gap in skills and training in data management which was perceived to be a substantial risk in terms of: industry sustainability, efficiency and potentially wider implications of safety as assets are transferred between operators and for decommissioning. The aim of this paper is to critically reflect on how academia and industry can work together to support emerging professions in information management.

Findings

The course development process was ultimately successful but also challenging and lessons have been learned which will be of interest to the wider professional and academic body. These include: securing resources and industry engagement for course development, negotiating cultural differences between academic and industry and managing stakeholder relationships throughout the lifecycle of the course development.

Design/Methodology

The paper draws on observations and interviews from key stakeholders involved in the course development.

Originality/Value

The paper demonstrates the challenges and opportunities of developing a university course in collaboration with industry partners. Oil and Gas Exploration and Production (E&P) is a data intensive industry but it was only relatively recently that attempts have been made to set industry standards and roles of 'data manager' or 'data analyst' have been created to manage these. This paper has wider implications for understanding the professionalisation of the nascent data management disciplines and contributes to the ongoing dialogue around the changing library and information science profession.

Introduction

The United Kingdom Energy Act (2016) recognises the need for management of petroleum data and increases the obligations and duties for licensees and 'other persons' with respect to the stewardship and reporting of information and samples. Sanctions can now be enforced for non-compliance and these developments reflect an emerging global trend towards regulation. In response to this regulatory backdrop, the Petroleum Data Management (PDM) Graduate Certificate course was developed in collaboration between Common Data Access (CDA) which is currently a subsidiary of Oil and Gas UK and Robert Gordon University, Aberdeen. CDA facilitates the sharing of costs and benefits of collaboratively managing high-value oil and gas geotechnical data, primarily from their sub-surface well and seismic data. As will be demonstrated in this paper, their scope and remit extends into the wider issues surrounding data management in the Oil and Gas industry. CDA operates on a membership basis, including most UK North Sea oil and gas operators, as well as service companies and universities.

The oil and gas industry continues to be a major provider of energy and employment and there is a need for both existing data management practitioners as well as fresh talent to maximise current and future opportunities. A report on data management (Common Data Access *et al*., 2011) revealed that 70 per cent of the value generated by the exploration and production activities of oil companies relies on accurate understanding of the subsurface, and accurate data is key to that understanding. However, as will be demonstrated in this paper, there is a widespread belief that data management is undervalued in the petroleum industry and, therefore, there is a compelling need to professionalise this area. In other professional disciplines this has been achieved by understanding the routes into the profession, the establishment of professional bodies and ongoing professional development i.e. through established education and qualifications along with training and evidence of competence. Prior to the development of the PDM course, this provision did not exist for petroleum data managers and it is this deficiency that provides the backdrop to the development of the Graduate Certificate PDM and to the wider professionalization agenda which will be discussed in this paper.

The course comprises four consecutive modules. The first module, *BS3965 Managing Subsurface Exploration and Production Data*, situates PDM practice within business needs. The second module, *BS3966 The Data Management Lifecycle*, is the core Information Management module in that it establishes the data manager's responsibility along the cradle-to-grave data lifecycle. The third, *BS3967 Providing Data Management Services*, allows students to step back from day-to-day user support and examine managerial challenges. The final module, *BS3968 Data Quality and Governance,* establishes the components of data governance. In essence, this course is an information management course that is heavily contextualised to E&P data management. The transferable skills developed in the course are in line with those developed in any IM course at this level.

As this paper will demonstrate, part of the challenge of professionalisation is that PDM is an interdisciplinary field combining geoscience, computing, information management and data management. In practice, this means that while PDM recruits staff from these fields, staff tend to 'stumble into' PDM rather than actively pursue it. Further there is an ongoing risk that having stumbled in, they will return to their original, clearer career path susbequently. More broadly, this also reinforces the notion that PDM is not an established discipline, or part of one, and cannot offer a fulfilling career path on a par with established disciplines, such as engineering. A consistent, transparent and, preferably, prestigious entry into practice is one of the hallmarks of a profession (Bourdieu, cited in McEwen and Trede, 2014). Thus, in this course development project a core challenge was to deliver a course that had both the necessary academic and 'real world' rigour and also advanced the professionalization of PDM by offering a transparent entry point into the field while ensuring that the wider educational values such as critical thinking and reflection were embedded in the learning outcomes of the course. This required intense collaboration between the academics and industry over a period of several years (including prior to the formal contract for development of the course being signed) and involved significant investment in time, resources as well as stakeholder management to achieve shared understandings and negotiations between the starkly different worlds of academia and industry. The aim of this paper is to critically discuss these challenges and opportunities within the wider context of the professionalisation of data management within the petroleum industry.

Literature Review

University-Industry Collaborations

Knowledge exchange and collaborations between universities and industry are well-established and are supported through government policy and funding awards. D'Este and Patel (2007) identify 5 key mechanisms of collaboration: creation of new physical facilities, consultancy and contract research, joint research, training, and meetings and conferences. These collaborations are generally regarded as a positive phenomenon with benefits including: financial income, adjunct faculty with industry experience and an opportunity for bringing together the strengths of university and industry to work in partnership to solve problems (Prigge, 2005). Many universities have dedicated support services to facilitate this although the focus of these services tends to be around research projects rather than course development. The majority of the academic literature on university-industry collaboration is also centred on research and knowledge exchange with a particular focus on spin-out companies and patents (D'Este and Patel, 2007) however, some of the findings are applicable in the context of course development. For example, Bruneel *et al.* (2010) reviewed barriers to university-industry collaboration and identified that the different systems for the production of knowledge lead to challenges of 'attitudinal alignment' (p859) but that the most significant challenges relate to transaction-oriented issues such as IP issues and interacting with university administrative structures. Further challenges can include conflicts of interest and perceived compromising of academic integrity (Prigge, 2005). These barriers need

to be overcome to facilitate university-industry collaboration and to allow for knowledge *exchange*.

In the wider university context industry engagement is also seen as being important in terms of student employability which is evaluated through various metrics. In some cases there is direct involvement of industry in course design to help identify skill sets that are integrated into curriculum design. Garrick *et al*. (2004) suggest that this could lead to new opportunities for knowledge production while also identifying gaps that could be filled by training. This can be considered positive in terms of graduate employability but raises some concerns about the pervasive rhetoric of consumerism in education and a risk that skill sets may be overly focussed on present rather than future needs of industry (Cox and King, 2006) which is of particular relevance in the rapidly developing roles related to data. As university-industry collaborations become standard practice, more consideration also needs to be given to the nature of the relationships. For example, writing about student industrial placements, Solnet *et al*. (2007) highlighted that understanding the relationship from a stakeholder and relationship management framework led to a more mutually beneficial experience for both industry and academic partners.

Library and Information Science (LIS) schools have a strong history of collaboration with the professional bodies and of producing graduates with practical skills (Benson and Willet, 2014). There has been a tendency for LIS education to be more focussed on the public sector and some critiques of LIS education highlight gaps in the provision of courses that have a commercial focus (Blankson-Hemans and Hibberd, 2004). However, as Robinson and Bawden (2013) demonstrate, the UK LIS sector recognises the overlap with other information-disciplines and is very adaptable. Um and Feather (2007) write that LIS academic departments tend to differentiate themselves based on specialisms while maintaining a core provision of 'traditional' LIS education. An example of university-industry collaboration in LIS course development is outlined by Robinson and Bawden (2010) when City University developed an MSc course in Pharmaceutical Information Management at the request of and in conjunction with a small profession body, The Association of Information Officers in the Pharmaceutical Industry. Similar to the PDM course this was also developed in close collaboration with the professional body and included practitioners as teachers. The authors write that the MSc course was discontinued following initial success due to low numbers of students and the changing professional environment. Specialised courses developed for a particular industry are vulnerable to external changes and the low price of oil, decline in North Sea production and a global need to switch towards renewable fuels to combat climate change could lead to challenges of sustainability to the PDM course in the longer term. The PDM course development team were mindful of this from the outset and steps were taken to mitigate this by partnering with an organisation with global connections and making it an online course with no geographic focus in the materials. For longer term sustainability, there is an intention to diversify the course to be applicable to other energy sectors and data-intensive industries.

The Business Value of Data

In response to the global interest in big data and associated technologies, businesses have invested heavily in enterprise applications that claim to support decision-making (Kwon *et al*., 2014). This is particularly the case in data-intensive organisations such as Oil and Gas companies but the so-called 'big data revolution' has impacted on organisations from almost every sphere. The academic focus of this field tends to be on systems or applications such as Business Intelligence and Analytics and how these can be utilized for organisations to understand themselves and their customers and to inform decision-making (Chen *et al.*, 2012). Organisations have come to regard data and information as assets to be preserved and exploited for business benefit and competitive advantage (Hillard, 2010). The hype and interest around big data is evident when it was deemed a new 'asset class' by the world economic forum in 2011 and as the 'new oil' (Rotella, 2012). Big Data Analytics is argued to have a positive impact on an organisations' ability to adapt and to enable them to develop internal and external knowledge management in order to gain insights for competitive advantage (Côrte-Real *et al*., 2017).

Significant challenges remain which include opacity, noise and relationality as well as how to export data from sources such as sensors without corruption and loss (Ekbia *et al*., 2015). This is particularly challenging in the petroleum industry which has a vast amount of proprietary technologies which are not compatible and lead to individuals having to manually move data (Palmer, 2011). A great deal of literature on business data/information management focuses on systems and, specifically, the development of 'business intelligence' solutions that are purported to maximise productivity within an organisation. For example, Enterprise Search systems in organisations allow staff to search across its own information assets, stored in multiple locations (Cleverley *et al*., 2017). New industries have been created around data management and numerous big data consultancy firms exist selling services to organisations under the auspices of helping them make the most of their data (Mayer-Schönberger and Cukier, 2013).

There are further challenges surrounding the governance and stewardship of data. As discussed previously in the paper, the value of data is not just derived from its initial application but also may have future use and value that is not immediately clear. These concepts have been explored in the context of scientific research data management due to the high volumes of data produced and associated tools and resources (Bawden and Robinson, 2017) that they generate. Furthermore, research data management has also been mandated by funding bodies to maintain data produced from publically funded research in institutional data repositories (Koltay, 2016). These developments have raised questions as to who should be responsible for data management as data producers such as scientists may not be the most appropriate people to be managing data longer term and arguably it is not a part of their role (Lynch, 2008). In the private sector businesses also need to have effective data and information governance strategies to ensure the long-term maintenance of this data. However, research suggests that there is a mismatch between management rhetoric around the importance of data and actual interest in managing data as an asset (Muir *et al.,* 2014).

There is a gap in education and formal training provision for roles such as data managers as much of the focus has do date been on algorithms and technical tools rather than on governance and ethical concerns with data (Miller, 2014). It is this 'data space' that LIS education can fill as Harris-Pierce (2012) assert and many of the core foundations of information science are of direct relevance in this field (Ortiz-Repiso, 2018). These newer LIS sub-disciplines are still developing and Koltay (2016) draws particular attention to data governance and data literacy as areas that should be more prominent in curriculums. It should be noted that data governance is regarded as a core concept in Digital Curation (Poole, 2016).

Professionalisation

Professional identity can reveal insights into motivation, individual and group dynamics, leadership, corporate image and many other factors (Alvesson *et al.,* 2008 p7). Early work on professions such as Greenwood (1957) identified five attributes of professions: (1) systematic theory, (2) authority, (3) community sanction, (4) ethical codes, and (5) a culture. The processes of professionalisation and the development of professional identity has moved beyond identifying the characteristics of professions and towards a more sociologicial understanding (usually involving neo-Weberian theories) of how professions acquire or develop bodies of knowledge to understand themselves and the often complex structural, organisational and institutional factors that influence the way that professional groups interact (Bresnan, 2013; Evetts, 2011b; Faulconbridge and Muzio, 2012). Professionalisation can happen 'from within' or 'from above' (McClelland, 1990 cited by Evetts, 2011a) and can have a positive impact on the group as they use the discourse of professionalisation to further their interests (Evetts, 2011a).

Professionalisation discourses impact on individuals' sense of self and value as professions act as cultural-cognitive agents, normative agents and regulatory agents (Scott, 2008; Muzio *et al*., 2014). They can be used as means of exerting professional values and codes of ethics and be viewed as a way of developing collegiality rather than hierarchical organisational structures (Evetts, 2011b). Professionalisation can also be used as a means of trying to control access to knowledge bases and solutions (Neal and Morgan, 2010) and can also lead to increased regulation, audit and assessment (Evetts, 2011b). For example, the publication of ISO 30401:2018 Knowledge Management Systems has been welcomed by CILIP as a key step in professionalising Knowledge Management (McFarlane, 2017). These values and codification of professional practice are not static and may be contested or change over time and therefore lead to forms of resistance or subversion (Fournier 1999). There is some controversy in the literature on professionalisation about the legitimacy of management sub-disciplines being regarded in the same way as 'traditional' professions and scepticism as to whether these can achieve the same status and recognition as established professions such as medicine or librarianship (Morris *et al*., 2006).

However, project management is often used as an example of a 'new profession' which has emerged with a codified knowledge base and professional association in the Association of Project Managers. Project Management is an interesting example because its claims to be a distinct profession are not strongly based on values or ethics (Morris *et al*., 2016) and the qualifications framework is heavily regulated, focussed on applied skills and reflects corporate interests (Hodgson *et al*., 2015).

Professionalisation can be challenging in interdisciplinary roles which can lead to 'identity tensions'. For example, studies have been conducted of creative workers who can feel constrained or conflicted about seemingly opposing professional identities such as being an artist and manager (Gotsi *et al*., 2011). Despite these caveats, professionalisation is generally regarded as positive and other 'new professions' such as data science also make claims to professionalisation as they require a high level of training and failure to meet professional standards can have severe consequences including loss of data, unethical behaviour, loss of revenue for corporations or even loss of life (Walker, 2015). Faulconbridge and Muzio (2012) wrote about how globalisation means that professions transcend national boundaries and that universities play a role in developing qualifications that are recognised internationally to facilitate this mobility. The petroleum industry is a truly global industry and so this was of key importance in the development of the graduate certificate.

Professional bodies can be enablers of professional identity change by providing space for debate and dialogue and the reframing of professional identities (Greenwood *et al.,* 2002). The challenges faced by the LIS sector, particularly in the public sector relate not just to the closure of services but also around a perceived 'de-professionalisation' of librarianship (Broady-Preston, 2006) which the professional body of CILIP is seeking to overcome through support and advocacy. It is also evident that there are roles for professional bodies in the formation of new disciplines. For example Higgins (2011) has written about the development of Digital Curation as a discipline and the iterative process of workshops and development of the knowledge base that ultimately led to "After a period of definition and consolidation, the subject now boasts a growing international professional base, a developing research agenda, practical tools and collaborative projects and a workforce trained to Higher Education level. " (Higgins, 2011 P84). Higgins (2018) has, more recently, highlighted the maturity of digital curation as a discipline and its potential to provide overarching paradigms for information science.

Methodology

The overall methodological approach of this paper is a case study of the course development of Petroleum Data Management. In keeping with case study methodologies, the paper draws on multiple strands of data collection including participant observation and analysis of documentation associated with the course development. A series of seven qualitative semi-structured interviews were conducted with key stakeholders. Interviewees were selected using a purposive sampling technique to get a range of perspectives. These included: a representative from CDA

who were the project sponsors and main partners, the academic lead who was involved in establishing the course and taking it through validation before leaving to take up a role at another university, three interviewees were senior data management practitioners who had been involved with the course development in roles such as developing the competency framework and/or contributing course materials as subject matter experts. A further interview was conducted with a representative from Oil and Gas UK to give the wider industry perspective. A final interview was conducted with a graduate from the first cohort to get their views on the course and what impact, if any, it had on their professional practice. The semi-structured interviews included topics on: motivations to develop the course, interviewees' roles and reflections on the course development process, how the course content and learning outcomes were decided, what have been the main challenges and benefits, lessons learned and future development. Interviews ranged between 29 minutes and 74 minutes and were recorded and transcribed. Data were analysed using the thematic 'framework' analysis methodology first put forward by Ritchie and Spencer (cited in Srivastava and Thomson, 2009), the transparent process of which is suited to research such as this, in which the researchers' *a priori* awareness or experience of the case. The framework approach provides a sound tool for assessment of actions from the perspective of the people that they affect. This was evident, for example, in connection with the analysis around discussion of the value of data to the organisation and how, sometimes, that value was not recognised until later.

Findings

Motivations for Course Development

CDA recognised that the lack of a structure for either accrediting or assessing the competency of the estimated 250 to 1,000 E&P data management specialists working in the UK meant that career development, recruitment and performance evaluation were being compromised along with the potential added value to businesses. The absence of formal training and competencies meant that all training in petroleum data management was being learned 'on the job' and there was a deficit in terms of standardisation and practices that were evident in other professions. As an extension of these issues, PDM staff report that their input in business discussions is sometimes undervalued due to their perceived lack of professional parity. As observed by one interviewee:

> ...there was a feeling amongst the council members that technical data managers as a community were generally undervalued… If you're working in the finance industry and you want an accountant you can go and get one and get it certified. If you're working in the oil industry and you want a good project data manager it's much harder (Interview with Practitioner 1).

Thus, the PDM community's desire to professionalise itself aligns with McEwen and Trede's (2014) view that "professions emerge when occupations rival professions for a closer position to the field of power". The theme of being 'under-valued' was reported widely amongst interviewees and this was said to have negative impacts on the self-

esteem of data managers in the industry and a lack of career progression. An interviewee reported that data management was regarded as a role that people had 'fallen or been pushed into' from other areas (such as geophysics) and that they often did not have a background in records management, information management or petroleum data management.

PDM has traditionally drawn its staff from the geoscience and computing disciplines which are much more established. Geoscience is a core discipline within the exploration and production industry, its fundamental necessity is unquestionable, its visibility within the organisation is good and the career path it offers is mature. IT is classed as a support service rather than a core discipline but it has some advantages over PDM in terms of recruitment and retention; it is an established academic discipline, the emergence of analytics aligns it more closely with core industry activities and its early adoption of service management models allowed it to increase its visibility and mature its career path offering.

A further theme reported by interviewees was that data managers could be rather reserved and the lack of formal recognition of the discipline meant that they lacked the confidence to take ideas or proposals to senior management within the industry. Significantly, interviewees also stressed that this presented significant risks to the petroleum industry which can be a very hazardous environment:

> It's almost a 'what if the data is wrong, what can go wrong?' And there are a lot of stories around companies drilling in the wrong place, there's some catastrophic stories involving loss of life. If you get the information wrong then there are real consequences, and the corollary of that is you get it right, it's good for your business in many ways, reducing risk, getting more opportunity to add value… reducing cost, all those sorts of things. (Interview with Sponsor Representative)

An interesting point that emerged from the interviews was that the understanding of data within the petroleum industry had shifted considerably over recent years. Several high-profile disasters and a stricter regulatory environment (which CDA had lobbied for) have forced petroleum companies to recognise that poor data management led to business-critical risks and resulting liabilities. There are legal obligations to maintain records and significant sanctions can be imposed if they fail to do this forcing organisations to be more disciplined with data management. On a more positive note, however, due to the development of new technologies and the growing prominence of 'big data' more widely, there had been a shift to viewing data solely in terms of liability to an asset that has significant value to petroleum organisations. Interviewees also reported that organisations were recognising that it was not just a technical issue for IT but that it was also about getting the right data to the right people to facilitate good decision-making, and that this required data managers. As one interviewee reported: 'I think that they could potentially play an invaluable role in having that broader perspective in who the potential stakeholders in data are. The people within those silos don't necessarily see…' (interview with Industry Representative).

Interviewees also emphasised that, unlike in some other professions, the value of data in the petroleum industry can sometimes not be evident until much later and that data management processes need to take into account the potential future value of legacy data and that this is not fully understood by senior management within oil and gas. In particular there is a need to curate and manage the data in such a way that the residual value can be extracted in future and therefore it needs adequate resources to enable this.

Establishing the collaboration and course learning outcomes

In 2010-2011 CDA conducted a review of the existing work on competency in industry. This involved research within a wide range of companies and PDM organisations in the UK, Norway, and North America. The review also sought to identify the current PDM roles in industry. DAMA Data Management Body of Knowledge was recognised as an important non-industry specific framework. Subsequent to the initial background review CDA began developing competency frameworks based on an accepted definition of PDM. There had been work done on competency matrixes in some individual petroleum companies but these were commercially confidential and not necessarily generalisable. The process of developing the competencies was described as being a collaborative process primarily involving 4-5 industry experts with a large amount of experience and knowledge in the area.

By 2013 two new competency matrices has been created for the key PDM domains, each with 31 activities and 5 skill levels. Around the same time CDA began looking at the sort of academic provision that would address the desire to being in new entrants as well as supporting existing practitioners who were beginning to use the competency frameworks. In 2013 Robert Gordon University (RGU) Aberdeen were identified as the preferred academic delivery partner.
This was in part because of existing relationships between the then Department of Information Management and the local Information Management Energy community. A previous Knowledge Transfer Partnership (KTP) project conducted in 2010-12 had resulted in the development of a successful 5 credit short online course in Document Control which has run since 2012. There have been further industry connections through the course of various research projects, attendance at industry events such as conferences and the 'Information Management Energy Forum' as well local connections through alumni and other groups which had established RGU as having a strong reputation as being effective partners who could be trusted to deliver the course. Nonetheless there was a long negotiation process before the final contract for course delivery was eventually signed in 2015.

CDA reported that they were initially discouraged by the cost of developing a bespoke course in collaboration with a university. However, a university course was considered to be the most appropriate option as it is a formal qualification. It was also

reported that this route allowed CDA to be co-creators of the curriculum and to work more closely in partnership than would have been possible if a private training company had been commissioned to develop the course. There was some debate and discussion regarding the type and level of qualification that would be developed. For example, interviewees mentioned that there were initial aspirations to develop a full undergraduate degree programme but that in the end it was decided that the RGU course would take the form of a Graduate Certificate which would be delivered entirely via distance learning. Face-to-face interaction options were considered, e.g. optional on-campus workshops, but it was decided to keep the offering as simple and accessible as possible by being online only in line with the long-standing experience of the delivery of distance learning education in information science which the university has.

A further MSc course is also under development which will be delivered by the University of Aberdeen.

A Graduate Certificate is an undergraduate qualification in the Scottish Credit and Qualifications Framework (SCQF). This Graduate Certificate is at the same educational level as the third year of a four- year undergraduate degree (i.e. SCQF Level 9). Graduate Certificate courses are often created as access routes to postgraduate study for students with experience but without an undergraduate degree. Therefore whilst the Graduate Certificate PDM has been created as a qualification in its own right, students who successfully complete the course are eligible to apply for postgraduate study. The decision was taken to offer the course entirely online and is therefore available internationally. Given the global nature of the oil and gas sector the development of international capability is important and therefore the course is not biased towards any one company, region of the world, or sector of the industry although it is focussed on Exploration and Production and the associated supply chain.

Curriculum and Content Development

The development of the Graduate Certificate PDM course required the creation of new materials to meet the needs of an emerging professional discipline. RGU had established courses in information and data management resources but the vast majority of content that was developed for PDM was bespoke. The collaborative and co-created nature of the course development continued throughout the development of the modules. Firstly, a Steering Group of CDA, a representative of their members and RGU staff agreed the high level content of each of the 4 modules. The content of the four modules covers the data types and how they are used, the lifecycle which the data manager shepherds them along, the service structure in which the data manager provides that service and the applicable quality and governance elements. Technologies are touched upon as a means to this end only. For example, file and media types, obsolescence and evergreening are all covered, but without any requirement for existing IT understanding.

Once the module/topics were agreed, workshops were run where the academic lead worked with industry experts nominated by the steering group to cross reference/map the curriculum to the various competencies as the basis for the course level learning outcomes. These were then translated into the course architecture (module descriptors, assessments reading lists and other materials) and an industry working group was established to assist with the development of materials. A lesson learned for future course developments was that interviewees reported that both the development of the competency frameworks and agreeing the scope and structure of the course was very time-consuming and took longer than had been anticipated. A further challenge that was reported by the academic interviewee who led the RGU side of the course development was developing a shared understanding of academic requirements for credit-bearing courses and that this was not a 'cost neutral' activity as it is a substantial time-investment for universities to develop new courses. It was also necessary to explain the university administrative processes involved in course development and validation and the requirement to meet standards for academic delivery and assessment. The involvement of multiple stakeholders was seen as being a strength of the course development but inevitably led to some delays as decisions were being taken collaboratively.

Managing the expectations of industry has been key to maintaining good relations for course development and also to boost student recruitment from these stakeholders. This included explaining the academic nomenclature and university processes which industry practitioners are understandably unfamiliar with. This is also true the other way around. One interviewee who was not directly involved in the course development but had experience of working with academia in other contexts noted that they felt frustrated at the lack of understanding or interest in Exploration and Production amongst academics and that both academia and industry had responsibilities for taking ownership of improving the relationship. Having a CDA consultant with experience in academia and an RGU staff member with experience in industry was seen as critical to the success of the project in that it allowed for stakeholder and project management to be performed to the satisfaction of both parties.

Body of Knowledge and Content Co-Creation.

A separate project was conducted by CDA prior to the development and delivery phase of the course which was initially described as being the creation of a 'Body of Knowledge' as is accepted practice in the development of new professions. There was also a contractual obligation for CDA to provide materials to be used in the course. Each part of the curriculum was reviewed and a target list of information was developed. This resulted in a repository of industry material being collected and collated by CDA but did not really represent a body of knowledge in the classic understanding of the term. These resources were useful as source material to provide industry context and examples but for use by students the course developer had to synthesise general data management principles and academic theory from other sources and contextualize them within an industry context. However, in absolute terms company practice/industry practice cannot be assumed to be synonymous with good or best practice. Additionally,

the course cannot be seen to be promoting one company's operating processes or procedures over another. It is estimated that no more than 10% of the final course content was derived from repository materials. However, an interviewee who was involved as an SME reviewer in the course content development reported that it was of value:

> You know that if you don't have a process for receiving a petrophysical information within your organisation and other processes will not only tell you you need those but also give you examples of those. The body of knowledge would be essential when you do that to stop you reinventing wheels. (Interview with Practitioner 2)

One of the perceived strengths of the course was the involvement of industry practitioners however this also brought with it challenges in terms of the clarity of roles and responsibilities. This became apparent during the development process when industry representatives were asked to "review" content. The challenges of this were identified by an interviewee:

> The process for that was OK. I would say I think there is probably opportunities for us to go forward to improve that process further...We were doing all this by emails and it's not hugely efficient. So the process is OK but I think if we could find ways of doing that more collaboratively online and through discussion forums and stuff. Frankly, if I see somebody from [a major operator] putting in a comment it prompts me to go and put in a comment as well because you don't want it to be dominated by one view. (interview with Practitioner 1)

The learning from these experiences is the criticality of recruiting subject matter experts at the project outset. In addition, there would have been benefit in having more comprehensive topic descriptors because, while in normal course development in higher education a module descriptor is a sufficient base to work from, the subject matter experts would have benefitted from a more specific brief. Working with experts to develop stronger descriptions would have been a valuable intermediate step, whilst maintaining academic control. Additionally, reviewers should be given explicit instructions about the scope and level of detail they are required to provide, albeit with the knowledge that some might follow their inclinations anyway. In the Graduate Certificate case this was achieved by providing a set of guide questions. Furthermore, rather than asking reviewers to go through the outline slide pack and notes, the process could have been streamlined by providing them with access to the content, which is now available on the Moodle Platform. This would provide reviews with a more rounded view of the material in a more realistic context.

Delivery and Assessment

As mentioned previously, the course was developed to be delivered solely via distance learning because the data management community is specialised and geographically dispersed. The development of distance learning materials is very time consuming and, unlike in on-campus teaching, the subject matter has to be all prepared in advance and also has to be available in a number of formats to cater for different students preferred learning styles and also where and how they want to study. This is also required in order to provide equitable access for students with learning differences and disabilities.

The Graduate Certificate PDM was available to students online, by audio and via downloadable pdfs. Students can study topics at their own rate (although there are constraints in that the assessments have fixed deadlines) and this flexibility has been commented upon as a positive aspect of the course. The multiple formats for materials (a standard approach for the university) have been considered to be positive:

> I think the modules are pretty good. And I like the fact that if you were incredibly busy, it's four assignments so you could blitz it if you needed to. Or, if you had more time you could go through and diligently work through every single task. Also it's great that you provide audio, MP3 files, I listen to a lot of audio books and things so I found that really useful... I could listen to them in the car so I could go over a point or go over something, I could listen to them at my desk if I wanted to, it's not affecting anyone. And I'm used to working and listening to something at the same time. If you had the PDF you could reference the PDF and go back and read over those or you had the lecture slides, which I also used. I didn't use the PDF so much, to be fair, I learn from audio. (Interview with Graduate)

The knowledge acquired during the project which is of major significance for future courses is that it took 16 hours of RGU time to create every 1000 words of materials however with the adoption/application of some of the other lessons learned from the project potentially this time could be reduced by a maximum of 15%. This does not include the research and industry review time but does include the instructional design. The assessments were also carefully developed and included aspects to assess soft skills using an 'authentic assessment' approach; in one assessment students are required to develop an infographic, in another there is a pseudo role-play exercise, where one student acts a consultant who has been contracted to assess the current state of data management at a company and report on it, and also to propose and justify a future improved state, including a plan to get there.

Though the course was designed as an entry point to PDM, most (but not all) of the students were already practitioners and already held a Higher Education award. Practitioners in the supply chain are as well represented as those in E&P operating companies, though the course was developed with industry advisors who were largely employed by operators. Students are located in North and South America, Europe and Africa, with a smaller number in Asia.

Maintaining course currency

A theme emerging from the interviews was that data management is a dynamic and evolving field and that it was very important to keep the course current and to amend content and even develop new modules as required. Expectation management has had to be applied here because course changes have to be justified and approved through university processes and there are resource implications for developing new content and if additional content is added it must come at the expense of taking out other content. However, most interviewees felt that it was necessary to integrate more content around data analytics as this has risen in prominence in the wider society and in the petroleum industry in particular. An interesting finding which should be explored in more depth through future work was that there was not the same consensus from interviewees about the relationship between data analytics and data management. One interviewee reported that he thinks that digitalisation and big data analytics will bring about massive changes in the industry and that it was essential that data managers and data management courses address this. Another interviewee felt strongly that analytics was an area that needed to be 'claimed' by data managers in order to maintain the boundaries of the profession.

> I think we have a challenge to absorb the evolution – sorry, the revolution that's come with the analytics world, we need to reach out and occupy the territory and become the go-to people within the companies for issues around information. And the management of that and where that fits in to making a difference with the business, we need to show leadership there too. (Interview with Sponsor Representative)

The relationship between data science and data management was discussed by some interviewees. One interviewee indicated that they were different but that 'one can't exist without the other' with data management being more of a service to the data consumers whereas data scientists are involved in the technical development of algorithms for machine learning, for example. This view was echoed by another interviewee who stated that they did not feel that the role of data managers would necessarily be changed by big data analytics because the core skills of data management are around governance, workflows and processes to facilitate the use of data for whatever the organisation seeks to do with it, including but not limited to analytics.

> ...the data scientists need to clearly elaborate what it is they want, what it is they need in order to do their job. And the data managers' role is to work out how to give it to them. And probably the role that the – the business role above that is to actually make the business case to say, well the data scientists, with the right data, can produce this much value for the business and therefore it's worth spending this amount of money on the data management bit to enable them to do that. (interview with Practitioner 3)

Wang (2018) characterises "data librarians as having a socio-technical context-dependent understanding of data. This is likely to resonate with PDM practitioners. However, this is independent of any specific data science requirement. This is in line with previous work by Robinson and Bawden (2017) which emphasised that data librarians should have technical competence to master data management technology as well as comprehensive knowledge of socio-cultural and ethical implications.

A further interviewee also urged caution about 'following trends' which were influenced by particular technologies, especially as there are a lot of courses and training in data analytics and data science already and that it was of more value to focus on core concepts and skills which would be transferable because "it's about giving people the tools to create knowledge rather than fill empty vessels." (interview with Original Academic Lead).

Further developments towards Professionalisation

It is too early to determine the impact of the PDM course on professional practice but early feedback from alumni and employers who sponsored members of staff on the course has been positive. One interviewee who had sponsored two members of staff from their organisation in the course reported that they had both increased in confidence and the course complemented the employee development activities that were being undertaken in that organisation. An interesting finding was that interviewees also noted that the soft skills developed through a graduate certificate such as negotiation and communication skills were also very valuable in building confidence to be on an equal footing with other managers. The course alumni reported that they felt that it has helped them raise the profile of data management and their own professional reputation within the organisation. Another interviewee whose organisation sponsored students in the first cohort noted that he felt that students could benefit from having industry mentors (ideally in their own organisation) to help them connect their learning in the course to their professional practice.

A theme that was mentioned by the majority of interviewees was that the formal qualifications was a part of the professionalisation journey but that they felt that other associated activities were required as well. This included the development of a professional society (https://societypdm.com/home) with a membership system with a good range of stakeholders to maintain engagement and promotion of the discipline. Once again, interviewees referred to more established professions such as accountancy and engineering as evidence that such associations are important in establishing a professional identity for a discipline.

> ... I do like the idea of a society because again, if the society is saying something it gives people ammunition to go back to their organisation and say, 'as a society, this is what they're saying', it's a stronger voice or it's a voice that is singing the same tune as you are, if you're a data manager in a company at the moment and you're not part of a professional society and you don't have a

professional qualification they your voice many not be heard. (interview with Practitioner 2)

One interviewee noted that it was important that any professional society actively engages members and that they have opportunities to 'take ownership' of the activities to avoid it being dominated by a small group. The proposed professional association was also considered to be beneficial in terms of providing opportunities for CPD such as specialized subject-specific training or leadership training as members advanced in their careers. Further suggestions included the development of joint resources and having newsletters or other professional publications to share news and best practice. There was also a view that the alumni of the PDM course could evolve into a community and for graduates to become advocates and ambassadors for data management within the industry. One interviewee also noted that alumni could assist with providing case studies and other 'real world' examples for course learning materials. However, one interviewee also noted that professional societies can become political and that therefore it is important that the society remains non-political and independent of any particular operators.

Course Sustainability and Future Directions

The final point of reflection regards the future of the petroleum industry and whether the course will be viable in the longer term. There is always a danger that by developing a course for a specific industry it may limit the market of potential applicants. It is estimated that the number of data managers in the petroleum industry is around 5000 people (estimated by one interviewee), which is not a huge target market. The PDM course was initiated at a time when the oil price was high and there was a lot of growth in the industry. Following the oil price crash there has been a considerable reduction in staff and the North Sea region has been particularly hard hit.

Several interviewees commented that roles such as data management seemed to be vulnerable to redundancy when companies were looking to make cuts. However, they blamed this in part to the lack of professional recognition and that this was changing as the value of good data management became more apparent to senior managers in the industry. Interviewees stressed the importance of the PDM course having a global appeal, especially in areas where the industry is still growing. Others suggested that parallel course developments could be undertaken to broaden the market to other data-intensive technical industries including renewable energy. Further, the focus of the North Sea region moves towards smaller operators who are taking over assets from the big operators. This has led to increased collaboration between operators which in turn requires more sharing of information and data. The focus of the industry is now turning to decommissioning where it is definitely true to say that good data management is essential to ensure that data is transferred. The uncertain future of the industry was noted by the alumni interviewee who noted the likely shifts towards renewables to combat climate change and that it was important to develop transferable skills to move into other areas rather than being solely focussed on petroleum-specific data management.

Conclusions and Lessons Learned

This paper critically explored university-industry collaborations for supporting emerging professions by presenting an evaluation of the course development of the Graduate Certificate in Petroleum Data Management. As was demonstrated through the paper, this was ultimately a successful course development process in terms of: meeting the needs of industry, developing an effective curriculum and in the inclusion of industry subject matter experts in the course design and delivery. However, there were significant challenges throughout the course development process. The process was lengthy, involving two years of negotiations and preparatory work before the contract for course development was signed which was then followed by intensive course development before the course was launched in September 2016. Some of this could perhaps be accelerated for future course developments (especially if there is a pre-existing relationship with industry) it is important that this 'pre-development time' is recognised as being valuable because it was a time of intense reflection and development of the core skills and competencies for the petroleum data management profession and was building from a very limited knowledge base. The time spent on course development ensured that the course was closely aligned with the needs of industry and that this was embedded fully throughout the course. However, this protraction did expose recruitment to training budget reductions when the oil price fell. Universities interested in corporate collaboration could amend their commercial and regulatory processes to more efficiently exploit short and medium term corporate opportunities, as processes are sometimes not as agile as are claimed.

One of the biggest challenges of the course development related to the differing perspectives and cultures of academia vs industry, especially related to university administrative procedures and the various academic quality standards and regulations that dictate course development. This was largely mitigated by appointing an academic who was very experienced in working with industry and practitioners and a CDA consultant with experience in academia but was still a source of frustration at times. A key lesson here is to ensure that there are clear boundaries with regards to academic regulations and an associated appropriate division of responsibilities.

The collaborative course design, although in the end a great asset to the course could have been managed more efficiently. A lesson learned from this was that subject matter experts should be appointed early and with specific topic areas to review and that they should be given more explicit instructions about their remit. It could have also been beneficial to have set up a review process through the learning management system or collaborative documents rather than conducting the process by email.

During the course development phase there was a dedicated budget for the recruitment of a course leader who worked exclusively on developing content (in collaboration with CDA and industry) and further resources were dedicated to ensure that high-quality educational resources were developed which involved working closely with educational technology teams at RGU. A further important area was marketing and

promotion. Having industry champions and a dedicated marketing and promotion strategy was essential for raising awareness of the course and boosting student recruitment.

At the time of writing the third run of the course is under way and continues to be well-regarded by industry and academia. To maintain success in the long-term it will be essential to maintain the close collaborative relationship between the university and industry to ensure that the course continues to meet the needs of the developing professional body of petroleum data managers. Initial feedback indicates that the professional qualifications are an important element of professionalisation but that this must be accompanied by developments such as the professional body and clear career development and recognition within the oil and gas industry. It will also be essential to maintain the course currency and discussions will continue about building additional content around data analytics, in particular. Future developments will also take into account the need to diversify the content for different technical, regulated industries through collaborating with other schools within RGU and to ensure that skills developed are transferrable.

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