‘TRAINING AND EDUCATION, THE GREAT COMPETENCE DIVIDE’,

11th International Pipeline Conference, Calgary, September 2016.

Co-Author: Phil Hopkins

QPPI
The Qualification Panel for the Pipeline Industry

Proceedings of the 11th International Pipeline Conference
IPC2016
September 26-30, 2016; Calgary, Alberta, Canada

IPC2016-64500

TRAINING AND EDUCATION: THE GREAT COMPETENCE DIVIDE…

Michelle Unger
munger@rosen-group.com
ROSEN Group
Floor 2, Q5, Quorum Business Park, Benton Lane
NE12 8BS Newcastle upon Tyne, UK
Tel: +44 191 215 4010, Fax: +44 191 247 5828

Phil Hopkins[1]
phil@philhopkinsltd.com
Phil Hopkins Ltd.
26 Kingston Drive, Whitley Bay, NE26 1JH, UK
Tel: +44 191 251 1174

ABSTRACT

All industries need ‘competent’ staff, and pipeline standards and regulations expect all staff in the pipeline industry to be competent. This is emphasized by a North American pipeline regulator stating in its report on a failure: *‘... the management of training and competency is particularly critical for an organization [operating pipelines*]’.

Competence is a mix of skills, knowledge, and experience, and is obtained from training, mentoring, and experience. Consequently, industry knows how to develop competencies, but how can companies prove their staff are competent? Staff can attend the many training courses on offer, but how can the industry know these courses are the required quality, and that staff have acquired and absorbed the necessary skills/training?

This evidence and demonstration are major problems in the pipeline industry, and need urgent solutions. Fortunately, the industry can learn from academia, who have been providing demonstrable skills for centuries.

Most current industry training courses are presented by good trainers, using good materials, through good training providers. Unfortunately, most of these courses/trainers/organisers are not accredited by any reputable organisation, the materials are not quality assured, the necessary competence levels are neither specified nor defined, and there is no assessment to demonstrate understanding. This learning process may be good and delivered in good faith, but it is disorganised, unregulated, with no control or benchmarking, and no assessment. This leads to a lack of credibility.

Academia has a well-established, but relatively simple system to ensure its learning process is credible. It has: courses that are assessed to a specified learning level, with clear objectives, outcomes, and qualification requirements; materials that are independently quality assured; lecturers that are qualified to teach; and, an assessment, qualification, and certification process that demonstrates the student has acquired all the stated skills. This leads to credibility.

This paper assesses current training in the pipeline industry, and highlights the good points and bad points, and the deficiencies in the learning process, that prevent demonstrable competencies. It then describes how academia has a rigorous learning process that allows this demonstration.

The paper ends with a ‘way forward’ for the pipeline industry, in its goal of demonstrating competency in its workforce.

[1] This paper was produced as part of the ROSEN-Phil Hopkins Ltd. partnership.

1. INTRODUCTION

The oil and gas industry is currently (April, 2016) experiencing a low oil price (~$45 barrel). This low price is due to oversupply, mild temperatures, and a struggling world economy [1,2,3]. The low oil price is expected to continue with prices in 2016 not predicted to rise much above $40 [4,5].

A low price affects spending on new projects: new projects worth hundreds of billions of dollars were halted in 2015, and tens of thousands of jobs have been lost in major energy companies [4], but throughout this turmoil, the oil and gas is still being transported, in increasing amounts [2].

The oil and gas infrastructure must continue to function safely, albeit at a much lower level of profitability. This is not a simple task: the infrastructure is ageing with most high pressure oil and gas transmission pipelines over 40 years of age (e.g., [6 - 8]). There are about 3,500,000 km of these pipelines around the world [7]. The replacement cost of this pipeline infrastructure (assuming a rebuild cost of $3,000,000/km) is about $10,000,000,000,000. This cost, added to the practicality of replacing the system, and the concurrent disruption in supply, means it is reasonable to assume these old pipelines will need to continue for many years.

Pipeline engineers working in operations are now presented with a difficult task: operate an ageing asset safely, with little prospect of that asset being replaced, certainly in the short term, due to market pressures. A concern is that the oil price may drop to such a low level that safety is compromised. Unfortunately, hazards associated with the transportation of oil and gas are not a function of oil price: they remain the same [9].

Engineers must maintain safety regardless of the state of their industry. This statement leads to the obvious question to ask: '*are our engineers good enough to meet this challenge*?', or, simply '*are our engineers competent*?'.

Competence is a mix of skills, knowledge, and experience, and is obtained from training, mentoring, and experience. Consequently, industry knows how to develop competencies, but how can companies prove their staff are competent? Staff can attend the many training courses on offer, but how can the industry know these courses are the required quality, and that staff have acquired and absorbed the necessary skills/training?

This paper assesses current training in the pipeline industry, and highlights the good points and bad points, and the deficiencies in the learning process, that prevents demonstrable competencies. It then describes how academia has a well-established and relatively simple, rigorous, learning process that allows this demonstration.

The paper starts with a review of the problems of ageing infrastructures, then covers competency, to give both context and background. It ends with a 'way forward' for the pipeline industry, in its goal of demonstrating competency in its workforce.

2. AGEING INFRASTRUCTURE

The effect of ageing on a structure can present threats: '*aging infrastructure is a significant threat to asset integrity...'* [10], but these threats can be mitigated by good management [11, 12]: '*... the safety of a well-maintained and periodically assessed pipeline is ensured regardless of age through diligent and well-planned integrity management[2] practices*.' [13].

There is wide-ranging evidence that failure rates in pipelines are not increasing [13-16] despite the ageing process, but these generic rates may mask specific causes that are increasing [17]. This is important, as it is now widely-accepted that the majority of accidents in industry are in some way attributable to human, as well as technical, factors, as action by people initiate or contribute to accidents [18].

Maintenance, protection, and all other elements of integrity management, are key to ensuring an ageing asset remains safe. This has resulted in many pipeline integrity management standards being published (for example, [19-23]), improvements in technologies, better data and information processes, and new regulations. The problem with these improvements is that they are all reactive: they will do little to prevent future failure types that have not yet been experienced; consequently, a more proactive approach is needed and expected [24-26]. The question now is… '*how can integrity management be improved both reactively and proactively?*'.

3. PREDICTING THE FUTURE

One way to improve integrity management is to take a broader view of what causes pipeline failures, and how these causes will change as the pipelines become even older. This will give a glimpse into the future.

3.1. Skills and Competency

An ISO standard [23] gives some insight into the causes of failures as pipelines age, as it states: '*The integrity of… [a]… system will have deteriorated since installation*', but it also highlights that failures from time dependent mechanism (such as corrosion) and poor engineering control (such as faulty modifications), are early-life failure types. Later failure types are related to peoples' competency, safety culture, and staff skills. This means that 'human failure' (human error (mistakes) or violations (deliberately doing the wrong thing) [27]) needs to be considered.

Violations will be linked to an operators' safety culture, and staffs' value, but human error can be attributed to deficiencies in skills and knowledge; that is, competency deficiencies.

3.2. Safety Culture

Skills and competency will be covered later in this paper, but 'safety culture' is [28] *'the collective set of attitudes, values, norms and beliefs, which pipeline operator's employees share*

[2] 'Integrity' means a pipeline system is structurally sound, and does not leak its product. 'Integrity management' covers all the activities pipeline operators must undertake to ensure that these leaks do not occur.

with respect to risk and safety'. Safety culture is the part of the overall culture of the organisation affecting the attitudes and beliefs of members in terms of health and safety performance [29], and should take the form of a clearly defined set of values that is communicated and demonstrated by top management [30]. 'Safety climate' is considered the current visible features of the safety culture obtained from the employees' attitudes and perceptions [29].

Reference 23 emphasises the importance of 'culture' as assets age, and other industries also stress its importance. The chemical process industry has seen its accident rate fall each decade, but the reasons for the accidents have changed, Figure 1 [31-36].

Figure 1 shows how 'eras' emerge and change. The 1950s saw technical issues/engineering causing accidents: this was a general trend, and a famous example from the aircraft industry was the first commercial jet (the de-Havilland Comet) crashing due to design/fatigue problems. In the process industry there have been more recent failures attributed to organisational failures; for example, the Texas City Refinery Report on the failure in March 2005 blamed the culture of the organisation on the failure, and considered poor organisation was the number one cause of the disaster: *'... managers and executives... were largely focussed on personal safety – such as slips, trips, falls, and vehicle accidents – rather than on improving process safety performance, which continued to deteriorate…*'.

Today, the situation is even more complex as there are still organisational problems, but now there are many more inter-organisational boundaries, as work and contracts become multi-layered and work implementation more distant.

Cleary, strengthening safety culture is important now and in the future, and may be a good way to stop some future pipeline failures. Staff competency is a key part of a company's safety culture, as the culture is a product of the individual and group values, which include competency [37]: *'safety culture of an organisation is the product of individual and group values, attitudes, perceptions, competencies, and patterns of behaviour…'.*

4. COMPETENCY REQUIREMENTS

4.1. Requirements in Standards and Regulations

Pipeline standards have always emphasised the need for competency in staff; for example:

- *'This Standard is not a design handbook, and competent engineering judgment should be employed with its use'* [38];
- *'... the Code is not a design handbook; it does not eliminate the need for the designer or for competent engineering judgment'* [39, 40];
- *'... the design, construction, testing, operation, maintenance and abandonment of the pipeline system shall be carried out by suitably qualified and competent persons'* [23];
- *'... the personnel involved in the [integrity management] program shall be competent, aware of the program and all of its activities, and be qualified to execute the activities within the program.'* [19].

Similarly, the USA Pipeline Safety Regulations Federal Register (Part 49 CFR Subpart O §192.915 (pipeline integrity management) [41]) states:

- *'Supervisory personnel. The integrity management program must provide… that any person who qualifies as a supervisor for the integrity management program has appropriate training or experience in the area for which the person is responsible.*
- *Persons who carry out assessments and evaluate assessment results. The integrity management program must provide criteria for the qualification of any person…Who conducts an integrity assessment… reviews and analyzes the results from an integrity assessment and evaluation; or… makes decisions on actions to be taken based on these assessments.*
- *The integrity management program must provide criteria for the qualification of any person… Who implements preventive and mitigative measures… or… Who directly supervises excavation work carried out in conjunction with an integrity assessment.'.*

4.2. Are we meeting Competency Requirements?

The conclusion is easy: standards expect staff working on pipelines to be 'competent' and 'qualified'. This may be obvious, but a study by the USA's NTSB [17] stated: '*The NTSB concludes that professional qualification criteria for pipeline operator personnel performing IM [integrity management] functions are inadequate'*.

There is evidence of a lack of competency in staff: a review of major accidents across hazardous industries found that a lack of competence contributed to many of those incidents [42], and most PIMS [pipeline integrity management systems] do not stipulate the human competencies that are required to manage the systems they support [43].

The conclusion is again easy: Regulators expect staff working on pipelines to be competent. But the question now is: '*what is competence, how is it obtained, and how is it demonstrated?*'.

5. DEFINING COMPETENCE

5.1. Competence

Two simple and understandable definitions of competency are [44, 45]:

- ‘competence’[3] is ‘the ability to do something well’;
- ‘competency’ is ‘an important skill that is needed to do a job’.

In practice, competence is the ability to undertake responsibilities, and to perform activities to a recognised standard on a regular basis [46], utilising a combination of practical and thinking skills, experience and knowledge [47, 48]. Competence development is through [49]: formal qualification; training; on-the-job learning; instruction; and, assessment [45].

Competency relates to the skills and behaviours needed to do a job well. This leads to confusion; for example, should the focus be on skills or behaviours? This paper does not attempt to differentiate – it considers both skills and behaviours as essential for a competent outcome to a task [50]. This gives a wider view of competency [50], where technical (functional) competencies alone are not sufficient: behaviours (attitude, physical ability, values) need to be addressed [52], and these will include staff and customer relationships, leadership, developing staff, etc.. This leads to the definition:

Competence = skills + experience + knowledge + values

where:

- skill is ‘*the ability to perform mental and physical activities acquired or developed through training or experience’* [53], or ‘*a demonstrable competency to perform a given task well, arising from talent, training or practice’* [54].
- knowledge is ‘*a body of information applied directly to the performance of a task’* [53], or ‘*understanding gained through experience or study’* [55].
- experience is *‘work activities accomplished... under the direction of qualified supervision... but not including time spent in organized training programs’* [39].

5.2. Setting and Assessing Competencies

How are competencies set and assessed? A specific job will require certain competencies at certain skill levels, and associated additional or complementary skills; for example, an aircraft pilot needs the skills to fly the aircraft he/she is asked to fly, but will need combat and weapons skills if asked to fly a fighter plane.

Competencies are both specified and assessed by a specialist in the area of that competence. In the pipeline business these specialists are usually referred to as a ‘subject matter expert’ or a ‘competent person’.

- A subject matter expert (SME) is often quoted in the literature and regulations. The USA Department of Transportation (which regulates pipelines) defines ‘subject matter expert’ as [53]... *‘An individual recognized as having a special skill or specialized knowledge of a process in a particular field, or of a piece of equipment.’* It is likely that a subject matter expert will need at least 10 years of relevant experience [56].
- A ‘competent person’ [57] ‘… *should have such practical and theoretical knowledge and actual experience of machinery or plant which he has to examine, as will enable him to detect defects or weaknesses which it is the purpose of the examination to discover and to assess their importance in relation to the strength of the machinery or plant in relation to its function*.’.

Clearly, an SME or a competent person must have demonstrable:

- education;
- training;
- practical and theoretical knowledge; and,
- experience.

Note that the USA Department of Transportation defines ‘demonstrate’ as ‘provide tangible evidence’ [55]. This emphasises the importance of: documenting training, etc.; and, record-keeping.

It is also worth noting that a subject matter expert or a competent person can be a body of people who collectively possess the necessary competencies [58].

5.3. Developing Competency

Competence is temporal: competence develops over time [49, 59]. The process of gaining competence is obtained from a combination of training, mentoring, and experience [60]. When developing competence, experience is the most important element. Figure 2 gives the classic split of 70:20:10 to experience:mentoring:training. The values in this split can be debated, but the point to emphasise is the inclusion of mentoring in the split, and that training may be the least important element of competency. Reference 59 covers ‘mentoring’.

6. TRAINING AND COMPETENCE

Competence is a mix of skills, experience, knowledge, and values. The acquisition of skills and knowledge is aided by training and study [53, 55]), but competencies are obtained and maintained through a mixture of training, experience, and mentoring. It is emphasised that training and experience alone is not sufficient to develop competencies: ‘... *it is not enough to assume that exposure to training and experience assures competence*’ [61], but this paper will concentrate on the training element.

[3] The word ‘competence’ has synonyms such as ‘capability’, ‘ability’, etc.. There are differences (for example, you may be capable of firing a gun, but you may not be competent enough to hit a target), but for brevity this paper will focus only on ‘competence’.

6.1. What is 'Training'?

Training has been defined as [55]: '*An educational or instructional process (e.g., classroom, computer-based, or on-the-job) by which an individual's knowledge, skills, and his/her capacity to do or act, physically and/or mentally, are improved'*.

Training helps staff to learn how to do something, and what they should and should not do, by giving them relevant information.

6.2. The Need to Demonstrate

The previous Sections have emphasised the importance of training in developing competencies, 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 [62]:

> *'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 [63]:

> *'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.'*

6.3. Training and the Pipeline Industry

How does the pipeline industry meet these requirements and qualifications? The training element of competency takes many forms, ranging from classroom-based lessons, to personal coaching in the field. Organisations such as NACE International Institute [64] offer comprehensive programs that both qualify and certify pipeline staff in certain skills. Similarly, API offer training programs for pipeline professionals [e.g., 65].

Most other industry training courses are presented by good trainers, using good materials, through good training providers. Unfortunately, most of these courses/trainers/organisers are not accredited by any reputable organisation, the materials are not quality assured, the necessary competence levels are neither specified nor defined, and there is no assessment to demonstrate understanding. This learning process may be good and delivered in good faith, but it is disorganised, unregulated, with no control or benchmarking, and no assessment. This leads to a lack of credibility [45].

This lack of credibility is a major problem in the pipeline industry, and needs urgent solutions [17, 45]. Fortunately, the industry can learn from academia, who have been providing demonstrable skills for centuries.

6.4. Learning from Academia

There are university masters programs in pipeline engineering topics (for example at Newcastle and Northumbria Universities in the UK). Any graduate from these programs will have a qualification to a specified level (e.g., a masters degree), certified by a reputable university, using quality-assured materials, and delivered by qualified staff. All employers of these graduates will be confident with their accredited, certified qualification, and the pipeline industry can learn from the academic approach.

6.4.1 Academia's System

Academia has a long established, and relatively simple system to ensure its learning process is credible. It has (Figure 3):

- courses that are assessed to a specified learning level, with clear objectives, outcomes, and qualification requirements for entrance onto the course;
- materials ('content') that are independently quality assured;
- lecturers that are qualified to teach;
- an assessment process (e.g., examination);
- a stated qualification (e.g. BSc); and,
- a certification process that demonstrates the student has acquired all the stated skills.

This leads to credibility. Academic courses must pass stringent tests before they are approved, and require considerable thought. Typical paperwork for a course are shown in Table 1.

This paperwork would then be assessed by an independent panel to ensure it met academic requirements, and suitably qualified teachers would then be assigned to deliver the course. Any student passing this course is demonstrably qualified to meet the stated outcomes of the course.

This academic approach is adopted by other industries; for example, the armed forces must ensure their troops are ready for combat and their skills/competence are – literally – a matter of life and death. The armed forces rely on training, but also leadership, mentoring, and experience for competence, and this is well summed-up in the old army saying '*trained doesn't mean ready'*.

6.4.2 Current Training Courses

Currently, most training courses for graduates and managers in the pipeline industry do not have the same rigour as academia (Figure 3):

- The trainer is usually a subject matter expert, but with no training/teaching qualifications.
- There are few or no learning aims/objectives (what the student is expected to achieve as a result of the course) or outcomes (what the student will be able to do, and in what context, and how well they will do it). Objectives and outcomes are similar; for example, '*students will be able to assess pipeline defects by applying fracture mechanics and fatigue theory, and*

simple analytical methods'. The main difference is that objectives state the goals and intentions of a learning programme (the 'input') whereas outcomes summarise the intended end point (measurable 'output') of the learning activities.

- The course content will usually have been written by a subject matter expert, but it is unlikely to have been through an accredited quality assurance system.
- There is rarely any assessment following the course [45].
- There is rarely any qualification, or level of qualification.
- There is rarely certification.

6.4.3 The Trainers

A course is only as good as its trainer. Course content, and the quality of the materials must be good, but a bad trainer will ruin any course, regardless of its content and quality.

Most current courses use experienced and recognised individuals from the industry, and hopefully this will continue. Some of these individuals have an academic background, so they will appreciate the importance of leaning objectives, etc., but many of the other trainers will have no experience in learning.

Another problem is likely to be the ageing profile of these trainers, and succession planning. In industry, preparing a course, and identifying a trainer is not simple: creating good materials takes many days, and convincing staff to stand up in front of large audiences in foreign lands, for eight hours per day, after an arduous long haul flight in the economy cabin, is not easy. Additionally, many managers do not see giving training as 'proper' work, and put it low down any list of priorities, and do not give course materials the same scrutiny as other work.

Trainers can benefit from attending presentation skills courses. These courses help with both trainer's delivery, and audience engagement. They also explain the key elements of training, and can show how teaching and training are different and can require different skills and experience, Table 2.

How can a trainer be assessed? Any trainer must have a better knowledge of the subject than the course attendees. This is obvious, but how can this be demonstrated? In academia, a lecturer will usually have a higher qualification that the student (lecturers teaching undergraduates will usually have PhDs), and the students are usually very young and inexperienced, which means the lecturer will have more experience in the subject than the students.

Simple criteria such as academic qualifications will not be sufficient for a trainer, as training courses often require practical knowledge of the topic, ahead of an academic understanding. This means that experience can be more important in a training course. This experience can be reflected in being a Professional or Certified Engineer. Also, membership of an institution (for example the UK's Institution of Mechanical Engineers), or recognition by an institution (for example a Fellow of the American Society of Mechanical Engineers), may be more important than academic qualifications.

Experience is clearly important, but it is not fool proof. You can be experienced but incompetent as:

- your experience may not be relevant (it is not the correct experience);
- you can do very similar work year after year (the experience has been repeated); and,
- the world is constantly changing (what was learned today may be of little use in a few years).

The ability to train is more difficult to specify, but 'natural selection' means that trainers who have been presenting courses for many years are likely to be good trainers… or nobody else wants to do it….

It is suggested that any trainer should be evaluated by:

- relevant industry experience in the topic being presented;
- experience in training in the topic being presented;
- qualifications;
- standing in the industry (relevant publications, committee memberships, etc.);
- membership/recognition by a professional institution.

The above list looks like a list of blockages for young trainers. That is not the intention: the industry is not looking for 65 year old trainers with a PhD, several books to their name, and a Fellowship of many societies. The industry is actually trying to replace these veterans. Also, as training is moving into e-learning and social media, the 'experience' needed is often contained within younger engineers.

Many modern topics require a young, fresh mind, and this can be taken into account when assessing the trainer. Indeed, academia rely on younger staff to do much of the teaching, and younger engineers should be encouraged to help with training. Academia do not require the same level of industry experience as required in training courses, Table 3.

7. THE WAY FORWARD

7.1. Technical Competencies

The system adopted by academia can be easily introduced into the pipeline training industry by ensuring all courses satisfy four criteria: course content and delivery; assessment criteria; qualification awarded; and, an independent body certifies the qualification, Table 4.

There is work involved in satisfying the criteria in Table 4, but once it is done, it need not be done again for a specific course, and it is not as big a task as many may fear. The work will be:

- Setting learning objectives/outcomes. This will be a short list, agreed with a subject matter expert.

- Course content. A subject matter expert will produce the materials, and pass them through a quality assurance system.
- Trainer. Simple presentation skills, etc., courses are available to help trainers.
- Assessment. Again, this will be the subject matter expert setting an appropriate assessment.
- Qualification. The student will be awarded a qualification that reflects the learning objectives; for example, if the course is only an introduction to a subject, then the student would be qualified to a 'foundation' level [45]. Higher, more ambitious objectives would allow high qualifications, such as 'practitioner' or 'expert' [45].
- Certification. The whole process must be certified by an independent body, who can themselves demonstrate competence in this learning process.

7.2. Behavioural Competencies

This paper has focussed on technical competencies, but behavioural competences and values are also important; for example, human failure due to 'violations' [27] will be due to failures in behaviour or values.

Engineers need their technical competencies, and these will be biased to intelligence quotient (IQ). IQ is a measure of a person, but IQ is both 'impersonal and non-social' [66]. There are other measures of a person, as IQ is only one measure [67]; 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.

8. DISCUSSION AND CONCLUSIONS

Competency is a complex topic. When you are young, and confident, everything seems easy, and competence even easier. As engineers gain more experience, they soon realise that confidence and competence are not the same, although many people confuse confidence with competence [45]. Gaining experience also has a sobering effect on an engineer's competency: the great Greek philosopher Aristotle (384 BC – 322 BC) summed this up very well when he said "*The more you know, the more you know you don't know*".

Training is an important element of competency development, but training is not simply a series of classroom courses and certificates: it is about 'continuous professional development' (CPD) [68]. This means lifelong learning.

How can the pipeline industry improve its training offerings, and ensure the requirements on competency in both standards and regulations are satisfied? A simple six step process is suggested:

1. SPECIFY: Ensure all courses have a structure/plan that can be scrutinised by both attendees and regulators (see Table 1).
2. ASSURE: Have quality-assured materials for the course, and specify the competency 'level' (for example, 'foundation', 'practitioner', and 'expert').
3. TRAIN: Have a competent trainer.
4. ASSESS: Specify an assessment for the course, related to the learning objectives/outcomes, and the level of the course.
5. QUALIFY: Award a qualification after passing an assessment.
6. CERTIFY: Have a reputable body to certify the whole process.

It is worth emphasising the importance of having a credible process for demonstrating competency. The industry's current training courses, with some notable exceptions (e.g., NACE), are not credible in terms of demonstrating competencies. The good news is that most are good, delivered by good trainers, and do not require much work to become credible.

Finally, a fact that may give a perspective on how training is currently managed in the industry. One of the authors has trained over 15,000 engineers all over the world. After every course, the attendees gave a detailed assessment of his performance, materials, etc.. He has been assessed 15,000 times. But…he has never been asked by a HR or training department for an assessment of any of the attendees on any of these courses... it is time to change.

REFERENCES

1. Anon., 'Oil Market Report', International Energy Agency. https://www.iea.org/oilmarketreport/omrpublic/. 13th October, 2015.
2. J Kemp, 'Global oil demand growing at fastest pace for five years', Reuters. http://www.reuters.com/article/2015/10/01/us-oil-demand-kemp-idUSKCN0RU2NX20151001#Gc54P3Igkakt1MQ2.97. 1st October, 2015.
3. Anon., 'Short-Term Energy Outlook', International Energy Agency. 12th January, 2016. https://www.eia.gov/forecasts/steo/report/prices.cfm)
4. C Adams, D Sheppard, 'Oil price collapse hammers big US energy groups'. Financial Times. http://www.ft.com/cms/s/0/718f6818-379c-11e5-bdbb-35e55cbae175.html#axzz3sEPisZkX. 31st July, 2015.
5. Anon., 'IEA releases Oil Market Report for January', International Energy Agency. 19th January, 2016.

https://www.iea.org/newsroomandevents/news/2016/january/iea-releases-oil-market-report-for-january.html
6. J F Kiefner, C J Trench, 'Oil Pipeline Characteristics and Risk Factors: Illustrations from the Decade of Construction', American Petroleum Institute. 2001.
7. M Mohitpour et al, 'Trends In Pipeline Integrity Inspection And Rehabilitation Techniques', Proceedings of 4th International Pipeline Conference September 29-October 3, 2002, Calgary, Alberta, Canada. Paper IPC2002-27035.
8. J F Kiefner, M J Rosenfeld, 'The Role Of Pipeline Age In Pipeline Safety', Prepared For The INGAA Foundation, Inc. INGAA. November 8, 2012.
9. Anon., 'HSE must not be compromised when striving for efficiency', Oil and Gas News, Volume 33, Issue: 4. January 25-31, 2016.
10. http://www.hse.gov.uk/aboutus/strategiesandplans/sector-strategies/gas-and-pipelines.htm.
11. http://www.hse.gov.uk/offshore/ageing/information.htm.
12. http://www.hse.gov.uk/offshore/ageing/information.htm.
13. Anon., 'Performance of European cross-country oil pipelines. Statistical summary of reported spillages in 2011 and since 1971', CONCAWE (conservation of clean air and water in europe). Report 3/13.April 2013. www.concawe.be.
14. https://hip.phmsa.dot.gov/analyticsSOAP/saw.dll?Portalpages/.
15. https://hip.phmsa.dot.gov/analyticsSOAP/saw.dll?Portalpages.
16. Anon., 'Gas Pipeline Incidents, 9th Report of the European Gas Pipeline Incident Data Group (period 1970 – 2013)', Doc. Number EGIG 14.R.0403, February 2015.
17. 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.
18. Anon., 'Competency Framework'. Institution of Gas Engineers and Managers. IGEM/TD/102. Communication 1761. June, 2012.
19. Anon., 'Managing System Integrity of Gas Pipelines', ASME B31.8S-2014. Supplement S of ASME B31.8. American Society of Mechanical Engineers. New York, USA. 2014.
20. Anon., 'Managing System Integrity for Hazardous Liquid Pipelines', American Petroleum Institute. API Recommended Practice 1160. Second Edition. September, 2013.
21. Anon., 'Pipeline systems Part 3: Steel pipelines on land. Guide to the application of pipeline risk assessment to proposed developments in the vicinity of major hazard pipelines containing flammables – Supplement to PD 8010-1:2004', BSI PD 8010-3: 2009. British Standards Institution. UK. 2009.
22. Anon., 'Integrity Management of Submarine Pipeline Systems', Recommended Practice. DNV-RP-F116. Det Norske Veritas. Norway. October 2009.
23. Anon., 'Petroleum and natural gas industries - Pipeline transportation systems - Recommended practice for pipeline life extension', Technical Specification. ISO/TS/12747. First edition. International Organization for Standardization. 2011.
24. Anon., 'Pipeline Process Safety Performance Monitoring', Industry Good Practice Guide. United Kingdom Onshore Pipeline Operators' Association Report Number: UKOPA/GP/03. November 2014. http://www.ukopa.co.uk/wp-content/uploads/2015/02/UKOPA-Good-Practice-Process-Safety-Performance-Monitoring.pdf.
25. Anon., 'Managing for Health and Safety', UK HSE Guidance Document, HSG65. 2013. http://www.hse.gov.uk/pubns/books/hsg65.htm.
26. Anon., 'Developing process safety indicators. A step-by-step guide for chemical and major hazard industries', UK HSE Guidance Document, HS254. 2006. http://www.hse.gov.uk/pubns/books/hsg254.htm.
27. Anon., 'Understanding human failure', HSE. UK. www.hse.gov.uk/construction/lwit/ December, 2012.
28. Anon., 'Pipeline Safety Management Systems', ANSI/API Recommended Practice 1173. 1st Edition, July 2015.
29. A M Collins, 'Safety Culture: A review of the literature', Health and Safety Laboratory, UK. Report HSL/2002/25. Crown copyright 2002.
30. PHMSA Focus Newsletter, 'Safety Culture - 'Moving from Good to Great'', Volume 3, Number 1, Fall/Winter 2007.
31. P Körvers, 'Accident precursors; pro-active identification of safety risks in the chemical process industry', Dissertation. TUE. Eindhoven, Netherlands. 2004.
32. J Groeneweg, 'Controlling the controllable: the management of safety', DSWO Press, Leiden. 1992.
33. B Wilpert, B Fahlbruch, 'Safety Related Interventions in Inter-Organisational Fields', In A Hale and M Baram Eds., 'Safety Management - The Challenge of Change', pp 235-248, Pergamon (Elsevier). 1998.
34. J Reason, 'Too little and too late: a commentary on accident and incident reporting systems', in: Schaaf van der, et al. (Eds.), 'Near miss reporting as a safety tool', Butterworth Heinemann, Oxford. 1991.
35. J Philley, 'Potential Impacts to Process Safety Management from Mergers, Acquisitions, Downsizing and Re-engineering', Process Safety Progress, Vol 21, No. 2, pp153-160. 2002.
36. B Sampson, 'Safety First', Professional Engineering, 8 July 2009. p 19-20.
37. Anon., 'Organising for safety', Advisory Committee on the Safety of Nuclear Installations (ACSNI). Study

group on human factors. Third report. HMSO. London, UK. 1993.
38. Anon., 'Oil and gas pipeline systems', CSA Z662-15, Canadian Standards Association. 2015.
39. Anon., 'Pipeline Transportation Systems for Liquids and Slurries', ASME B31.4 – 2012, American Society of Mechanical Engineers. New York USA. 2012.
40. Anon., 'Gas Transmission and Distribution Piping Systems', ASME B31.8 – 2014, American Society of Mechanical Engineers. New York USA. 2014.
41. http://www.ecfr.gov/cgi-bin/text-idx?node=49:3.1.1.1.8.15&rgn=div6
42. Anon., 'Inspection of Competency Management Systems at COMAH Establishments', UK Health and Safety Executive. December, 2011. http://www.hse.gov.uk/comah/guidance/inspection-competence-management-systems.pdf
43. V Zaman, 'Managing Operational Risk', World Pipelines. May 2014. p.83.
44. P Hopkins, 'The Skills Crisis in the Pipeline Sector of the Oil and Gas Business', Journal of Pipeline Engineering, 2008.
45. M Unger, P Hopkins, "Competency' in Engineering', 28th International Pipeline Pigging & Integrity Management Conference Houston, USA, February 8-11, 2016.
46. Anon., 'HSE Human Factors Briefing Note No. 2. Competence', Health and Safety Executive, UK.
47. Anon., 'Developing and Maintaining Staff Competence'. HSE (2002), ISBN 0 7176 17327. http://www.hse.gov.uk/humanfactors/topics/competence.htm.
48. https://primis.phmsa.dot.gov/oq/glossary.htm
49. http://www.hse.gov.uk/construction/cdm/faq/competence.htm
50. http://www.hse.gov.uk/competence/.
51. T Hoffmann, 'The meanings of competency', Journal of European Industrial Training, Vol. 23 Issue 6, pp.275 – 286. 1999.
52. Anon., 'Managing for sustainable employee engagement: Developing a behavioural framework' Chartered Institute of Personnel and Development. http://www.cipd.co.uk/binaries/6067%20Sustainable%20engagement%20RI%20(WEB).pdf
53. Anon., 'Pipeline Personnel Qualification', American Society of Mechanical Engineers. ASME B31Q-2010. 2010.
54. http://www.phmsa.dot.gov/staticfiles/PHMSA/DownloadableFiles/Files/Pipeline%20Training/OQ%20Guide/e_Chapter_II.pdf.
55. http://phmsa.dot.gov/pv_obj_cache/pv_obj_id_BF6EE0607833B868B82760368849EFF526890100/filename/e_Chapter_II.pdf
56. S Little, T Ray, 'Managing Knowledge', 2nd Edition. Open University. Sage Publications. London. 2011.
57. Anon., 'UKOPA Competency Framework Document', Version 2.3. UKOPA/02/0076. August 2002.
58. Anon., 'Safety of pressure systems: Pressure Systems Safety Regulations 2000', Approved Code of Practice and Guidance. HSE Books. UK. Second edition 2014. http://www.hse.gov.uk/pubns/priced/l122.pdf.
59. M Unger, P Hopkins, 'The Forgotten Art of Mentoring', World Pipelines. December, 2015.
60. M M Lombardo, 'Career Architect Development Planner', 3rd Edition ('The Leadership Architect Suite'). January, 2000.
61. M Wright, D Turner and C Horbury, 'Competence assessment for the hazardous industries', Health and Safety Executive Research Report 086. UK. 2003.
62. 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.
63. 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.
64. http://www.naceinstitute.org/certification/pipeline-industry-program.aspx.
65. http://www.api.org/Certification-Programs/IndividualCertificationPrograms.
66. S S Hallmay, 'The Older-and-Wiser Hypothesis'. The New York Times Magazine. 6th May, 2007.
67. K Jensen, 'Intelligence Is Overrated: What You Really Need To Succeed', Forbes. 12th April, 2012.
68. Anon., 'Health and safety training. A brief guide', UK Health and Safety Executive. INDG345 (rev1). November, 2012.

ANNEX A: TABLES

Element	Comment
Entry	entry requirements (qualifications/experience of student)
Aims	aims/objectives of course
Reading	a reading list, and any other required learning materials
Content	a detailed course syllabus (content), passing an accredited quality assurance process
Outcomes	learning outcomes
Delivery	delivery (classroom, e-learning, etc.), including teaching staff
Assessment	assessment (examination, dissertation, viva, etc.)
Feedback	feedback methods

Table 1. Typical Structure of a Course Plan.

	Teaching	Training
Venue/Layout	Good, bespoke, predictable	Unpredictable
Expectations	Attendees and teacher have same expectations	Attendees and trainer may have differing expectations
Learning objectives	Specified, agreed, known by all	Often not specified, not agreed, and not known to anybody
Content	Specific topics	Specific topics
Audience	Known, with similar abilities, and 'have to be there'	Unknown, with mixed abilities, and do not 'have to be there'
Engagement	Usually large class: engagement difficult	Usually smaller class: allows engagement
Assessment	Yes	No
Duration	Short session	Long session
Questions	Narrow, predictable	Many, wide-ranging, unpredictable
Crowd control	No issues (no movements allowed)	Issues (movement allowed)
Distractions	Controllable by rules	Constant distractions (email, smartphones, coffee breaks, etc.)

Table 2. The Differences between Teaching and Training.

	Importance	
	Teaching	Training
Qualifications	High	Medium
Relevant industry experience in the topic being presented	Low	High
Standing in the industry	Low	Medium
Experience in the topic being presented	Low[4]	High
Membership/recognition by a professional institution	Medium	High

Table 3. Differences between Skills Sets for Teaching and Training.

The Course	The Assessment	Qualification	Certification
Clear, documented learning objectives/outcomes	Assessment criteria	A qualification is awarded according to the learning objectives/outcomes	The qualification is certified by an independent body
Quality assured content and trainers	Feedback mechanism	The qualification will be to a specified level (e.g., 'foundation', or 'practitioner')	The independent body would have an expert committee to guide certification

Table 4. Training Course Requirements.

[4] Teachers should be able to deliver any topic within their skill set, as: they have been trained in teaching; the topics are not new; and, the audience has little experience in the topic.

ANNEX B: FIGURES

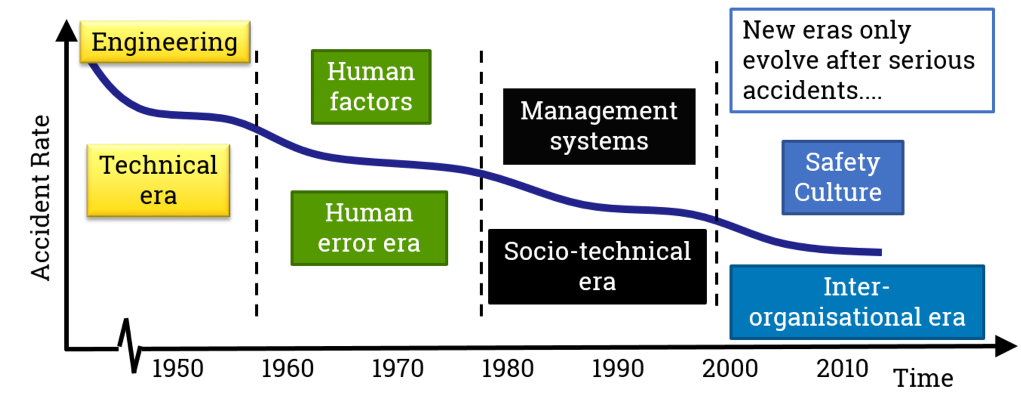

Figure 1. Changing Reasons for Accidents in the Chemical Process Industry [31-36].

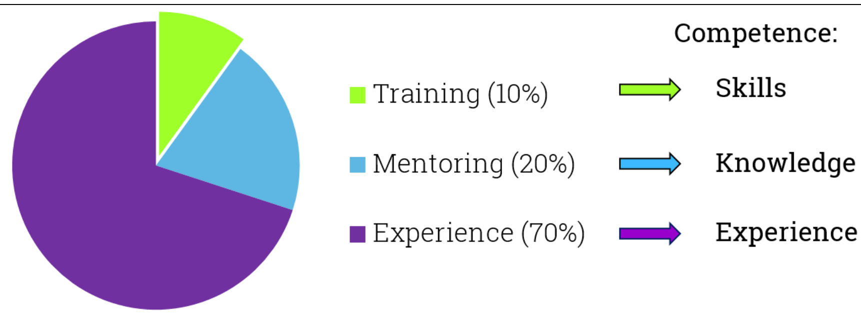

Figure 2. Developing Competency.

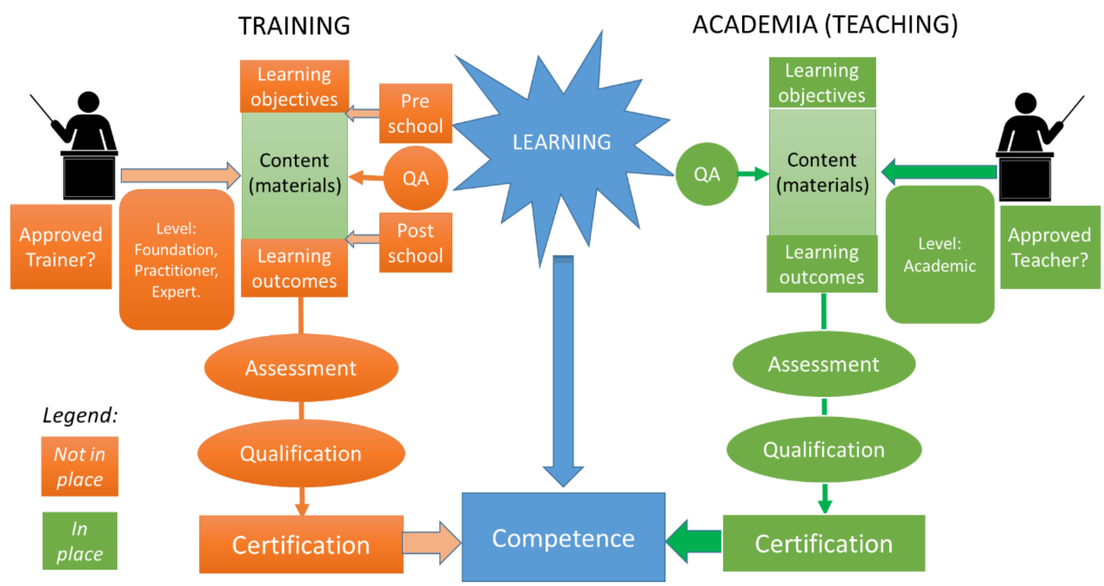

Figure 3. Comparison between Academia's Qualification Process and the Training Industry.