‘A QUALIFICATION ROUTE MAP FOR THE PIPE-LINE INDUSTRY’,

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Co-Author: Phil Hopkins

A Qualification Route Map for the Pipeline Industry

M Unger, ROSEN Group, UK

P Hopkins, Phil Hopkins Ltd., UK

Pipeline standards and regulations require pipeline engineers to be both competent and qualified, but these requirements are neither defined nor explained. This paper starts by defining and explaining both competency and qualifications, and how to demonstrate and attain both. It also emphasises the importance of, and difference between, 'job qualifications', 'academic qualifications', and 'professional qualifications'.

The key part of the paper presents a qualification 'route map' for the use in the pipeline industry. It is a process involving competency-based learning programs, leading to certified qualifications in various pipeline engineering disciplines. The main features of the process are:

- qualifications, based on…
- competency standards, which are…
- objectively assessed, and supported by…
- competency-based learning programs.

The paper presents examples of both these qualifications and standards, and explains a certification procedure for the qualification. The process can be used by both individuals seeking to confirm their competency, or by companies seeking to implement competency-based qualifications and systems.

1. INTRODUCTION

We all expect to work, and deal, with competent people. Our workplace, schools, highways, stores, government, etc., should be populated with competent people. Fortunately, there are very few incompetent people in a workplace, but they do exist, and in safety-critical industries such as the pipeline industry they can be dangerous. These industries must employ competent staff, and pipeline standards and regulations require staff to be 'competent' and 'qualified' to do their jobs [1]. But… what is meant by 'competent' and 'qualified'?

1.1 Competence

Competence is the ability to undertake responsibilities, and to perform activities to a recognised standard. It is a combination of practical and thinking skills [1, 2], experience [3], and knowledge [4], with a heavy bias on experience[1] in engineering professions, Figure 1. Developing and maintaining competencies involves training, mentoring (coaching) [5], and experience [1, 6]: typically this is made up of 10% training, 20% mentoring, and 70% experience, Figure 2. The definition of competence must also include 'values' or 'behaviours'[2] [6]. All these components of competency have overlap and dependency; for example, 'knowledge' is understanding gained through experience or study.

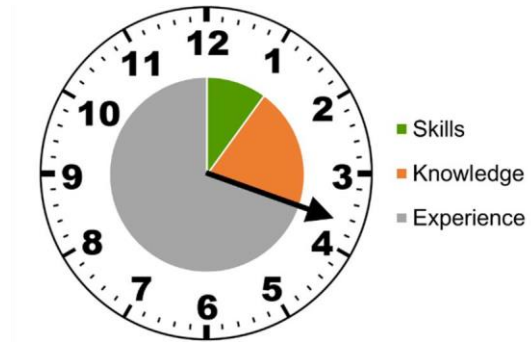

Figure 1. The Competence Clock.

Figure 2. The Gaining Competence Clock.

1.2 Qualifications

A 'qualification' is an official record or document which shows a person has completed a course of study or training, and is qualified to practice a profession or activity. A qualification is expressed in a formal document (e.g., a certificate, degree, diploma, or award).

A qualification has been defined as [7]: '*a formal outcome of an assessment and validation process which is obtained when a competent body*[3] *determines that an individual has achieved learning outcomes to a given standard*'.

1.3 Why do Companies hire Incompetent People?

The meaning and importance of competence is well-understood, so, why do companies hire incompetent people? We have all met competent, and incompetent people in our workplace: the competent work on driving the company forward, while the incompetent work on creating road blocks. Additionally, we have all seen our managers spending many hours trying to improve, motivate, or train incompetent colleagues, and have all been asked to rectify the mistakes of these incompetent colleagues.

[1] Experience is the process of obtaining knowledge and skills in a workplace from doing and/or participating in relevant projects. Experience is work activities accomplished under the direction of qualified supervision, but excluding time spent in organised training programs, and will be years of experience, level of experience, and type of experience. The accumulation of knowledge and skills leads to a competency.

[2] Values are important: incompetent people may have the necessary job competencies, but may be lazy, or lack work values, and hence choose to be incompetent.

[3] A 'competent body' is an individual or group of individuals which can demonstrate appropriate knowledge, skills, and experience to perform the necessary assessments of the topic, skill, or competence under consideration.

Hiring is simple: an interview for about 30 minutes against a simple job specification[4]: a review of a two page CV (written and validated only by the interviewee); and, a short interview panel discussion. You're hired! How did the incompetent pass their interview, and how do they survive and, sometimes, thrive? Unfortunately, many incompetent staff survive due to politeness, and social norms: colleagues and managers are loathe to tell colleagues they are useless or dangerous. These 'bad hires' indicate: an inefficient and flawed hiring process; and, mismanagement of the competency of staff. The solution is therefore simple:

- Hiring staff… should be competency-based. The interview panel need to be competent, the job specification needs to be based on the required competencies, the CV independently validated, and the whole process needs to be structured.
- Managing staff… should be competency-based, and outcome-based. This is important: if you have hired an incompetent person, you may have hired someone very clever, but still incompetent. Incompetent people are often good delegators, do not take risks, and follow company/office rules (this gives them a low profile in troubled times), and focus mainly on working for the 'decision-makers' (this gives them a high profile in good times) [8, 9].

Another common mistake by managers hiring staff is that many managers are over-impressed by confident staff. Confidence is misleading… incompetent people can be very confident people. A previous paper has covered the problem of confidence versus competence: many managers commonly misinterpret displays of confidence as a sign of competence [1]. The incompetent do not know they are incompetent and are unaware of the required skills for a job [10]. Similarly, incompetent managers tend to recruit in their own image.

1.4 The Need for Staff with Demonstrable Competencies

There is no room for incompetent people in the pipeline industry. Standards require competent staff. The Canadian pipeline standard Z662 [11] defines 'competent' as having three components: '*qualified, trained, and experienced to perform the required* duties', but does not define any of its three components. Regulations are also clear about the requirement for competent staff, and the characteristics of competent staff [12]:

- they must have sufficient knowledge of the tasks to be undertaken and the risks involved;
- the experience and ability to carry out their duties, and recognise their limitations.

Staff competencies must also be 'demonstrable': this means supported by tangible evidence. This requirement is supported by past major incidents: they show that the lack of certain skills or knowledge led to errors that contributed to the incident [13]. It had been assumed that:

- an individual with a certain level of experience or training would be competent; and/or,
- the dissemination of a procedure would be sufficient.

Also, as we increasingly rely on 'multi-tasking', 'delayering', and 'downsizing', we expect staff to be able to take on a wider range of responsibilities with less supervision. This increases the need to check competence.

How can companies ensure they hire competent staff, and maintain and demonstrate their staffs' competencies? Two changes are needed: one in hiring staff, and the other is in ensuring staff have the correct qualifications for the job. This paper will now take a closer look at changing to competency-based hiring and ensuring staff have the correct and demonstrable qualifications.

2. CHANGING FROM JOB SPECIFICATIONS TO JOB QUALIFICATIONS

Job specifications give a job title (and seniority level), and usually specify the 'essential' and 'desirable' competencies (Figure 3), but:

- The specification is not always produced to a standard, and does not detail how the competencies are demonstrated.
- The competencies are ad hoc, and directly related to a specific job, and defined and assessed by an interview panel.

[4] There is often confusion between a 'job specification' and a 'job description'. A 'job description' summarises the primary duties and responsibilities of a position in a company (what is to be done in the job), but a 'job specification' summarises the qualifications and competencies needed for the position ((what is needed to do the job).

- Most job specifications will have a headline title (e.g., Senior Design Engineer), but the level ('Senior') will be related to a company's pay/promotion scheme, and the listed competencies will relate to job/company/client/project needs. This creates a highly variable and subjective job specification.
- The job specification lists competencies, but a job applicant does not have any means of showing he/she can meet the competences, other than by answering questions, and pointing to his/her CV.

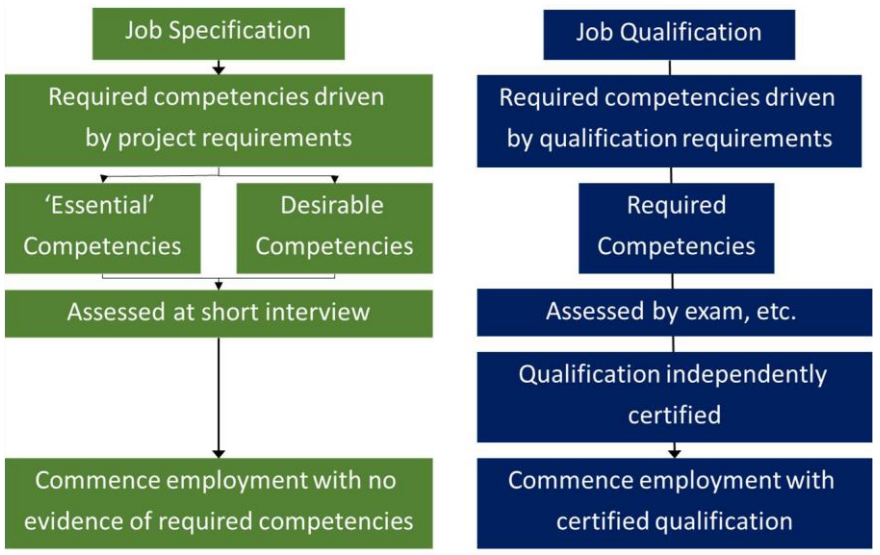

Figure 3. Job Specifications versus Job Qualifications.

The problem is the CV: it is a document that is not verified, nor validated, and is rarely supported by credible documentation. We hire staff on this basis, but would never buy a product on this basis. When a candidate has been selected based on his/her CV, consider the following facts:

- up to 50% of job seekers 'deviate from the truth' on their CV [15, 16];
- about a third of people embellish or exaggerate their academic qualifications when applying for jobs [17]; and,
- most employers spend less than 5 minutes reviewing a CV [16, 17, 18].

You can trust a university when it presents a degree, and you can trust a professional organisation when it presents a qualification, but can you trust an employee when he/she presents a CV?

Job specifications need to change to job qualifications, where an interviewee is asked, and can show evidence of the required competencies, Figure 4. Hence, when the post of 'Senior Design Engineer' is advertised, the applicants must have a qualification in design engineering, at a senior level, and this must be demonstrable. The next section explains why this change to 'qualifications' is both needed and essential.

CV Content	Example	Demonstrable Competencies in the Content?	Content Certified?	Content Verified?
Academic qualifications	BSc	Yes (e.g., by examination)	Yes (e.g., by a university)	Yes (e.g., paper certificate issued)
Professional qualifications	PEng	Yes (e.g., by assessment and interview)	Yes (e.g., by a professional institution)	Yes (e.g. paper certificate issued)
Job qualifications	Previous jobs and experience	No (previous experience and competencies gained rely on the interviewee's opinion and perception)	No (previous employers only certify job titles and time in position)	No (previous employers do not verify the contents of a former employee's CV, relating to their employment)

Figure 4. The CV Dilemma…

3. ENSURING OUR STAFF ARE QUALIFIED

A 'qualification' has been defined above as '… *the formal outcome of an **assessment** [e.g., an examination] and validation process which is obtained when a **competent body** determines that an individual has achieved **learning outcomes**[5] to a given standard'.* So… a qualification requires (Figure 5):

- **learning outcomes** [19] to a standard;
- an **assessment**; and,
- validation (certification[6]), by a **competent body**.

Academic qualifications (e.g., a BSc) have all these requirements:

- the degree program will have had a learning program with defined learning outcomes;
- the degree would have been continually assessed (e.g., by examination) against the stated outcomes; and,
- the program, outcomes, assessments, and results of the assessment will have been validated and certified by a 'competent body (i.e., a university).

[5] A 'learning outcome' identifies and states what a learner will know and be able to do by the end of a course or program. The learning outcomes give measurable results from studying a course/program. Assessment is against these outcomes.

[6] There is often confusion over the terms 'qualification' and 'certification'. Engineering standards ask for 'qualified' personnel ('qualified' through training and/or experience) to produce the products to the required standard. Standards such as ASME B31.4 and B31.8 ask for these qualified personnel, but never ask for 'certified' personnel.
Companies often decide who is 'qualified', by assessing their personnel's training and experience against their own processes and criteria. The customer must trust the companies' processes. These processes and criteria are documented but they are not usually 'certified' (a verification that the product, service or system in question meets specific requirements). These 'employer-based' qualifications will lead to a variety of criteria, inconsistency, and may lead to a lack of credibility. A better approach is for an independent third-party certification body to certify the qualification, based on a central certification standard, or agreed processes and criteria. ISO [20] defines 'certification' as: '*the provision by an independent body of written assurance (a certificate) that the product, service or system in question meets specific requirements*.'

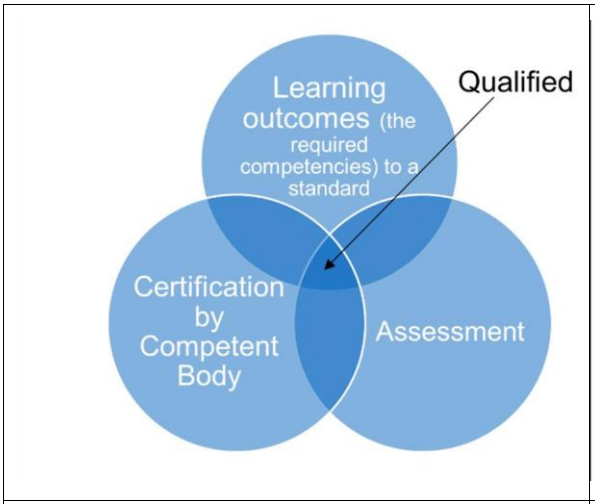

Figure 5. Components of a Demonstrable Qualification.

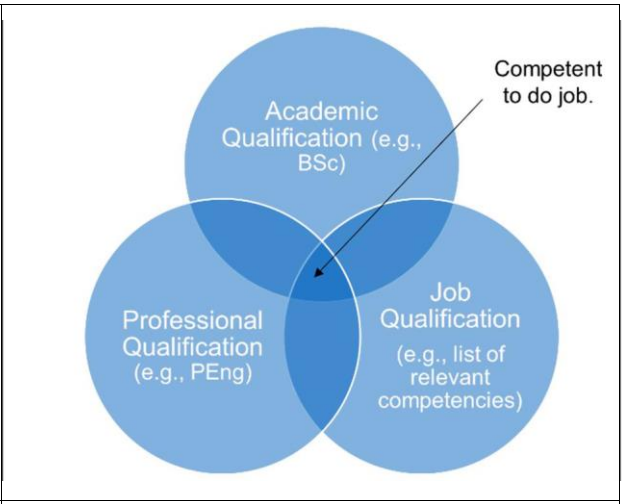

Figure 6. Types of Qualifications.

Unfortunately, academic qualifications are just one of three qualifications needed to demonstrate competence in a job. These three types of qualifications are (Figure 6):

- academic (e.g., a university degree);
- professional (e.g., PEng);
- job-specific (e.g., competent to a junior/senior/principal/expert level in a specified area).

This combination of three qualifications make a member of staff competent. Both academic and professional qualifications meet the above three criteria for a qualification (learning outcomes, assessment, and validation/certification). A problem with academic qualifications is that a college degree at the start of a working career, or during a career, cannot address the need for the continuous acquisition of new skills, particularly as career spans are lengthening, Figure 7. Similarly, professional qualifications are usually generic, and related to ethics, integrity, character, professionalism, and experience: these characteristics (other than experience) should be constant/consistent throughout a career.

Job-specific qualifications/competencies do not meet the above three criteria (learning outcomes, assessment, and validation/certification). How can a company demonstrate staff competencies, without these criteria? The major problem with job-specific qualification is that the competencies are not assessed nor certified by a competent body, in contrast to the other qualifications, and their relative importance to acting competently dramatically changes with time, Figure 7.

Figure 7 illustrates how the key qualification is the job-specific qualification, but it is the one that is rarely certified. This means that job competencies may not be demonstrable.

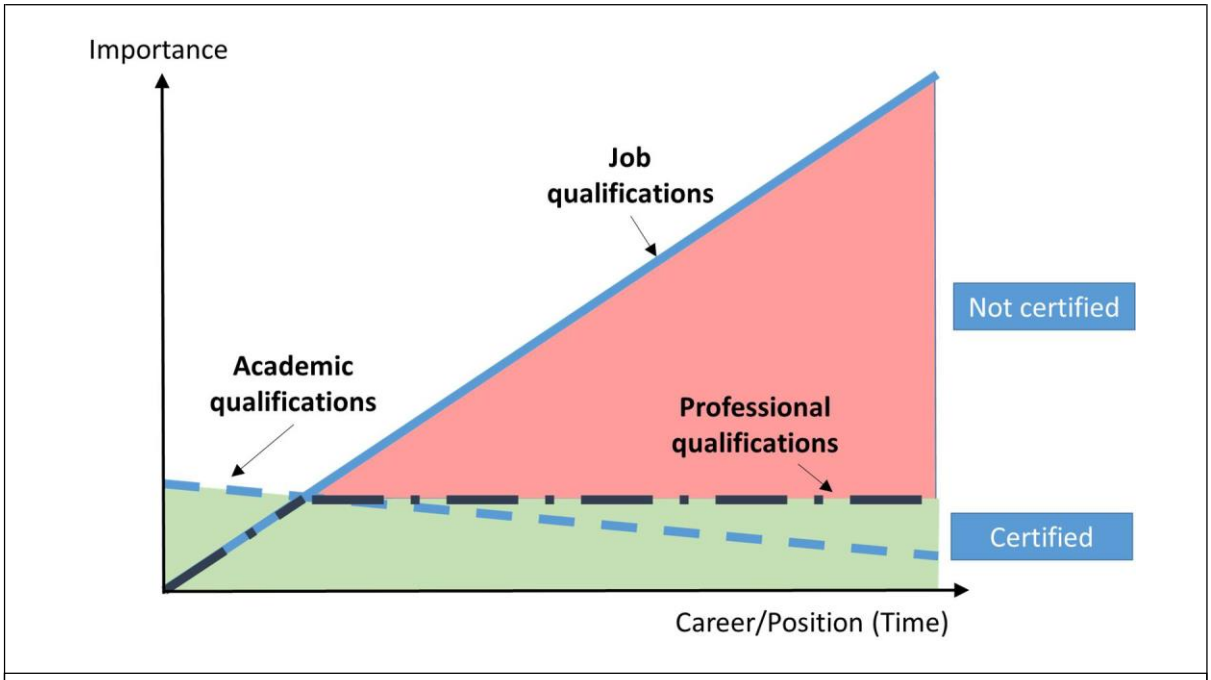

Figure 7. Relative Importance of Differing Qualifications with Time.

4. THE VALUE OF COMPETENCY

Competency in the pipeline business is both a regulatory requirement, and specified in pipeline standards [1]: it is a requirement and expected. Competency also has real value to a business [21]. It can be viewed in the same way as 'net present value' (NPV) [22]. We all know that the money we have in our hands today is more valuable than money we will have next year: future money is also less valuable because inflation erodes its buying power. We compare money now with money in the future by using NPV: a simple way to protect our money today is to invest it, or put it into a bank savings account. This investment can protect its value. Competency is the same, and its value needs to be assessed: what will be the cost of competency development, how will performance be improved, and how much return on the cost (investment) will be achieved? Reference 21 covers these type of calculations.

An additional consideration with competencies is reward. More competence should lead to higher positions in a business. Competence development takes time, Figure 2, but the required expertise is likely to take more than 10 years to achieve [23]. Increasing competence may not always be rewarded: an analysis of American wage growth by economists at the New York Federal Reserve showed that the bulk of earnings growth took place between the ages of 25 and 35; on average, after the age of 45 only the top 2% of lifetime earners see any earnings growth [24].

5. LEVELS OF COMPETENCY

Staff will require differing levels of competency: few staff need to be on an expert level in all their required competencies. It is necessary to categorise the competency of staff in the same way as staff are graded by job. Table 1 gives a summary of typical competency levels quoted in the literature [1, 25, 26, 27].

Competency Level (characteristic)	Description	Knowledge	Supervision	Responsibility	Summary
Awareness (probation)	This level is for new or inexperienced staff with no competencies, and staff (such as senior managers) who only want an 'awareness' of a competency. These staff can be considered in a '**probation'** or '**awareness'** period, where time is allowed for a job holder to demonstrate basic understanding of the job competencies, but is not required to carry out work without close and continuous supervision in all of these tasks.				Can interpret and evaluate the knowledge, and can both communicate it and present coherent arguments.
Foundation (knowledge)	Understanding of effects and consequences.	Knowledge and understanding of best practice[7].	Is able to carry out work **with supervision.**	The Practitioner/ Expert supervises their work.	Critical understanding and analysis of the knowledge, and able to **apply the knowledge.**
Practitioner (application)	Demonstrates competence to select the most appropriate options.	Aware of current developments, and has demonstrated experience, and can apply knowledge to new situations.	**No supervision required.**	Can supervise Foundation Level.	Able to self-manage, with a critical and systematic understanding of the knowledge, and can **make judgements and propose solutions.**
Expert (creation)	Breadth of experience and knowledge. Deep understanding of best practices.	Demonstrated managerial skills to undertake overall responsibility of a function, and can apply new knowledge to new situations, and deliver solutions.	**Can train and assess others.**	Can supervise Practitioner Level.	A self-learner with a critical awareness of current and complex issues and best practices, and is able to do original work, deal with multiple problems, able to explain theoretical bases and weaknesses, and can propose new solutions. **A subject matter expert.**

Table 1. Competency Levels.

6. A ROUTE MAP TO DEMONSTRABLE COMPETENCY

How can a company ensure a member of staff is competent to do his/her job? The answer is in being able to demonstrate competency, and this is done by gaining a qualification, Figure 6. This section presents a route map to demonstrable competency. It is a process involving competency-based learning programs, leading to a certified job qualification (Figure 6) in various pipeline engineering disciplines. The main features of the process are:

- qualifications are obtained, based on meeting…
- 'competency standards', which are…

[7] 'Good practices' are practices, documents, and guidelines produced by: government departments; standards-making organisations (e.g. ISO, ASME, CEN); trade federations; professional institution; etc.. They are readily available, and recognised as current practice. They can be considered 'minimum' requirements. 'Best practice' goes beyond these 'good practices', and would be expected to be the best available practice, supported by other practices that give a measured and demonstrable improvement.

- objectively assessed, and supported by…
- competency-based 'learning programs'.

The process is summarised in Figure 8. The whole process can be then certified by an independent body (the 'competent body'). This results in demonstrable competence through having a certified qualification.

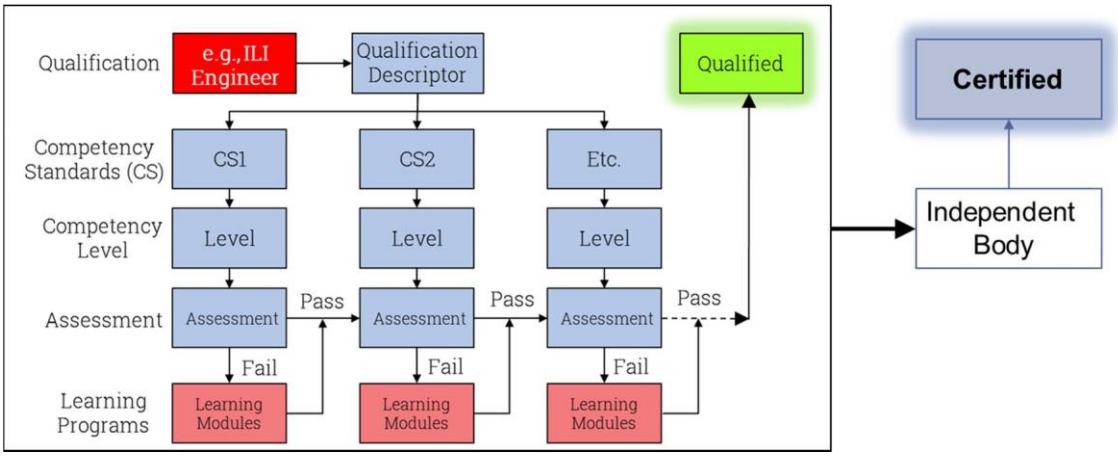

Figure 8. Competence Route Map.

6.1 The Start: 'Qualification Descriptor'

The route map starts with defining the required qualification for the job; for example the qualification for a pipeline integrity engineer. This pipeline integrity engineer qualification will need a list of required competencies (for example being able to perform fatigue calculations), for each job level of this engineer (for example; pipeline integrity engineer, senior pipeline integrity engineer, principal pipeline integrity engineer). As the job level rises, the number of competencies, and the mastery of these competencies, will increase.

The qualification requirements and expectations, and how to gain the qualification, are encapsulated in a 'Qualification Descriptor'. A Qualification Descriptor (QD) is [27]:

- a statement of the main outcomes which are to be assessed, and which a holder of the qualification should be able to demonstrate for the award of the qualification; and,
- a statement of the wider abilities that a typical holder of the qualification would be expected to have developed, to give a wider view of the capabilities of the holders of the qualification.

A QD will also detail the learning demand the learner will encounter at each job level (e.g., between a senior and a principal integrity engineer), and demonstrates the nature of change between levels. The key part of the QD is the qualification 'outcome'. This is the outcome to be expected from staff completing the qualification. Outcomes will vary between each job level and reflect the increasing demands as the job levels increase; i.e., as the level of expected competency increases. Appendix A gives an example of a QD for a pipeline integrity engineer.

The QD lists all the required competencies included in the qualification, and the required levels of these competencies, Table 1. Each of these competencies are detailed in a 'Competency Standard'.

6.2 Competency Standards

Competencies of a job holder need to be assessed against a defined standard to ensure validation. There is little point in asking an engineer if he/she is competent in a certain skill (most will say 'yes'), or ask him/her how competent they are (they will probably say 'very').

Competency Standards provide a common definition of a competency, with its minimum requirements, elements, and how the competency is obtained (training, experience, etc.) [29, 30, 31, 32]. It is best to keep these standards simple, but also measurable, and auditable. Hence, the

Competency Standard must detail 'outcomes': what a member of staff will be able to do in some measurable way (there may be more than one measurable outcome defined for a given competency).

Appendix B gives an example of a Competency Standard for ‘pipeline engineering principles’.

6.3 Competency Assessment

The competence route map requires all competencies to be ‘demonstrable’. This means a record of ‘assessment’. An assessment is an evaluation and demonstration of understanding against the stated learning outcomes in a competency standard. Assessments are conducted against specified criteria. ASTM E2659-15 [33] considers this ‘criterion’ approach as ‘… determining a passing standard for a learner assessment based on subject matter expert-identified performance standards and not based on the performance of other students.’

All staff in a company will have a job specification which details the job title, job level (e.g., junior, senior, or principal), the competencies required, and what he/she is expected to be able to do in his/her job. A competency-based system additionally requires applicants to demonstrate these competencies and abilities. This demonstration will involve an assessment. There are various methods of assessing competencies: self-assessment [34]; performance; examination; and, interview. The Competency Standard will specify the type of assessment, Appendix B.

6.4 Competency Matrix

Companies will require staff on differing levels of competency and seniority. In an engineering department this will usually be on three levels: engineer; senior engineer; and principal engineer. This route map uses these three job levels.

These three job levels can be used to construct a competency matrix that summarises the competencies required at each job level, and the competency level, Table 1. Appendix C gives an example of a competency matrix for a pipeline integrity engineer.

Listing the required competencies for a qualification, and how they are assessed, allows staff to appreciate what is needed to obtain the qualification. The competencies are obtained by a combination of training, mentoring, and experience, and these three elements are detailed in a Learning Program.

6.5 Learning Programs

Learning Programs consist of Modules: these Modules can involve training, mentoring, and gaining relevant experience in a particular skill, and lead to a qualification, following an assessment (e.g., an examination). Consequently, a Learning Program is a planning document, detailing:

- profile, necessary qualifications, and co-requisites and pre-requisites of the learner;
- method of delivery;
- learning needs, strategy, and outcomes;
- competencies being addressed/delivered;
- assessment criteria; and,
- trainer/teacher requirements.

An example of a Learning Program to achieve an onshore pipeline engineer qualification is given in Appendix D. The qualification can then be certified after completion of the Learning Program, by an independent organisation/competent body, as being to a required standard, Figure 8.

6.6 Certification

Any individual or organisation can obtain a qualification, if they follow the requirements of the qualification descriptor, and – where necessary – successfully complete the Learning Program, Figure 8. It is necessary to independently ensure that an individual or organisation has followed the required process, and satisfied all the requirements. The process is assessed by a Competent Body who determines if the process demonstrates the required competency.

Certification is a 'stamp' of approval, which states and confirms a Qualification Descriptor will provide the qualification it is describing, and contains an assessment to prove it. Certification shows that a procedure and process (as detailed in this document) has been followed and approved by a Competent Body.

The route map described in this paper uses the Qualification Panel for the Pipeline Industry [35] for certification. This panel systematically checks the qualification procedure to ensure it produces competent staff.

7. DISCUSSION

The previous Sections have emphasised the importance of competence in the pipeline industry, but the competencies have to be demonstrated (i.e., provide tangible evidence) and documented. The pipeline regulator in the USA is very clear about this [36]:

'Verify that the personnel who execute the activities within the integrity management program are competent and properly trained in accordance with the quality control plan… Personnel, including vendors and subcontracted personnel, involved in the integrity management program are expected to be competent, aware of the program and all of its activities and are to be properly trained to execute the activities within the program. Documentation of such competence, awareness and qualification, and the process for their achievement, is to be a part of the quality control plan.'.

Similarly, a pipeline standard quotes [37]:

'Management should establish clear competence requirements for all the roles... from senior levels to technicians and operations staff. A process should be put in place to ensure that only competent personnel are assigned to posts unless they are training under supervision.'

How does the pipeline industry currently meet these requirements and qualifications? There is still a great reliance on training in the form of courses. The training element of competency takes many forms, ranging from classroom-based lessons, to personal coaching in the field. Organisations such as NACE [38] offer comprehensive programs that both qualify and certify pipeline staff in certain skills. Similarly, API offers training programs for pipeline professionals [e.g., 39], but most of these programs are aimed at technician/operator levels, and do not cater for graduate-level jobs, or managerial posts.

Most industry training courses are presented by good trainers, using good materials, organised by good training providers, but most are not accredited by any reputable organisation, and there is no assessment to demonstrate understanding: this leads to a lack of credibility [40]. This lack of credibility is a major problem in the pipeline industry, and needs urgent solutions [1, 40].

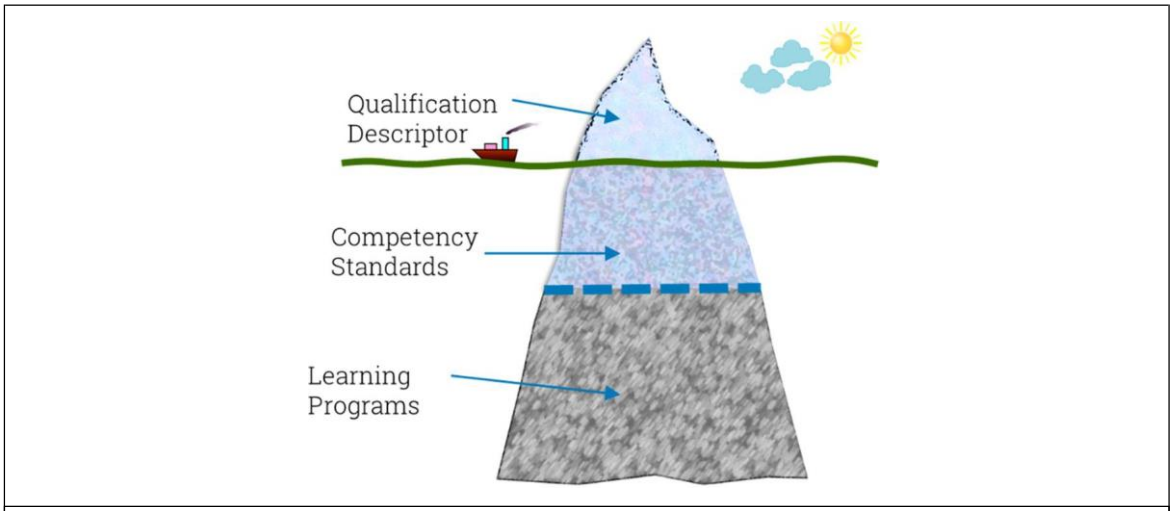

Figure 9. The Qualification Iceberg.

The route map (Figure 8) presented in this paper can overcome these concerns. Competence demonstrated using this route map will not be easy: it will involve a lot of work and management, and it is the Learning Programs that are likely to be the biggest element of the route map, Figure 9.

The route map starts with a qualification descriptor, and ends with a learning program. This is a 'top-down' approach to learning and competency development (Figure 8), and is the approach adopted in academia [6]. Industry has traditionally adopted the opposite approach: starting with training courses and working up towards a qualification (bottom-up). In effect, this is turning the iceberg upside-down, Figure 9, and is not the correct approach to learning and qualifications.

It is important to emphasise that the route map in this paper is focussed on technical competencies, but behavioural competences and values are also important; for example, human failure due to 'violations' [41] will be due to failures in behaviour or values.

Engineers need their technical competencies, and these will be biased to intelligence quotient (IQ). But IQ is only one measure of a person, and IQ is both 'impersonal and non-social' [42]. There are other measures of a person, as IQ is only one measure [6, 43]; for example:

- EQ (Emotional Intelligence): being aware of your own feelings and those of others;
- BQ (Body Intelligence): what you know about your body, how you feel about it, and take care of it;
- MQ (Moral Intelligence): your integrity, responsibility, sympathy, and forgiveness.

These other quotients explain how technically competent engineers may not be good leaders or managers, and may commit violations. Consequently, it is necessary to take a broader view of competencies, if all human failures are to be reduced. This broader view will have the major, additional advantage of having technically competent people with values that go beyond knowledge and skills: they will be consistent workers; pay attention to detail; have a good work ethic; share knowledge; and, possess good people and communication skills, allowing them to easily fit into teams.

8. CONCLUSIONS

1. 'Competence' is a mix of skills, knowledge, and experience.
2. A 'qualification' is an official record or document which shows a person has completed a course of study or training and is qualified to practice a profession or activity; i.e., they are demonstrably competent to practice.
3. There are three types of qualifications: academic; professional; and job. An individual's academic and professional qualifications are certified and validated by independent bodies, but their qualifications (competencies) needed for a job are neither certified nor validated, and rely on the individual's CV.
4. This paper has presented a 'route map' that ensures job qualifications (competencies) are demonstrable, certified and validated. The route map is summarised as:
    - QUALIFICATION: This process starts with a 'qualification descriptor' which details the qualification requirements and expectations, and how to gain the job qualification. The qualification descriptor summarises all the required competencies for that job.
    - COMPETENCY STANDARD: Each competency is fully described in a 'competency standard'. These standards provide a common definition of a competency, with its minimum requirements, elements, and how the competency is obtained (training, experience, etc.).
    - ASSESSMENT: Each competency is assessed (e.g., by examination) against specified criteria.
    - LEARNING PROGRAM: A learning program is detailed that contains the training, mentoring, and experience requirements to gain each competency.
    - CERTIFICATION: The whole qualification process can be certified by an independent body, resulting in a qualification, containing demonstrable competencies, which is both certified and verified.
5. Finally, this paper has focussed on technical competencies. Staff behaviour and values are also important and need to be included in an overall competency management system.

9. ACKNOWLEDGEMENTS

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10. REFERENCES

1. M Unger, P Hopkins, ‘‘Competency’ in Engineering’. 28th International Pipeline Pigging & Integrity Management Conference Houston, USA, February 8-11, 2016.
2. Anon., ‘Pipeline Personnel Qualification’, American Society of Mechanical Engineers. ASME B31Q-2014. 2016.
3. Anon., ‘Pipeline Transportation Systems for Liquids and Slurries’, American Society of Mechanical Engineers. ASME B31.4-2016. 2016.
4. https://primis.phmsa.dot.gov/oq/glossary.htm.
5. M Unger, P Hopkins, ‘The Forgotten Art of Mentoring’, World Pipelines, December, 2015.
6. M Unger, P Hopkins, ‘Training and Education: The Great Competence Divide’, 11th International Pipeline Conference, IPC 2016. Calgary, Alberta, Canada. Paper IPC2016-64500. 2016.
7. Anon., ‘European Qualification Framework for Lifelong Learning’, European Parliament and Council of the EU, 2008.
8. T Chamorro-Premuzic, ‘Why do so many incompetent men become leaders?’. Harvard Business Review, August 22nd, 2013. https://hbr.org/2013/08/why-do-so-many-incompetent-men.
9. J Francis, ‘Why Incompetent People get Hired (and Promoted)’, HR Gazette. October 26, 2015.
10. J Kruger, D Dunning, ‘Unskilled and unaware of it: how difficulties in recognising one’s own incompetence lead to inflated self-assessment’. J. Pers. Soc/ Psychol. December 1977 (6): 1121-1134.
11. Anon., ‘Oil and gas pipeline systems’, CSA Z662-15, Canadian Standards Association. 2015.
12. http://www.hse.gov.uk/construction/cdm/faq/competence.htm
13. Anon., ‘Competence assessment for the hazardous industries’, UK’s Health and Safety Executive. Research Report 086. Her Majesty's Stationery Office. UK. 2003. http://www.hse.gov.uk/research/rrpdf/rr086.pdf
14. Anon., ‘CV lies’, The Guardian. UK. 24th June, 2009. https://www.theguardian.com/careers/cv-lies.
15. C D Korver, ‘The Ethics of Resume Writing’, Harvard Business Review. May 19th, 2008. https://hbr.org/2008/05/the-ethics-of-resume-writing-2.
16. K Dill, ‘More Than 50% Of Employers Have Found a Resume Lie - These are some of the Most Memorable’. Forbes. August 18th, 2015. http://www.forbes.com/sites/kathryndill/2015/08/18/more-50-of-employers-have-found-a-resume-lie-these-are-some-of-the-most-memorable/#36f6db5c5835.
17. J Rowley, ‘Degree deceit: does it pay to lie on your CV?’. The Guardian. UK. 18th June 2014. https://www.theguardian.com/careers/careers-blog/lie-degree-cv-jobseekers-graduate
18. Anon., ‘Poll Reveals HR Takes Less Than 5 Minutes to Review a Resume’, Society for Human Resource Management. April, 2014. https://www.shrm.org/resourcesandtools/hr-topics/talent-acquisition/pages/shrm-resume-poll.aspx
19. Anon., ‘Standard Practice for Certificate Programs’, ASTM E2659. ASTM International, West Conshohocken, PA, 2015, www.astm.org.
20. http://www.iso.org/iso/home/standards/certification.htm.
21. J. Ford Brett, ‘Investing in People: How to Quantify the Value of Competency Development’. Petroskills White Paper. April, 2013. https://www.petroskills.com/blog/articles/white-paper_ford-brett_investing-in-people.pdf.
22. A Gallo, ‘A Refresher on Net Present Value’, Harvard Business Review, November 19, 2014. https://hbr.org/2014/11/a-refresher-on-net-present-value.
23. S Little, T Ray, ‘Managing Knowledge’, 2nd Edition. Open University. Sage Publications. London. 2011.
24. Anon., ‘Pathway Dependency – turning qualifications into jobs’, The Economist. 14th January, 2017.
25. Anon., ‘Competency Framework’. Institution of Gas Engineers and Managers. IGEM/TD/102. Communication 1761. June, 2012.
26. Anon., ‘Guidelines for Competency Management Systems for COMAH Sites’, cogent. July 2012. www.cogent-ssc.com.
27. http://www.ihrdc.com/pdfs/CMBrochure.pdf

28. Anon., ‘Pipeline Personnel Qualification’, ASME Code for Pressure Piping, B31. ASME B31Q-2010. 2010.
29. Anon., ‘UK Quality Code for Higher Education Part A: Setting and Maintaining Academic Standards’, Part A. The Frameworks for Higher Education Qualifications of UK Degree-Awarding Bodies. October 2014.
30. Anon., ‘APIA Pipeline Engineer Competency Standards’, Australian Pipeline Industry Association. Revision A. 2010.
31. http://www.opito.com/media/downloads/competence-assessment-and-verification-guidelines.pdf. OPITO, the Offshore Petroleum Industry Training Organisation.
32. Anon., ‘UK-SPEC UK Standard for Professional Engineering Competence’, Engineering Council, UK. Third edition. 2013. www.engc.org.uk.
33. Anon., ‘Standard Practice for Certificate Programs’, ASTM E2659-15, ASTM International, West Conshohocken, PA, 2015, www.astm.org.
34. Anon., 'Competency Self-Assessment Worksheet User Guide', APEGA. Canada. November, 2016. https://www.apega.ca/apply/work-experience/competency-self-assessment-worksheet/
35. http://education.rosen-group.com/##team
36. Anon., ‘Gas Integrity Management Inspection Manual’, Inspection Protocols with Supplemental Guidance. Pipeline and Hazardous Materials Safety Administration. Office of Pipeline Safety. USA. January 1, 2008.
37. Anon., ‘Pipeline systems. Part 4: Steel pipelines on land and subsea pipelines – Code of practice for integrity management’, Published Document PD 8010-4:2012. British Standards Institution. 2012.
38. http://www.naceinstitute.org/certification/pipeline-industry-program.aspx.
39. http://www.api.org/Certification-Programs/IndividualCertificationPrograms.
40. Anon., ‘Safety Study: Integrity Management of Gas Transmission Pipelines in High Consequence Areas’, National Transportation Safety Board, USA. NTSB/SS-15/01. PB2015-10273. January, 2015.
41. Anon., ‘Understanding human failure’, HSE. UK. www.hse.gov.uk/construction/lwit/ December, 2012.
42. S S Hallmay, ‘The Older-and-Wiser Hypothesis’. The New York Times Magazine. 6th May, 2007.
43. K Jensen, ‘Intelligence Is Overrated: What You Really Need To Succeed’, Forbes. 12th April, 2012.

APPENDIX A: EXAMPLE OF A QUALIFICATION DESCRIPTOR

Qualification Title		**Pipeline Integrity Engineer**
Purpose of this Qualification		The 'Integrity Engineer' Qualification is designed to produce engineers who can deal with pipeline integrity problems, with supervision.
		The Integrity Engineer can assess defects reported in a pipeline, using and understanding best practices, and produce conclusions and recommendations, with supervision.
		The Integrity Engineer can write clear reports, understanding the objectives and consequences of his/her work, and is able to engage with clients at meetings, and explain their work.
Qualification Outcome[1] (what a holder of the qualification should be able to demonstrate, in terms of knowledge, understanding, skills, communication, judgement, and application of the knowledge/skills).[2]	**Competency Standard**	This qualification indicates that the holder:
	1	is able to **describe** pipeline engineering principles, **discuss** best practices, and **explain** their bases;
	2	is **aware** of his/her ethical duties to all stakeholders;
	Etc.	
	5	can **describe** differing pipeline inspection and surveillance methods, and **compare** the best methods;
	Etc.	
	14	can **define**, and **distinguish** between, differing integrity management methods/techniques, particularly pipeline integrity management and systems, and can **list** the threats to pipeline safety and the consequences of pipeline failure;
	Etc.	
	32	can **explain** the history of fracture mechanics, its principles, models (elastic, elastic-plastic, and plastic), **compare** differing models, **defining** the best assessment methods using fracture mechanics, and **define** and **distinguish** between the traditional approach to fatigue assessment, and the fracture mechanics approach to fatigue assessment;
	Etc.	
	47	is **aware** of health, safety, environment, and security responsibilities;
	Etc.	
Wider Outcomes (wider abilities that a typical student would be expected to have developed).		The Pipeline Integrity Engineer can write clear reports, understanding the objectives and consequences of his/her work, and is able to engage with clients at meetings, and explain their work.
		He/she can give reasoned conclusions and recommendations on pipeline engineering critical assessments, with supervision.
Qualification Requirements		**Awareness Level (see Table 1).**
		Competency Standard No 2: Pipeline Engineers: Ethics and Responsibilities
		Etc.
		Competency Standard No 47: Health, Safety, Environment, Security
		Etc.

	Foundation Level (see Table 1).
	Competency Standard No 1: Pipeline Engineering Principles
	Competency Standard No 5: Pipeline Inspection and Surveillance
	Competency Standard No 14: Pipeline Integrity Management
	Competency Standard No 20: Pipeline Defect Assessment
	Competency Standard No 32: Fracture Mechanics
	Etc.
	Practitioner Level (see Table 1). None
	Expert Level (see Table 1). None
Entry Requirement/Pre-requisites	1. Progressing or completed CEng or PEng or equivalent.
	2. Qualified as either a Subsea Pipeline Engineer or Onshore Pipeline Engineer.
Learning Programs' Content	The content of the Learning Programs for each of the specified levels are detailed in the individual Competency Standards, and must be submitted to the Competent Body (expert panel), for approval.
Modes of Delivery of Learning Programs	Learning Programs are detailed in the individual Competency Standards.
Assessment of Learning Programs	Assessments of Learning Programs are detailed in the individual Competency Standards.
Competence of Trainers and Assessors	Competence of the Trainers and Assessors of Learning Programs are detailed in the individual Competency Standards.
Recognition of prior learning	Prior learning can be used as satisfying parts or all of this Qualification.
	The prior learning must be detailed, and validated.
Certification (Training, Mentoring, and Experience) Requirements	Training, mentoring, and experience requirements are detailed in the individual Competency Standards. A Pipeline Integrity Engineer is expected to have at least 2 years' experience as a qualified Pipeline Integrity Engineer before progressing to a Senior Pipeline Integrity Engineer qualification[3].
	A Pipeline Integrity Engineer has 2 years to attain all the Standards specified in this Descriptor[4].
Certification Process	This Descriptor will be submitted to the Qualification Panel
Competent Body	Qualification Panel.

Notes:

[1] Qualification outcomes imply the assessment criteria.

[2] Outcomes must be measurable, therefore, 'active' verbs are used such as: analyse, calculate, classify, copy, compare, define, develop, design, discover, duplicate, distinguish, describe, evaluate, explain, identify, interpret, implement, label, list, locate, manage, match, name, observe, outline, perform, plan, produce, quote, recall, recite, recognize, record, repeat, reproduce, state, summarise, tabulate, tell, use, undertake, etc.. For definitions see Reference 28.

[3] This experience is after satisfying all the standards in this qualification. The member of staff is not qualified until he/she has satisfied all the competency standards for this qualification.

[4] It is recognised that obtaining a qualification will take time. Staff start this qualification with only the necessary pre-requisites and are recommended a timescale to obtain the competencies (e.g., 2 years). Longer and shorter time periods are acceptable, but the member of staff is not qualified until he/she has passed all the standards.

APPENDIX B: EXAMPLE OF COMPETENCY STANDARD

Overview	
Competency Number	2
Competency Title	Pipeline Engineering Principles.
Competency Level (Awareness, Foundation, Practitioner, Expert)	Foundation (see Table 1).
Competence Description	The underlying principles, concepts, and technical parameters in pipeline engineering.
Competency Purpose	Gives the student a foundation in pipeline engineering principles.
Competency Outcomes:	
These outcomes should cover:	
'Ability' is able to do a task… this is 'skill'.	1. Can conduct work on pipelines, under supervision.
'Understanding' is able to understand and explain the task… this is 'knowledge'.	2. Is able to describe pipeline engineering principles, discuss best practices, and explain their bases.
'Supervise' is able to manage staff with these abilities and/or understanding.	3. Can summarise key pipeline concepts (e.g., fluid flow), properties (e.g., geometry), types (e.g., oil or gas), and their standards and specifications.
'Train' is able to train staff with these abilities and/or understanding, and/or supervisory abilities.	4. Cannot teach this competency.
Qualifications (e.g., academic or professional)	Progressing or completed CEng or PEng or equivalent.
Pre-requisites [1]	None.
Co-requisites [2]	None.

Competency Elements		
Competency Elements:	**Detail**	**Assessment [3]**
skills (ability to do a task)	None.	None
knowledge (understanding the task)	1. History of pipeline, their standards, types, use, and benefits.	Examination
	2. Line pipe manufacture, types, and coatings.	
	3. Pressure, fluids, phases.	
	4. Material strength ductility, fatigue.	
	5. Stress, design factor, design pressure.	
supervising and/or training	None.	None

Training Courses that Satisfy the Training Element of this Standard	
Training/coaching/experience recommended to gain this competency	Take module on this competency at Northumbria University Distance Learning Program, UK, or purchase learning 'key' from Clarion Press, USA.

Mentoring and Experience Requirements	
Mentoring (guided-learning… years to obtain the knowledge)	These requirements are detailed in the Learning Program where this competency is quoted.
Experience (self-learning… type, years, supervision to obtain the knowledge)	These requirements are detailed in the Learning Program where this competency is quoted.

[1] The required knowledge or conditions that must be satisfied before being considered for this competency. A pre-requisite is a requirement that must be met before you attempt this competency.
[2] A co-requisite is a requirement that must be taken at the same time. Co-requisites usually contain information needed to allow the specified competency to be achieved.
[3] Assessment is the process of ensuring that individuals are competent to undertake their job roles in accordance with this Standard and its elements.

APPENDIX C: EXAMPLE OF COMPETENCY MATRIX FOR AN INTEGRITY ENGINNEER

Element		Engineer	Senior Engineer	Principal Engineer
Competency (skill element)[2]	Subject Matter Expert			E[1]
	Pipeline Engineering Principles	F	F[1] →[1]	P[1]
	Pipeline Engineers: Ethics and Responsibilities	A[1] →	F	F
	The Oil and Gas Industry	A	A	A
	Pipeline Project Control	A →	F	F
	Pipeline Inspection and Surveillance	F	F	F
	Onshore Laws, Regulations, Standards	A	A →	F
	Subsea Laws, Regulations, Standards	A	A →	F
	Pipeline Hydraulics	A	A	A
	Pipeline Risk Management	A	A →	F
	Onshore Pipeline Design	A →	F	F
	Subsea Pipeline Design	A →	F	F
	Pipeline Repair	A →	F	F
	Pipeline Materials	A →	F	F
	Pipeline Integrity Management	F	F	F
	Internal Corrosion Mechanisms	A →	F	F
	Internal Corrosion Prevention and Monitoring	A →	F	F
	External Coating Selection and Field Joints	A →	F	F
	Pipeline Defect Assessment	F →	P→	E
	In-line inspection Technologies and Procedures	F	F →	P
	Pipeline Inspection Technologies & Procedures	A	A	A
	Cathodic Protection and Monitoring	A	A →	F
	ILI Data Analysis and Reporting	F	F	F
	Stress Analysis	F	F	F
	Verification of Inspection Results	A	A	A
	Fracture Mechanics	F →	P	P
	Failure Analysis	A →	F →	P
	Pipeline Welding	A	A →	F
	Onshore Pipeline Routing	A →	F	F
	Subsea Pipeline Routing	A →	F	F
	Failure Modes and Mechanisms	A	A	A
	Risk Analysis Tools/Techniques	A →	F	F
	Probability Theory	A	A	A
	Consequence Analysis	A →	F	F
	Health, Safety, Environment, Security	A	A	A
	Pipeline Defects	A	A →	F
Mentoring (years)[3]		0-1 →	3-5 →	≥5
Relevant Experience (years)[4]		0-2 →	3-7 →	≥10

Notes:
[1] A = Awareness, F = Foundation, P = Practitioner, E = Expert. → Progression.
[2] This is both skill (what you can do) and knowledge (understanding what you are doing). Competency is on four levels: Awareness (Level 0); Foundation (Level 1); Practitioner (Level 2); and, Expert (Level 3). See Table 1.
[3] It is recognized that staff may not have access to a mentor, or not have a mentoring record for parts of their career; therefore, the mentoring requirement is less that the relevant experience requirement.
[4] 'Relevant' means relating to these competencies and the qualification purpose (see the Qualification Descriptor). A mentor is required to direct, monitor, check, and confirm this experience.

APPENDIX D: EXAMPLE OF LEARNING PROGRAM FOR AN ONSHORE PIPELINE ENGINEER

1. Training Program									
Program Learning Modules (linked to competencies)			**Training Program Delivery**						
Competency No.	**Competency Title**	**Competency Level (see Table 1)**	**Materials' Location**	**Delivery Mode**	**Duration (hours)**	**Training Location**	**Training Provider**	**Assessment?**	**Schedule (week no)**
1	Pipeline Engineering Principles	Foundation	*e.g. in-house,*	*e.g., on-line*	18	*e.g., Houston*	*e.g., external*	*e.g., examination*	5
2	Pipeline Engineers: Ethics & Responsibilities	Awareness			3				2
3	The Oil and Gas Industry	Awareness			2				3
4	Pipeline Project Control	Awareness			2				4
5	Pipeline Inspection and Surveillance	Awareness			2				12
6	Onshore Laws, Regulations & Standards	Awareness			2				10
8	Pipeline Hydraulics	Foundation			12				9
10	Onshore Pipeline Design	Foundation			18				8
12	Pipeline Repair	Awareness			2				18
13	Pipeline Materials	Foundation			18				6
14	Pipeline Integrity Management	Foundation			12				23
15	Internal Corrosion Mechanisms	Awareness			2				19
16	Internal Corrosion Prevention and Monitoring	Awareness			2				20
17	External Coating Selection and Field Joints	Awareness			2				21
18	Onshore Pipeline Construction	Awareness			4				15
21	Non-Destructive Testing Technologies	Awareness			2				11
25	Cathodic Protection and Monitoring	Awareness			2				22
28	Onshore Pipeline Operation	Awareness			4				14
30	Stress Analysis	Awareness			4				17
34	Pipeline Welding	Awareness			2				7
35	Pipeline Testing	Awareness			4				16

36	Onshore Pipeline Routeing	Awareness			4				13
47	Health, Safety, Environment, Security	Awareness			3				1

2. Mentoring Requirement	
Mentor and Role	**Mentoring Time Requirement**
The mentor should be an Expert Level in at least one of the listed competencies. A mentor sets the goals of the program (which are defined in the Learning Program Descriptor), and will periodically check the implementation and progress of this program, and advise the student and line management of any special coaching required for the student to pass this program. The mentor either gives, or arranges, directed learning (coaching) in competence areas, where necessary, and validates all the above competencies (training, mentoring, and experience), and states that the competency outcomes have been met.	The mentor validates all the above competencies and states that the competency outcomes have been met. This requires mentoring for the duration of the qualification. The mentoring/coaching time requirement is estimated at 240 hours.

3. Experience Requirement	
Experience Organisation	**Experience Time Requirement**
Experience in the listed competency areas, under the supervision of a competent member of staff (Senior or Principal Onshore Pipeline Engineer), is required to pass this Qualification.	At least two years.