



# World Plumbing Council Scholarship Report

A Comparative Education Study of Plumbing and Training: Hong Kong and England

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## About the World Plumbing Council

The World Plumbing Council (WPC) is an international organization that aims to develop and promote the image and standards of the plumbing industry worldwide. The WPC's mission is:

***To promote the role of plumbing in improving public health and safeguarding the environment, by uniting the World Plumbing Industry, for the benefit of all***



*Simon Reddy was winner of the World Plumbing Council Scholarship 2015 and visited Hong Kong in 2016. This World Plumbing Council Scholarship Report was published in 2017.*

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## **Executive summary**

The key findings to emerge from this comparative education study of Hong Kong and England are grouped under the headings 'Importance of plumbing to public health' and 'Importance of high-quality training and progression opportunities'.

### **Importance of plumbing to public health**

The importance of the relationship between plumbing and public health was by far the most powerful and recurring theme that emerged from my visit to Hong Kong. This study presents a strong reminder to all nations about the health implications of plumbing in terms of the importance of sanitary engineering and the essential need for quality drinking water.

#### **Sanitary engineering**

In light of the SARS (severe acute respiratory syndrome) outbreak in Hong Kong, serious attention has been paid to sanitary engineering in Hong Kong. The report consequently discusses some aspects of the importance of competent sanitary engineering and the need for licensed professionals to deal with it in both Hong Kong and England.

#### **Drinking water quality**

Lead in the water supply was also a salient issue in the study. The report presents analyses of the data derived from expert perceptions, informal interviews and observations as well as the relevant academic literature and scientific reports. Plumbing materials, along with their specification and installation requirements on plumbing contracts, are also discussed. The report recommends urgent action for Hong Kong authorities in addressing the serious problem of lead in the water supply. A significant health risk is also identified in England, in regard to existing imperial (pre-1980s) copper plumbing systems with lead solder joints – found to present a danger to health without the necessary public health warnings.

### **Importance of high-quality training and progression opportunities**

A number of themes associated with the importance of high-quality training and progression opportunities emerged. The notion of 'quality' is a social construct, and it is interpreted differently depending on culture. This study reviews the relevant literature and analyses some views on what constitutes high-quality training, derived from different actors' perceptions in the study.

#### **Importance of a 'quality' experience in vocational education and apprenticeships**

At the University Polytechnic of Hong Kong, professional building students undertook the planning, management and building of a typical apartment dwelling, which closely replicated the reality of the workplace. Students learned how to build a structure and run a project, while developing empathy with craftspeople and an understanding of 'quality' and how difficult and time-consuming it is to achieve it. The report recommends that simulations and models should be integrated with teaching, learning and assessment to improve the quality of the student experience (as opposed to the student being continually taught in the classroom and distanced

from the workshop). In light of a mandatory three-year minimum time-serving period in Hong Kong for licensed plumber status, the report also recommends that the Trailblazer Standard for English apprenticeships at Level 3 must specify a mandatory duration of time-serving in the workplace with qualified supervision, with no exceptions.

### **Importance of high-fidelity simulations in vocational institutions**

High-fidelity simulations are practical training situations in a college that closely replicate the workplace. In Hong Kong, these were found to represent a safe and pragmatic approach to vocational training in college contexts, which did not create any conflicts of interest with businesses. By contrast, practical simulations were found to be poor in England and sometimes conflicting with external labour requirements. The report describes some English further education colleges that buy old houses for their full-time construction workers to work on and renovate. The report argues that there is a moral hazard in this English approach and that students may stand to lose out (Reddy, 2016b, 2016c). Moreover, the report recommends that English colleges need to review their practical training simulations and judge Trailblazer assessments in relation to workplace fidelity (Reddy, 2014).

### **Strong sense of professionalism in Hong Kong plumbing community**

In Hong Kong, high-status professionals, such as chartered engineers and engineering doctors were visible amongst construction students at every level. In England, the system is more dichotomous in that higher education professionals are separated from further education technicians/operatives. This may be a key factor affecting the continuing low status of English vocational education. This report recommends a cultural shift towards professional status both for college teachers and plumbing workers in England.

### **Skills shortages**

Skills shortages in England have been used to attract people into the plumbing sector, and some types of education marketing have been shown to be misleading (Reddy, 2014, 2016b). The Hong Kong vocational institutions did not need to mislead people because of a strong skills shortage linked to high student progression rates and high pay (compared to England's relatively weak skills shortage, reflected in falling wages and lack of progression). The report recommends further research into the meanings of skills shortages in England compared to skills shortages in other developed nations.

### **Sharing good pedagogical practice**

My new theory of practice called Facebook Pedagogy was presented to tutors and students as a way of supporting apprentices' collaboration and motivation by using social media in classroom sessions. This report recommends a World Plumbing Council pedagogical collaboration between plumbing teachers on a global level.

# 1 Introduction

The introduction for this comparative education study between Hong Kong and England is divided into three parts. The first deals with the context and history of Hong Kong. The second section describes the welcome I received and some of my cultural experiences in Hong Kong. The final section introduces the investigative report for the comparative study of plumbing and education.

## 1.1 Hong Kong context

Hong Kong is an autonomous territory and former British colony in south-eastern China. Its densely populated urban centre is a major port and global financial hub with a skyscraper skyline. The central business district features architectural landmarks like the Bank of China Tower. The Dutch engineering consultancy Arcadis ranks Hong Kong as the third most expensive place for construction in the world after Switzerland and Denmark (Zhu, 2015). It is also a major shopping destination, famed for its bespoke tailors and Temple Street Night Market.

Hong Kong has a rich six-thousand-year history, but it has undergone a remarkable transformation over the past century and half to become an international metropolis (Hong Kong Museum of History, 2016). It became the centre of the contraband opium trade to China after being ceded to Britain in 1842. At the same time, it served as the entrepôt for lawful trade in wool, clothing, metals, Indian raw cotton and other products destined for ports on the China coast, while Chinese products including tea, silk, porcelain, bamboo matting, sugar and pigments were exported overseas through Hong Kong. Figure 1 shows some examples of Hong Kong's more recent manufacturing history.

Hong Kong has a monsoon climate, dominated by the seasonal alternation of wind direction and the resulting contrast in weather between winter and summer. Temperatures range from a low of just over freezing to highs of above 35 degrees centigrade in summer. The mean annual rain fall is 2398.50 mm, and 80% of this falls between May and September. My visit to Hong Kong took place in the month of July 2016, so it was very hot and humid.

Hong Kong as the 'Pearl of the Orient' earns a lot of revenue through its tourist industry. Tourism has been actively promoted since the 1950s, and its abundant supply of reasonably priced goods, have made it a shopper's paradise. The success of the tourist industry has also encouraged the development of industries, such as retailing, restaurant, entertainment and transport services. Today, tourism remains a major earner for foreign exchange (Hong Kong Museum of History, 2016).

The 30<sup>th</sup> June 1997 is remembered in history as the concluding chapter in Hong Kong's colonial legacy. A handover ceremony was held in the Hong Kong Convention and Exhibition Centre and at midnight, the national emblem of the Peoples' Republic of China was erected at all Hong Kong government offices (Hong Kong Museum of History, 2016).



Figure 1 Some of Hong Kong's history of manufacturing (Hong Kong Museum of History, 2016)

## 1.2 Welcome to Hong Kong

I was made extremely welcome in Hong Kong, largely owing to the hospitality and professionalism of the Hong Kong branch of the Chartered Institute of Plumbing and Heating Engineering (CIPHE-HKB). Dr Eric Wong of Hong Kong Polytechnic University (HKPolyU) was both a friend and mentor during the trip. He is a licensed plumber and research scientist at HKPolyU, so we shared some biographical similarities. He was incredibly knowledgeable about plumbing engineering, and he had an extensive professional network. He did a superb job of introducing me to trainees, plumbers, tutors, masters, employers and other CIPHE-HKB members. I thoroughly enjoyed the time I spent with Dr Eric Wong through our many research interactions and social events.



*Figure 2 Welcome to Hong Kong!*

Dr Eric Wong often gave up his own time, especially over the weekends, to help me explore the more exotic haunts in Hong Kong, and he would send me little maps through the phone with very precise details:



Figure 3 Map to Hong Kong ferry port for trip to Island Cheung Chau

Dr Eric Wong had excellent local knowledge. He knew the best places to shop and buy electronics, the best places to eat ‘very reasonable’, and he knew the best places to visit, how to get there and what to see when we got there. I took a Ferry with Eric to the Island of Cheung Chau, for example, where our first port of call was the fish market to reserve our dinner for later! It was customary for the locals to get to the market early to reserve the best live lobsters, clams, fish and prawns. Eric had impeccable taste! We then explored the narrow streets, which were full of colourful tourist shops. There were no cars on the island. As the sunlight dissolved into darkness, we went in search of a restaurant to cook our seafood. Our banquette consisted of live fish-head soup, live prawns, lobster, scallops and whole fish, all cooked to perfection. The restaurant made its profit from a modest kitchen fee and our purchase of drinks. After dinner, we walked along the seafront in the warm evening, taking vintage Chinese tea in one of the shops amidst the bustling restaurants. I knew though that the other tourists would most likely not experience the freshness and quality of food that I had just enjoyed thanks to Eric’s native Hong Kong insider knowledge!

Other members of CIPHE-HKB were equally hospitable. Dr Henry Hung was the managing director of Ridgid Plumbing Limited in Hong Kong, and he took time out of his busy schedule to accompany me on a field trip to one of his building sites (discussed below). As a fellow of CIPHE-HKB, Dr Hung also secured a meeting with branch members for plumbing- and education-related discussions. Present at this meeting were, among others, Kenneth T.C. Chan (chairman), Dr Eric Wong (vice-chairman), Dorothy Kung Sui King (chair of the Social Committee), Kenny Wong Ming Bun (chair of the Membership Committee), Calvin Lai Kwong Ying (deputy

chair of the Technical Committee), along with Linus Hui and Simon Lai of CIPHE-HKB Committee.

I also owe a special thanks to Dr Eric Wong and Kenneth Chan for their support on field trips and to Patrick Lee (chairman of the Technical Committee CIPHE-HKB) for travelling hundreds of miles from mainland China to Hong Kong to welcome me on the first evening and for his contribution at other important meetings.

### **1.3 Introduction to study**

The World Plumbing Council Scholarship was created to allow a plumbing teacher to work and study within the culture of another country in order not only to look at the plumbing industry operation in that country but also to develop industry networks and an ongoing opportunity for further exchange within the broader World Plumbing Council Community. This report describes my research experiences while learning about plumbing materials, systems and training in Hong Kong, in comparison to England. A key aim of this study is to better understand the quality of students' training experiences, by analysing the differences in approaches between the two countries.

Following this introduction, the report sets out the study's methodology in Chapter 2 (research instruments, methods, samples, analysis and ethics). The ten research sites are also described in this chapter using pictures and ethnographic narrative. These extensive field trips reflect the productivity of my visit and support the subjective adequacy, or robustness, of the samples in terms of the number of sites visited and people interviewed and the time spent researching in the field.

Chapter 3 presents the results and a discussion of the findings. Relevant supporting literature is used to analyse the results, which are grouped under the following two headings: 'Importance of plumbing to public health' and 'Importance of high-quality training and progression opportunities'. The final chapter four draws some conclusions and gives some implications and recommendations for change.

## **2 Methodology**

### **2.1 Introduction**

This chapter discusses the research instrument (me), the sites, samples and the type of knowledge that emerged from the research activity along with the credibility of the research and research ethics.

Most scientific studies involve some type of instrumentation, and this one is no different. However, the instrument employed here was me, and I am not neutral, valid or reliable. Validity and reliability are terms not suited to the type of interpretive (qualitative) research conducted for this study. This report's purpose was rather to produce a credible deeper understanding of the issues under scrutiny, which would have been difficult to capture through other research measures, such as remote surveys or other statistical types of research.

Rather than hide my interests and position in the research, therefore, they are made explicit in this chapter. I also introduce the reader to the Further Education (FE) and socio-economic contexts relating to plumbing training in England in the period

immediately preceding the Hong Kong study. This study and its methodology have been informed by my doctoral study on English plumbing training (Reddy, 2014).

## **2.2 About the research instrument**

As a registered plumber and subsequently master plumber, I worked in domestic plumbing and heating for over thirty years. For much of this time, I also taught plumbing, mainly part-time in the evenings, in the English FE sector. Just over a decade ago, I became interested in education, which led to an interpretive research study of plumbing training and culminated in a Philosophy Doctorate (PhD) in education. A key reason for undertaking such a study was my concern over the quality of full-time plumbing courses and apprenticeship training in college and work contexts.

My PhD study explored teachers' and students' perceptions and experiences of both full-time college courses and apprenticeships in plumbing in order to deepen our understanding of these particular types of vocational preparation. Ethnographic snapshot observations were recorded during lessons in three FE colleges and at the workplaces of five plumbing students, and formal 1:1 semi-structured interviews were conducted with 15 tutors and 14 students. The data were thematically analysed, and three key findings emerged from the many issues that the study identified relating to the opportunities offered and the challenges posed by the different pathways into plumbing:

1. There was strong evidence of a dislocation between theoretical and practical learning both within the college setting for full-time students and between the workplace and college settings for apprenticed learners. This had implications for the quality of plumbing learning in terms of students having difficulties making meaning from the curricula, which impacted on their levels of motivation.
2. The study revealed the importance of supervised work experience that was centred on long-term knowledge acquisition and relationship development for apprentices with support from their college tutors and co-workers.
3. The findings showed the importance of authentic assessment. It was found that simulations in college could not adequately replicate the experience of doing the job in the real world. Given the inherent risks and problems regularly encountered in the plumbing profession, this signalled significant health and safety implications.

## **2.3 Approach, sites, data collection, analysis and ethics**

### **2.3.1 Research approach**

This study may be described as interpretative in that the emergent knowledge is not necessarily generalisable but it is nonetheless empirical. It is important because this type of knowledge can aid our understanding of plumbing training located within a particular socio-economic context (e.g. within a skills shortage or skills oversupply context). The key function of my research was located in its relevance to legitimate public concerns, such as health and safety and the training of plumbers, and in its ability to provide information that may be judged to be credible (Hammersley, 1992). Research credibility indicates that the findings are believable and trustworthy and that they reflect the participants' experiences of phenomena whilst giving one of

many plausible interpretations from the data (Laverty, 2003; Corbin and Strauss, 2008). Corbin and Strauss (2008) preferred to use the term ‘credibility’ when talking about interpretive research as a way of eschewing the dogmatism of truth. In relation to the criterion for the research findings to be trustworthy, Bruyn (in Layder, 1998: 85-86) introduced the notion of ‘subjective adequacy’. This refers to methodological issues, such as length of time spent studying the phenomena, the degree of intimacy achieved and the number of different vantage points from which the objects of research were studied.

### 2.3.2 Sites

The research samples were neither representative nor random. I interviewed and met with professionals and other workers who were chosen by CIPHE-HKB in relation to my documented requests via the World Plumbing Council (WPC) Scholarship. The data were gathered at ten key sites over a continuous 17-day period in Hong Kong from a diverse range of participants in different educational and work settings. The ten sites are listed below (see Section 2.4 for samples):

#### **Higher education institutions**

1. The Hong Kong Polytechnic University – I attended several lectures on Plumbing Engineering, was given a tour of the campus and observed their Professional Construction provision. I shared my own practice of Facebook Pedagogy with postgraduate engineers and plumbing experts.
2. The Hong Kong College of Technology – I learned about the Master of Science in Plumbing degree programme and looked at their information technology facility. I shared my own practice of Facebook Pedagogy
3. City University of Hong Kong – I attended a lecture on CIPHE-HKB Chartered Engineer options followed by a meeting with Dr Henry Hung and HKCIPHE branch members.

#### **Further education colleges**

4. Vocational Training Council (VTC) – I observed their general pre-apprenticeship provision and plumbing apprenticeship college facilities and was given a tour of their workshops and classrooms. I also conducted interviews with some of the teachers and younger students.
5. Plumbing Technology Student Association (PTSA) – I observed the plumbing assessments for licensed plumber status and other training activities. I was given a tour of their workshops, assessment centre and classrooms. I conducted informal interviews with staff and adult students.
6. Construction Industry Council (CIC) – I observed adult (over 18 years of age) trainees on 90-day preparatory ‘access to construction industry’ building site training. I was given a tour of their workshops and conducted informal interviews with teachers and adult students.

#### **Workplaces**

7. Ridgid Plumbing Company Ltd - field trip to live building site
8. Kitson Plumbing Company Ltd – introduction to new technologies
9. JF Thermal Systems – field trip to two air-source heat pump installations
10. Cinotech Consultants Limited - Interview with Dr H. F. Chan concerning lead in Hong Kong’s water supply

### 2.3.3 Data collection

My data collection objective was to engage in both detailed observations and interviews with key informants, as recommended by Charmaz (2006), in order to build up as complete a picture as possible. Interviews alone fail to constitute the entire reality of an educational setting or event. The interview questions used were similar to those used in Reddy (2014) and were aimed at collecting data on (i) the curricula and the relations between theory and practice in Hong Kong colleges, (ii) supervision and the length of time apprentices spent at work and (iii) plumbing assessment. For some of the interviews with the plumbing and engineering professionals, I asked questions that addressed criteria specified by the World Plumbing Council Scholarship, such as the requirement to investigate plumbing materials and their contact with the water supply. Throughout all of the visits, sessions, meetings and interviews, an English person took notes while I discussed matters of plumbing and training with participants. These scratch notes were later transcribed into more detailed field notes. This process allowed me to become involved in conversations, discussions and questioning without the distraction of note-taking. The field observations were 'ethnographic snapshots' in that I undertook 'a descriptive and explanatory snapshot of reality' at the events at the research sites in the study (Crabtree & Millar, 1992: 3).

### 2.3.4 Analysis

The data from the observations in Hong Kong (photographs, notes and supplementary documentation) were analysed in a thematic way. This involved searching for themes that could be considered to be the dominant traits of the phenomena under study (Teddlie & Tashakkori, 2009), based on the WPC scholarship's promotion of continued learning about plumbing training and the types of plumbing systems and issues facing plumbers in other countries. The thematic approach generates emergent themes evolving from the study of specific pieces of information that the investigator has collected (Teddlie & Tashakkori, 2009). Two major principles in thematic analysis were used, which are described by Spradley (in Teddlie & Tashakkori 2009: 253):

1. The 'similarity principle' states that the meaning of a symbol can be discovered by finding out how it is similar to other symbols
2. The 'contrast principle' states that the meaning of a symbol can be discovered by finding out how it is different from other symbols.

### 2.3.5 Ethics

When undertaking any research project, the researcher must be alert to the ethical issues that may need to be addressed. Simons (in Pring, 2000: 142) described the ethics of educational research as 'the rules of conduct that enable us to operate defensibly in the political contexts in which we have to conduct educational research'. The permissions for entry, interaction and photographs of students, teachers, workers and academics were well planned and agreed both prior to and during the study. It was important that none of the participants in this study should experience any harm or distress as a consequence.

## 2.4 Fieldwork

### 2.4.1 Introduction

The following section describes the fieldwork I carried out at ten different sites in Hong Kong. These are divided into three groups: HE institutions, FE vocational colleges and workplaces.

### 2.4.2 HE institutions

The following section reports on my visits to HE institutions in Hong Kong.

#### 2.4.2.1 Hong Kong Polytechnic University

I was made very welcome at the HKPolyU. In addition to being shown around the 'Industrial Centre' relating to construction and engineering, I also attended lectures given by high-ranking professionals and plumbing engineering experts.



Figure 4 Hong Kong Polytechnic University

The lectures were on topics relating to plumbing design, and they formed part of the Professional Diploma Course in Public Health and Plumbing Engineering. The CIPHE logo was visible at every lecture. The lectures were attended by up to seventy students, including highly qualified engineering doctors, chartered engineers, sanitary engineers and scientists. The speakers I observed included:

**Mr Kenneth Chan**, chairman of the CIPHE-HKB (2015-2016). This interesting lecture included regulations, guidelines, testing and commissioning for

building drainage and sewage treatment. The outbreak of SARS in Hong Kong was discussed in relation to sanitary engineering, and this emerged as a key theme in terms of the health implications of plumbing.

**Mr Allen Chung Chun Wah**, Water Supplies Department. Mr Chung was a Water Works inspector. He explained water connection application procedures in Hong Kong with reference to wholesome water and salt water flushing water along with the plumbing materials that come into contact with water.

**Dr Anthony Ma**, Hong Kong Services Water Treatment. An accomplished chartered engineer and scientist, Dr Ma drew on his years of industrial experience in this lecture. In relation to salt water flushing, he suggested the possibility of up to 'one third saving by use of sea water', but he gave a balanced account by detailing the expensive maintenance and high corrosion involved. He also described the difficulties in recycling sewage because of salinity.

The speakers I observed took a mainly didactic stance, and the lectures were teacher-centred, which was the case for the majority of lectures I observed in my English study. It was apparent that both England and Hong Kong could benefit from a more creative pedagogical intervention aimed at generating a student-learning response rather than imposing learning on the student. This is discussed further in Chapter 3.

However, there was much to learn from the pedagogy in Hong Kong. The importance of the quality of experience in regard to occupational training, was a strong theme to emerge at HKPolyU (as well as from the other Hong Kong training institutions). The picture below shows professional construction students building a high fidelity simulation of a high-rise dwelling at the HKPolyU.



*Figure 5 High-fidelity simulation at Hong Kong Polytechnic University*

The educational objective was to give professional construction students of subjects like architecture, surveying and civil engineering some practical work experience. The authentic simulation provided a means of contextualising classroom learning and bringing greater meaning to the theoretical aspects of the curriculum. Students were provided with a realistic work environment, built within HKPolyU for knowledge and skill development, and a means to empathise with the challenges and difficulties that emerge in the process of craft work. The students were expected to perform in a professional way at all times, receiving visitors such as teachers, researchers and professors in a safe and professional way. A female construction student (pictured above) welcomed visitors to the project and described her own responsibilities. The quality of the experience (in terms of student opportunities for meaning-making and understanding) was a key theme to emerge from the data across all the educational sites observed. This is discussed further in Chapter 3.

#### 2.4.2.2 Hong Kong College of Technology

A key priority during my visit to this college was to discuss the Master of Science in plumbing (although the degree programme is likely to include information on air conditioning and ventilation, public health in plumbing design, sustainable design and development, energy systems and our carbon footprint). It was found that there was still work to do to finalise the MSc course but that the college are working with a leading UK University to complete the programme.

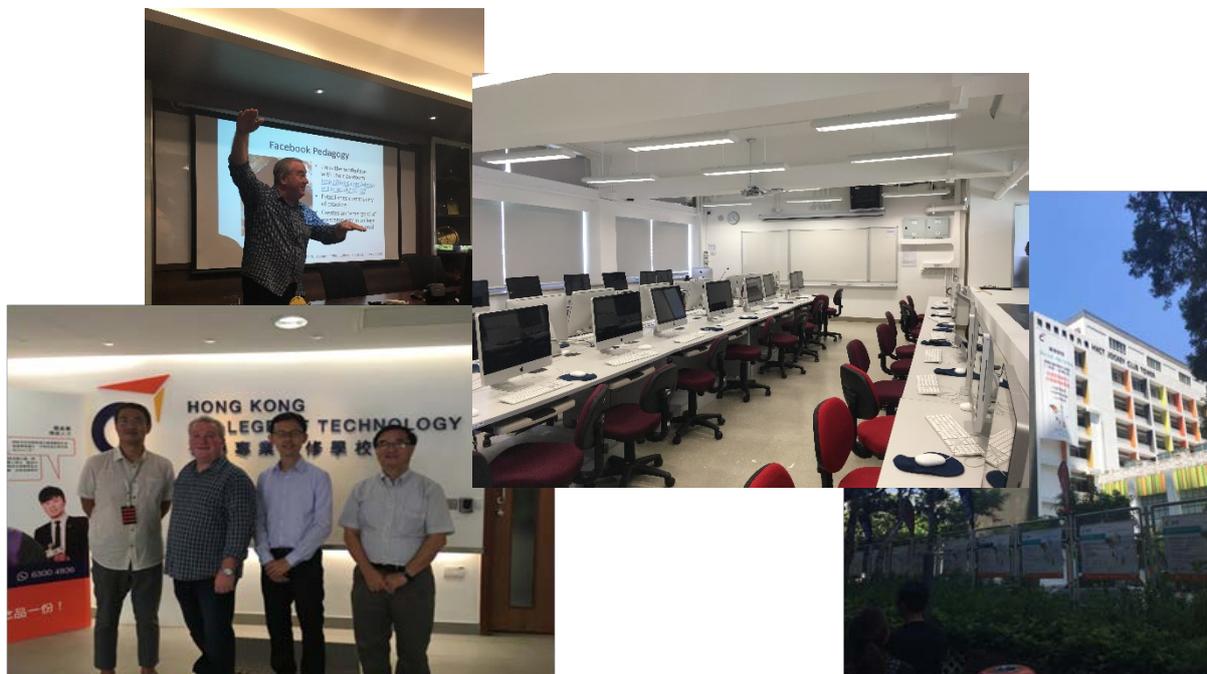


Figure 6 Hong Kong College of Technology

Both Dr Wong and I were received by Gary S.C. Tse (head of the Centre of International Education) and Dr Ivan Y. Chan (head of programme in the Department of Professional and Advanced Studies), who showed us around the campus. The college was colourful and welcoming with rooms fitted out with the latest Apple

computers and learning technology (The Apple Garden). It was a great pleasure to share my own teaching and learning strategy, Facebook Pedagogy, with the tutors and management team at the College. Both tutors and management were very interested in using this strategy in the future to help their own students' technical and artistic learning.

#### *2.4.2.3 City University of Hong Kong*

An audience of around 300 people turned out for an evening at the City University of Hong Kong to learn about the CIPHE's route to Chartered Engineer status. The speakers explained how existing plumbers may be eligible to progress to being a Chartered Engineer through routes other than university.



*Figure 7 City University of Hong Kong*

It was apparent that Hong Kong plumbers and plumbing-related professionals were very interested in professional status. This is in contrast to the apathy that seems to surround English professional formation in the plumbing industry. For example,

membership of the CIPHE-HKB was highly valued by Hong Kong plumbing professionals and industrial engineers. At this event, I had the great pleasure of meeting plumbing engineering professionals Raymond Chan and William Poon Wai Yee, from the Hong Kong Licensed Plumbing Professionals Association.

### 2.4.3 FE institutions

#### 2.4.3.1 Hong Kong Vocational Training Council (VTC)

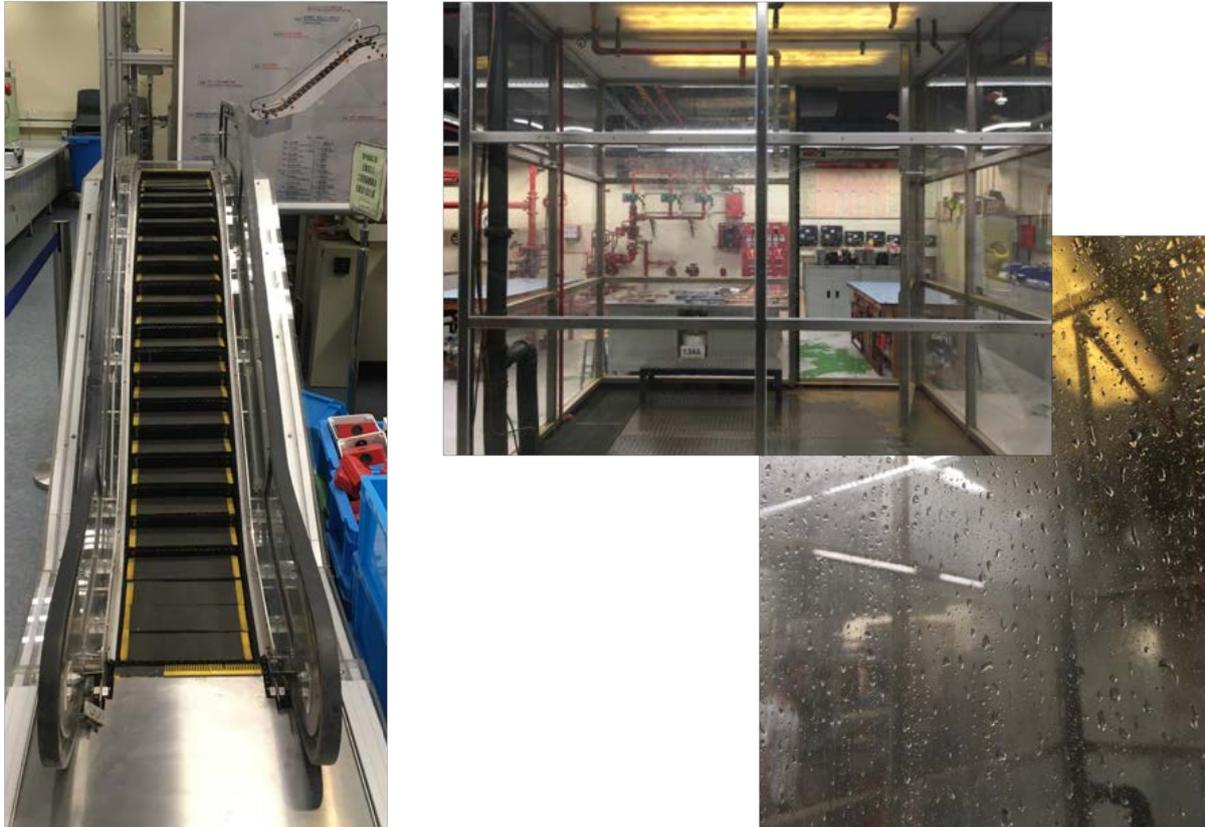
The VTC was established in 1982 to provide full-time and part-time pre-employment craft training for apprentices along with a diverse range of other courses similar to the FE sector in England. I had a very warm welcome at this college from Mr Chin, who explained the college's ethos as well as some contextual issues. In the technical training departments, Mr Lau Po Ping, Mr Cheung Kwok Sun and Ng Chor Kwong were very helpful to my research and incredibly professional in the way they represented the college.



Figure 8 Hong Kong VTC

The college provides continuing professional development (CPD) courses, licence-to-practice qualifications in, for example, the plumbing, firefighting and electrical sectors and short training courses for subjects like unvented hot water. It also runs mainstream vocational courses leading to degree pathways, just like colleges in the English FE sector.

The training for licensed plumbers runs over a four-year period, but exemptions apply (similar to England for apprentices). For licensed plumbers, two certificates are required. The VTC constructed working-scale models (e.g. of a working escalator and fire sprinkler simulator) to help students better understand the theoretical curriculum delivered in the classroom (see below).



*Figure 9 High-fidelity simulations at Hong Kong VTC*

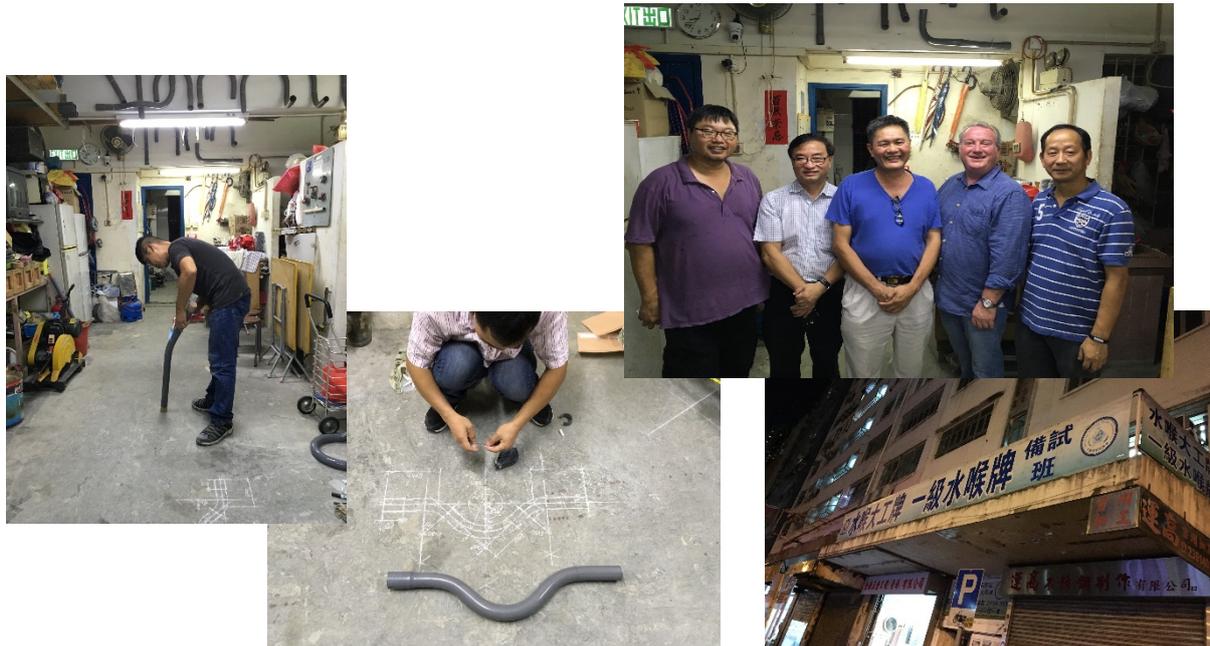
It seemed important for Hong Kong tutors to be able to show students how a whole system looked and worked by using ‘high fidelity’ models that closely replicated the reality of situations and the components in the workplace. This high-fidelity simulation promoted a high-level replication of the work context, which even included the human interactions found in such occupations as firefighting and plumbing through, for example, client role play situations.

The college were proud of the fact that they managed to progress 100% of their full-time pre-apprenticeship plumbing students onto full-time courses and into employment. This was one of the key themes to emerge from the report and will be discussed in the next chapter.

#### *2.4.3.2 Plumbing Technology Student Association (PTSA)*

I was given a warm welcome by the PTSA staff Wendy Yip, Simon Wong Kam Tim, Wong Pin Fai and Choy Tin Sung. I had a tour of their workshops, assessment centre and classrooms, and I chatted with master plumbers and adult students. I also

observed plumbing assessments for licensed plumber status and other training activities.



*Figure 10 Plumbing Technology Student Association*

PTSA had a welcoming atmosphere in general, and the master plumbers, plumbers and plumbing students were friendly and kind. A plumber immediately passed me a bottle of chilled water on my arrival, so I knew I was amongst friends.

While assessments progressed, the master plumbers played a pastoral and supportive role with students doing their licensed plumber tests. Dr Eric Wong worked at the Hong Kong PolyU, but he had assessment responsibilities in regard to quality control in the process of licensed plumber qualifications. The high visibility of plumbing engineering professionals like Dr Eric Wong as well as the master plumbers at PTSA, working together in a supportive atmosphere, seemed to bode well for the credibility and quality of the assessment product they offered at the centre.

Students used the floors to draw chalk dimensions for pipe bending, and the plastic pipes were sand-loaded before being heated to bend. I was able to chat with tutor Simon about the quality of plumbing materials and about jointing. He shared several course documents and a catalogue of a new type of stainless steel compression fitting and informed me of the wide range of technical and professional courses offered at PTSA centre.

#### *2.4.3.3 Construction Industry Council (CIC)*

I was welcomed to the Construction Industry Council Training Centre by Mr Patrick Lin and Mr Jimmy Tsang, an experienced plumber, teacher and member of the CIPHE-HKB. Mr Tsang's office at the Kwai Chung Training Centre was decorated with pictures of plumbing students holding trophies won in previous World Skills competitions. His plumbing apprentices had won four World Skills competitions, and his students were trained to work to high standards. Mr Tsang was proud to be a

professional who was not frightened to get his hands dirty. I observed him helping apprentices to bench the drains. His certificates for mastery and competence were displayed on the walls of the classrooms, so he was visible to the plumbing students as a highly experienced and qualified professional plumber, and his membership of CIPHE-HKB reflected this status.



*Figure 11 Construction Industry Council Kwai Chung Training Centre*

Mr Tsang was in charge of the plumbing workshops, where training was provided to students who were over 18 years of age. There were four centres in all, including the Hong Kong VTC centre I had visited a few days earlier. The Kwai Chung Centre provided training for basic-level craft and technician plumbers, who were issued with a site safety card. However, the process of assessment was kept separate (in a different centre). This is the type of arrangement planned for English apprenticeships as part of the new Trailblazer standards and their end-point assessments. Mr Tsang explained that many of his students were unemployed but that the government sponsors construction firms to employ the students in college for 90 days of paid basic training. The students mainly learn practical skills during the training, which supports the practise and 'embodiment' of skills to help students perform satisfactorily on arriving at the construction site (Guile, 2011).

It was apparent that licensed plumbers had to do an intermediate trade test to become qualified and that they also required a minimum of three years' work experience. The organisation of Hong Kong plumbing apprenticeships is as follows:

- Year 1 - Basic site training (such as that at Kwai Chung)
- Year 2 - VTC part-time day release
- Year 3 - VTC part-time day release

Again, there was a very high rate (90%) of students progressing into relevant paid employment following the training. The 10% of adult students not progressing were said to decline jobs because of personal or family reasons.

One of the positive features of Hong Kong plumbing training was the close proximity between the classroom and the workshops. For the basic plumbing training, Mr Tsang stated that he kept the classroom learning to a minimum and focussed mainly on teaching students practical plumbing skills. This stands in stark contrast to English plumbing courses, which have been found to be mainly theoretical (Reddy, 2014). All the pipe work practical scenarios that students worked on were live, unlike in England, where simulated plumbing training is more often disconnected from the liquid/gas/pressure of a system installation and diminished to making small pipe frames on benches. In addition, Hong Kong students were using electrically powered pipe threading machines, but in England, all the threading I observed in colleges was carried out with hand threading machines (Reddy, 2014). Mr Tsang said it was unlikely that hand threading machines would be used on a job in Hong Kong, because the work would not be quick enough to meet the standard. The same is probably true for England, but many colleges, with a view to health and safety, still insist that students use hand-threading machines which make the college-based tasks much longer to complete.

The images in Figure 12 show the classroom connected to the workshop space in Hong Kong. This close proximity between classroom and workshops allowed tutors to use simulations, models and practical resources to help students better understand the theoretical classroom learning. In my English study of plumbing training, the classrooms were observed to be dislocated and a considerable distance from the workshops. Tutors complained there were limited opportunities for them to bring their groups to the workshops for learning. The plumbing teachers in my study described the workshops as 'always full', so models and important practical learning resources (practical simulations) were often never available in England to help students make meaning and better understand their classroom learning (Reddy, 2014).

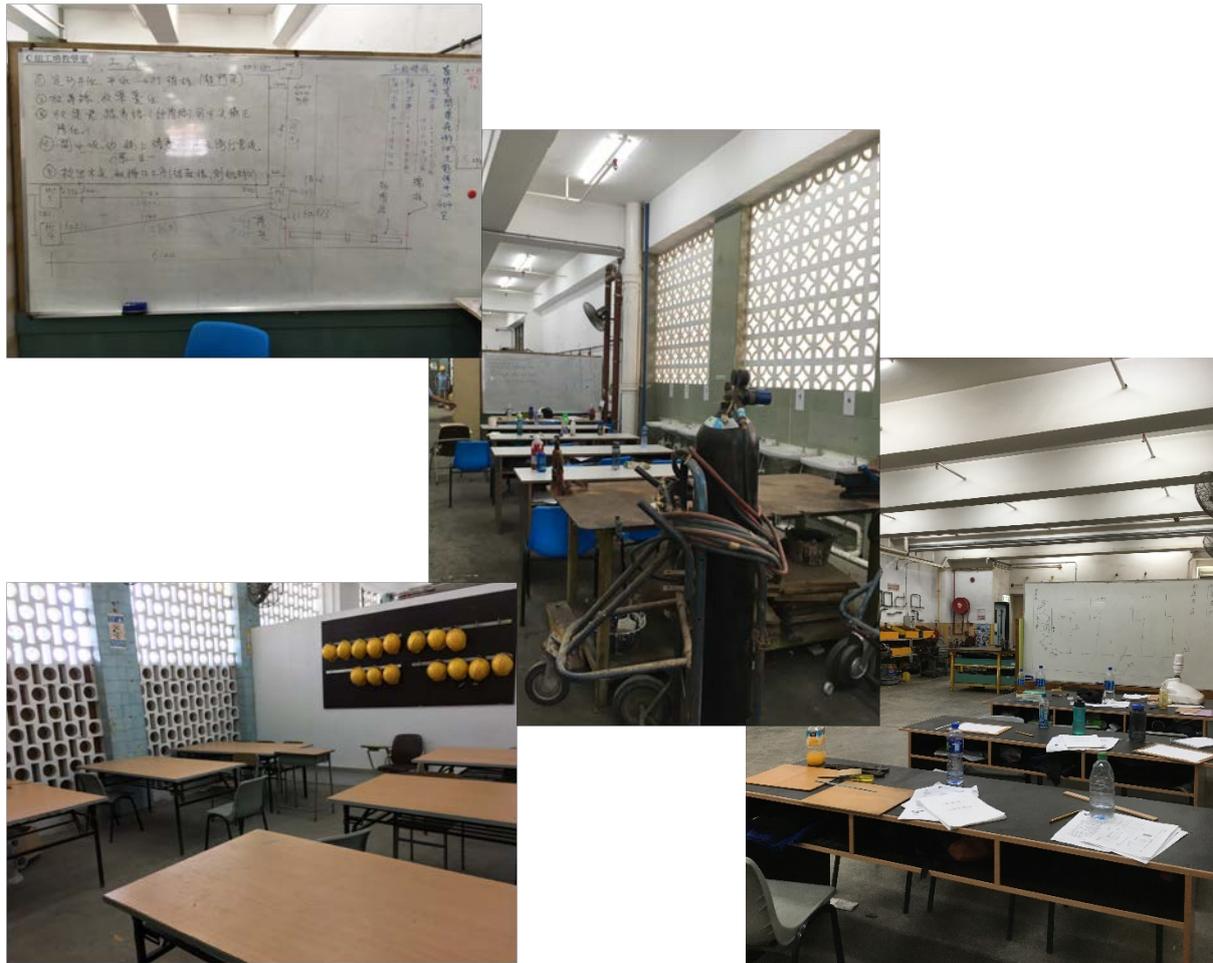


Figure 12 Construction Industry Council Classrooms in Workshops

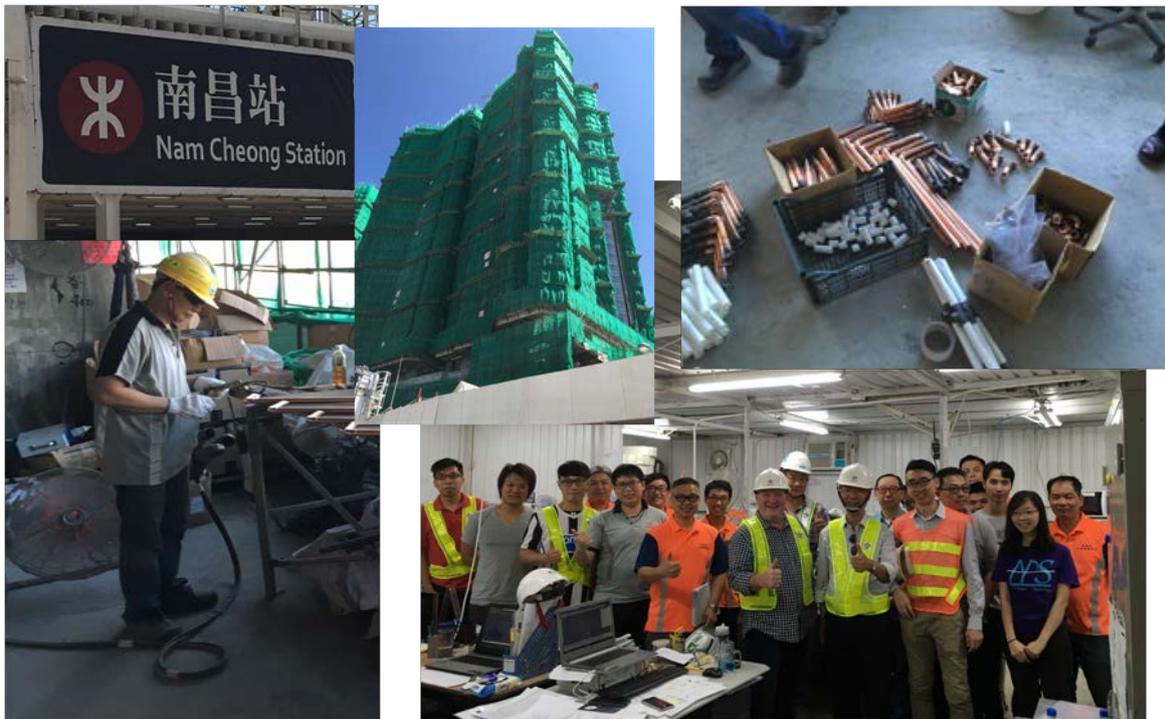
One of the adult students at CIC was class representative Hu Yeung Hillman, who was 27 years old. He described his occupational background as a qualified chef but told me he had been attracted to switching to a career in plumbing because there was a construction skills shortage and a potential for better pay and working hours (nine till five in construction compared to low-paid split shifts as a chef). The issue of skills shortages was a key theme to emerge in the report. Table 1 in the next chapter shows the differences between the weak signs of skills shortage in England compared to the strong signs of skills shortage in Hong Kong and is accompanied by a discussion.

## 2.4.4 Field trips to industry

### 2.4.4.1 Ridgid Plumbing Company – construction site visit

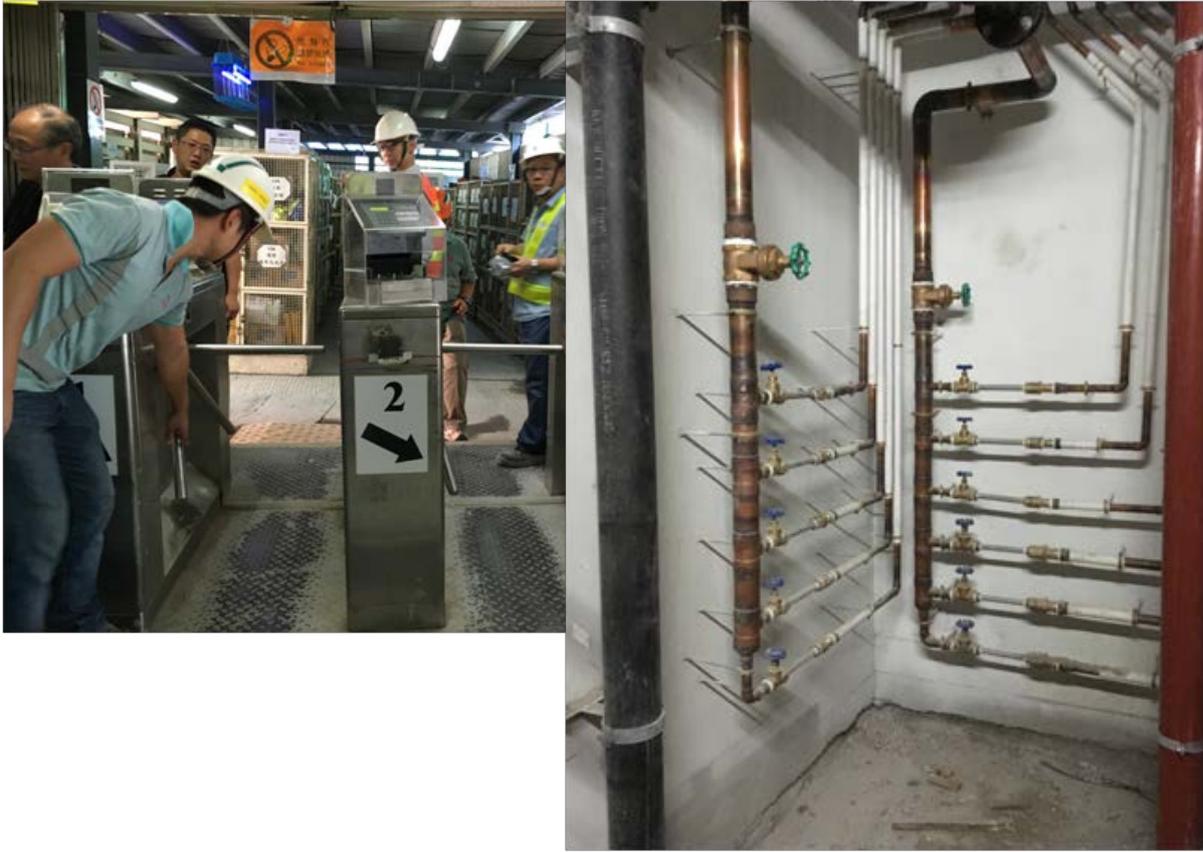
The offices of Ridgid Plumbing Limited were located in a high-rise building with magnificent views over Kowloon Bay. I was most privileged to meet with Dr Henry Hung, who was a remarkable man with a humble disposition. He established Ridgid Plumbing Limited in 1972 as a plumbing and contracting firm, and the company has since developed into one of the most respected leading engineering companies in Hong Kong. Dr Hung was a founder of CIPHE-HKB, and he has taught on

professional postgraduate plumbing engineering courses at HKPolyU. He is a consummate plumbing professional, and it is clear that he has been a role model to others in CIPHE-HKB. On taxi journeys, Dr Eric Wong would often point out a magnificent building and say 'highest in Hong Kong and plumbing installed by Dr Henry Hung's firm'. Indeed, the reputation of Ridgid Plumbing Limited was clearly reflected in their mission statement, which is 'to be reliable and professional' and their slogan, 'plumbing engineering you can trust!'



*Figure 13 Ridgid Plumbing Limited, Hong Kong Nam Cheong Station Construction Site*

On a field trip to a construction site near the Nam Cheong Station, I was able to get a good look at the on-site first-fix plumbing installation. First fixing involves the installation of plumbing into the carcass of the building before floors and walls are finished. The levels of safety on this site were comparable with those I have seen in the United Kingdom in the last five years, and personal protective equipment was mandatory and carefully checked by safety officers before entry to site (see below).



*Figure 14 Ridgid Plumbing Limited*

The site was tidy and materials were well organised and well stored. I managed to observe plumbers in action, silver brazing pipes as the preferred method of jointing. This type of jointing, which reduces the number of metals in the joint, is approved for wholesome water supplies. I was also impressed by the quality of materials being used on site. One of the requirements of the water company inspector was that contractors display a board with a sample of all the plumbing materials used on site. I also visited the construction office, which had a good atmosphere amongst the workers, who were happy to take a moment for a photograph.

#### *2.4.4.2 JF Thermal Systems – visits to two air source heat pump installations*

As already mentioned, I attended lectures on plumbing engineering at the HKPolyU, one of which was given by Mr Kenneth Chan, chartered engineer, fellow of the CIPHE and chairman of the CIPHE-HKB. I had the good fortune to have several meetings with Mr Chan. Both Mr Chan and I visited Mr Arthur Wong of JF Thermal Systems, who was an expert in air source heat pumps. Our meeting involved a short lecture given by Mr Wong on the different types of JF Thermal air source heat pump installations and the rationale for why they were cost-effective options, offering a pay-back within five years.

Mr Wong explained that air source heat pumps extract energy from the surrounding air to heat or cool water. While the air source heat pumps are supplemented by peak-rate power when required, the need for peak-rate power is considerably

reduced. A big part of Mr Wong's sustainable philosophy is built on the quality of materials he uses. His world view was pragmatic and he explained that 'many systems, either solar or heat-pump systems, can cost a lot of money to maintain'. Mr Wong said that if the equipment is not reliable or sustainable, then it will be quickly scrapped, which impacts on the quality of the environment. The clients of JF Thermal expected a ten-year guarantee, and Mr Wong explained how heat pumps could meet this expectation, lasting for around 13 years. However, this was dependent upon a good schedule of corrective/preventative maintenance along with the continual monitoring of the energy systems in use. The pictures below show both Mr Wong and Mr Chan accompanying me at heat pump installations for swimming pools in Hong Kong.



*Figure 15 JF Thermal Systems, Hong Kong*

#### *2.4.4.3 Deodorising toilets at Kitson Plumbing Company Limited*

I was most privileged to meet with master plumber Mr Kenny Wong, chair of the Membership Committee CIPHE-HKB and owner of Kitson Plumbing Company Limited. Mr Wong's father established Kitson Plumbing Limited in the 1960s, and the firm now had as its key focus maintenance and renovation. The company did employ some plumbers, but most of the labour was on a subcontract basis. This said, most of the subcontracted workers had worked for the company for twenty years. The company prided itself on employing professionals, such as master plumbers, bringing high-quality workmanship and the added value of direct connection to the customer. Mr Wong also had other innovative business interests in regard to water conservation, water saving devices and deodorising toilets.



Figure 16 Kitson Plumbing Company Limited, Hong Kong

At Kitson Plumbing Company Limited, I was shown a deodorising toilet, which was a most impressive product. The deodorising function operated by means of a fan, triggered by an infrared sensor when someone sits on the toilet. The fan immediately starts to create negative pressure within the toilet cistern. Atmospheric pressure then pushes clean air into the toilet bowl, and this displaces the smells, which are drawn into the cistern. Mr Wong explained that there were five substances that made up faecal odour and that three of the five gases could be dissolved in water in the cistern and the other two could be filtered out. Flushing the toilet removes the gases that are dissolved in the cistern water. The product could also be retro-fitted to existing W.C. units, and it was particularly useful in hotel rooms that did not have an opening window, which were abundant in Hong Kong.

At Kitson, I also had the honour of meeting Master Plumber and Chartered Engineer Mr K. K. Chan. There was a moment of proud reflection as we three master plumbers stood in the Kitson Plumbing Company office, since only ten existed in the whole of the Hong Kong population of around 8 million.

#### *2.4.4.4 Meeting with Dr H. F. Chan (Cinotech Consultants Limited)*

This meeting with Dr H. F. Chan was also attended by Dr Eric Wong and an English person, who took notes during the discussion. Dr Chan is an environmental consultant and government official working on the Advisory Committee on Water Quality and Water Supply, which helps to inform the director of water supplies in regard to public education. Dr Chan was appointed chairman of the advisory committee on water supplies until 2018. The committee is made up of twenty one members who are invited from government with nine members from government departments. Meetings are arranged three times a year, and there are three working task groups, each with a chairman dealing with water quality, water conservation and water resources. At the meeting, Dr Chan and I discussed water in contact with plumbing materials and the key findings are discussed in the next chapter.

## **3 Findings and discussion**

### **3.1 Introduction**

The following chapter presents the key themes to emerge from the data collected at the ten sites and discusses the study's findings. The key themes are organised under two main headings: 'Important health implications of plumbing' and 'Importance of high-quality training and progression opportunities'.

### **3.2 Important health implications of plumbing**

#### **3.2.1 Sanitary engineering and human flourishing**

A key theme to emerge from the data was the importance of sanitary engineering to human flourishing. A strong concept of sanitary health seemed to be embedded within the Hong Kong public consciousness. This is most likely owing to the outbreak of SARS in 2003. The disease affected a total of 1750 people, with 286 dying from the condition in Hong Kong (Hung, 2003).

The outbreak of SARS in the Amoy Gardens housing estate in Kowloon was particularly intense. An investigation was conducted by the Department of Health in collaboration with eight other government agencies, which indicated that environmental factors had played an important part in the outbreak. Each block at Amoy Gardens had eight vertical soil stacks serving all floors. The soil stack was connected to the water closets, basins, bathtubs and bathroom floor drains. Each of these sanitary fixtures was fitted with a U-shaped water trap to prevent foul smells and insects getting into the toilets from the soil stack. Clearly, for this to work, the U-traps must contain water. However, because most households were in the habit of cleaning the bathroom floor by mopping rather than flushing with water, the U-traps connected to most floor drains were probably dry and not functioning properly (Hung, 2003; Lee, 2003; Hung, Chan & Law et al, 2006) (see diagram below).

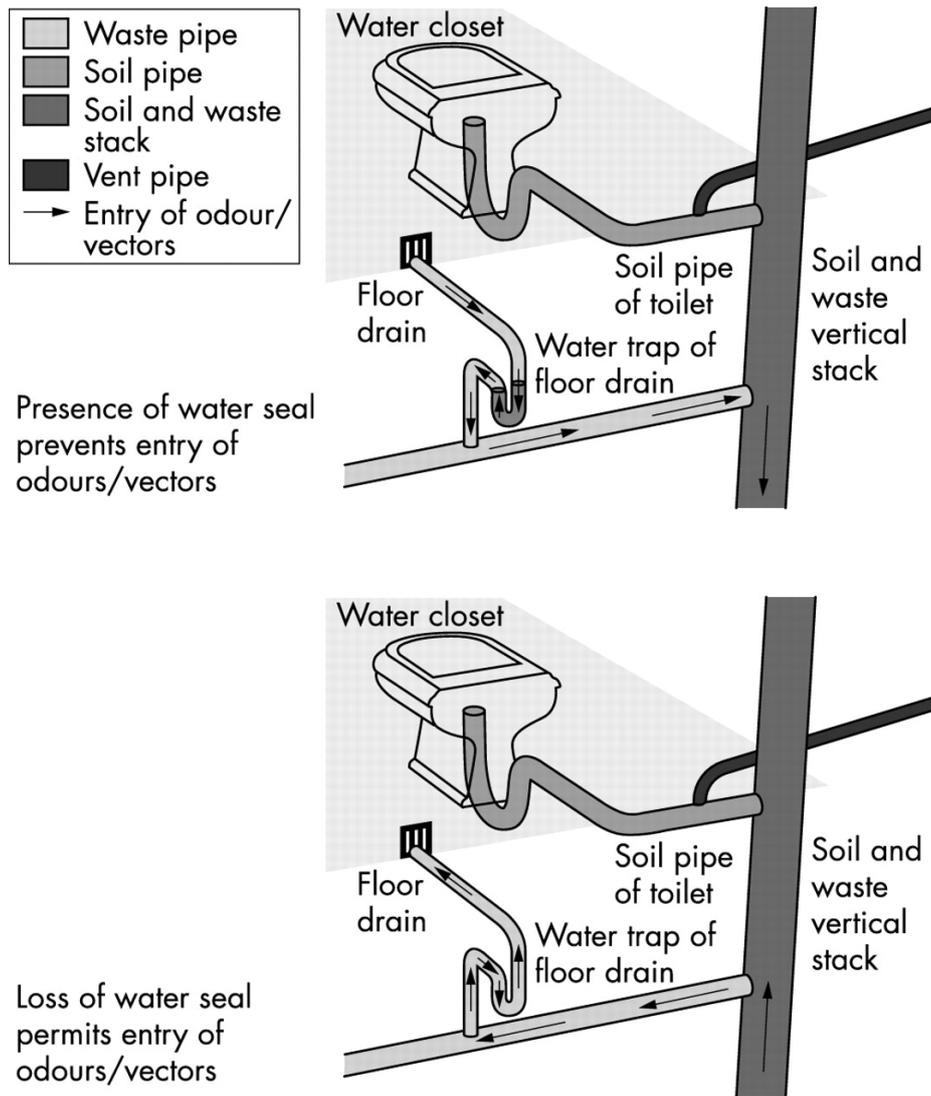


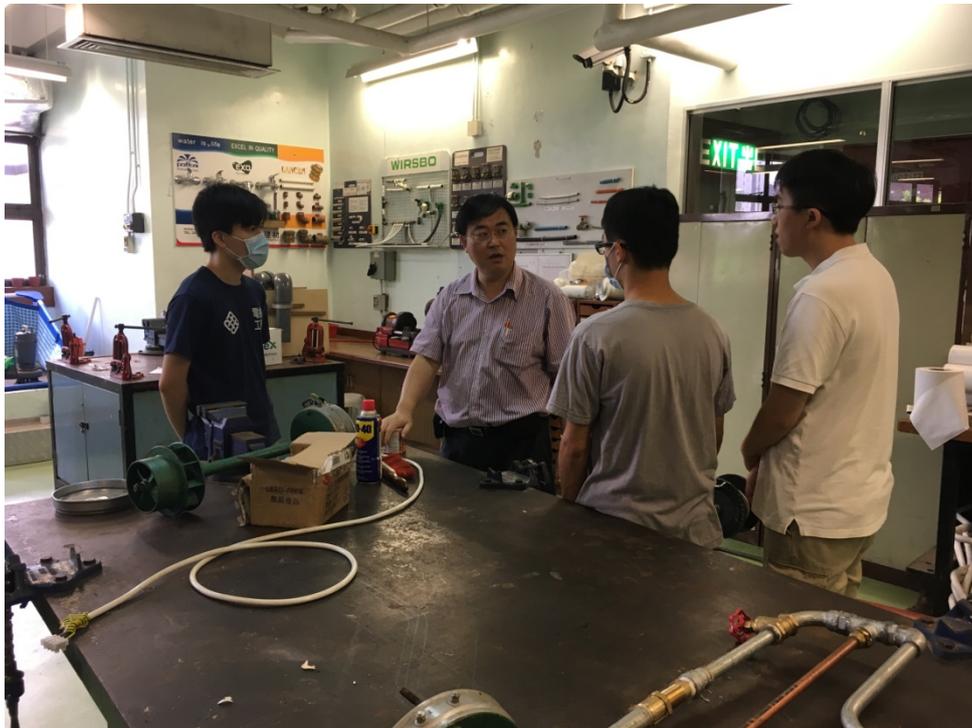
Figure 17 Sanitary pipe work detail in Lee (2003: 653)

According to Lee (2003: p.653):

*The 'bathroom floor drains with dried up U traps provided a pathway through which residents came into contact with small droplets containing viruses from the contaminated sewage'. These droplets entered the bathroom floor drain through negative pressure generated by exhaust fans when the bathroom was being used with the door closed. Water vapour generated during a shower and the moist conditions of the bath room could also have facilitated the formation of water droplets. The chance of exposure was increased given that the bathrooms in apartment units of Amoy Gardens were generally small in size (about 3.5 square metres). Contaminated droplets could then have deposited virus on various surfaces, such as floor mats, towels, toiletries, and other bathroom equipment. Transmission of the disease by airborne, waterborne route, and infected dust aerosols have been examined but these were not supported by the epidemiological picture and laboratory results. A team of experts on environment from the World Health Organisation (WHO) were later invited to visit the Amoy Gardens and to study the result of the*

*investigation. The WHO experts were in agreement with the findings of the investigation report.*

The legacy of the SARS outbreak in Hong Kong still lives on (Hunt, 2013) in the population's consciousness. People working in close proximity with others who suspect they have a cold are inclined to wear face masks to help minimise the risk of spreading the infection.



*Figure 18 Hong Kong Polytechnic University student with Face Mask*

To be amongst Hong Kong plumbing professionals who have faced the challenges of SARS has been enlightening for me as a plumber. The experience has given me a renewed sense of respect for the importance of sanitary engineering and for the importance of competent plumbing. The implications of plumbing in regard to health and human flourishing, was a key theme in the research. In relation to this theme, the next topic (Section 3.2.2) sets out the challenges presented to humanity in terms of the drinking water quality.

### **3.2.2 The importance of wholesome water to human flourishing**

The subject of lead in the water supply emerged early on during my visit to Hong Kong. I was about to take a drink from a drinking water fountain when Dr Eric Wong advised me to let the water run for a couple of minutes to allow any lead that may be dissolved in the drinking water to run off. At this point, I understood there was a serious problem, not only in terms of the wastage of water and energy but also in regard to the serious health implications.

The problem of lead in the water supply was widely reported in the media, with the South China Morning Post (Yau, 2015) reporting that 'Independent tests show higher levels of lead in water supply at Hong Kong public housing estates'. Moreover, the

article explained that the 'Expert report to commission of inquiry, based on different testing method from that used by government, says problem was worse than first thought'. The factsheet produced by the Hong Kong government's Information Services Department (ISD) (2016) gives information on the nature of lead:

*Lead is a naturally occurring heavy metal which usually presents in very small amounts in the environment. Lead and its compounds may be found in products such as batteries, lead-based paints, lead-containing ceramics, lead solder and leaded petrol. In everyday life, lead is found everywhere and exposure seems inevitable. Notwithstanding this, it is always good for health to achieve the lowest possible lead level in the body*

However, if lead is ingested into the body, the Department of Health Centre for Health Protection (2016: 1) describes the consequences:

*Lead can enter the human body by ingestion, inhalation and skin absorption. When lead is absorbed into the body in excessive amount, it is toxic to many organs and systems. Depending on the lead level inside the body, significant exposure to lead is associated with a wide range of effects, including neurodevelopmental effects, anaemia, high blood pressure, gastrointestinal symptoms, impaired renal function, neurological impairment, impaired fertility and adverse pregnancy outcomes. Infants, young children, pregnant women and lactating women are more likely to be affected by its adverse effects.*

In July 2015, the legislative council found levels of lead in the Hong Kong water supply to be exceeding that stipulated by the WHO. Moreover, the Democratic Party (Legislative Council, 2016) stated that more public housing estates had been sampled and more cases of lead had been found in the drinking water supply. An investigation took place with a Task Force led by Dr H. F. Chan (interviewed in this study) which included academics and other scientists. The Task Force were employed to conduct rigorous research and gather substantive evidence to link lead in the water supply to the solder used in copper plumbing fittings (Report of the Task Force, 2015). The government also set up an independent committee chaired by a judge.

In my interview with Dr Chan, he stated that water imported from China contains around '1-3 micrograms/decilitre' of lead and that after treatment, there is either '1 microgram/decilitre' or an undetectable amount. However, the problem of lead in the drinking water was found to be on the Hong Kong user 'service side' in that it was householders' plumbing systems that contained the excessive lead and not the water distributed by the Hong Kong water undertaker. Eleven public estates were found to have high lead content in the water supply with '5 micrograms/decilitre'. Dr Chan stated that separate plumbing systems were being arranged for these properties.

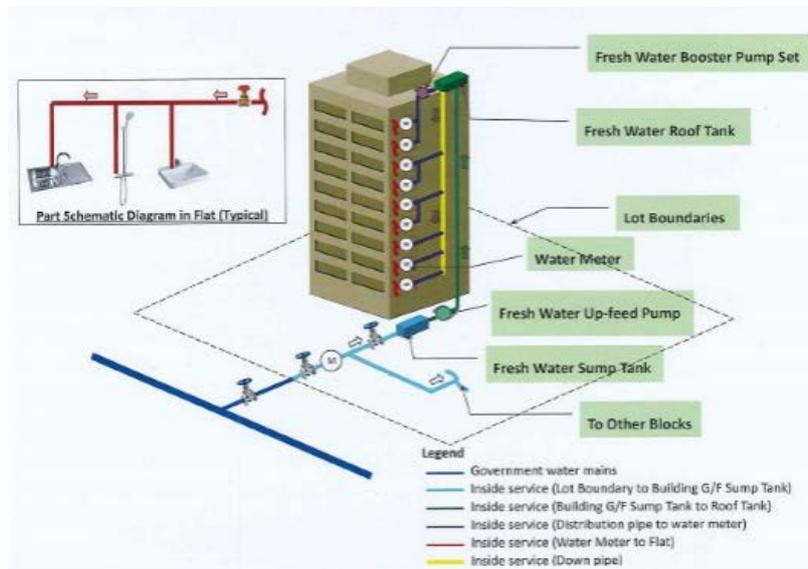


Figure 19 Typical Hong Kong domestic water service (Report of the Task Force, 2015: 7)

Nevertheless, the Hong Kong public may still be exposed to some risk. The Report of the Task Force (2015: 57) stated: 'As hot water increases the amount of lead that may leach from pipes and fittings, only water from a cold water tap should be used for cooking and drinking'. However, the Report does not warn against bathing babies and small children, who may be at risk of accidentally ingesting contaminated water by swallowing. Indeed, towards the end of the Report (2015: 56), there is a list of points to note for the attention of the public, which included the following warning:

*According to the results of stagnation and flushing tests conducted by the Task Force, the heavy metal contents in water will increase with its stagnation time in the water supply chain if there is leaching of heavy metals from its components. In addition, the test results also indicate that the heavy metal contents in the stagnated water can be reduced substantially after flushing for about two minutes. Therefore, if water has been standing in pipes for a long time (for instance, after several hours of non-use, overnight, over a weekend or after a holiday), the tap should be run for two minutes or longer before using it for drinking or food preparation in order to avoid high concentration of lead in the stagnated water. The flushed water could be saved and used for purposes other than drinking and cooking.*

A cold tap running at a flow rate of '5 litres per minute' would waste 10 litres of water at each person's engagement with drinking, cooking and bathing in the affected districts. At the lecture given by Dr Anthony Ma (at Hong Kong PolyU during my visit), he stated a wastage of water presented a significant wastage of the energy needed to treat the water for drinking and then again to treat it as sewage. At the time of writing, Hong Kong officials are debating the length of time the water must flow before taking a reading to test for lead, in other words, testing quickly gives a high lead content compared to leaving water to run for a few minutes. Until this debate is concluded, the people and province of Hong Kong face a crisis that affects their health and wellbeing.

### 3.2.3 Bad workmanship

The 'Report of the Task Force on Investigation of Excessive Lead Content in Drinking Water' (2015: 16) also revealed that solder joints still leached lead after cleansing the deposits although the leached amounts had been reduced: 'elemental analysis showed that the lead contents of the solder in most of the joints tested were between 33% and 41%, which were well above the limit for lead-free solder stipulated in the BS12 of 0.07%'. The Report (2015:16) therefore considered that lead leaching also occurred in the solder joints.



*Figure 20 Cross-section of leaded solder joint (Report of the Task Force, 2015:16)*

The Report (2015:16) stated that 'Solder materials seeped into the pipe due to poor workmanship by overheating for an extended period of time and/or applying excessive solder'. Dr Chan explained that there was a shortage of licensed plumbers and that although the water regulations stated that licensed plumbers should be doing the work, they mainly worked in a supervisory capacity. Dr Chan described a discrepancy between what should be done and what is actually happening in practice, which was in keeping with the position of Dr Raymond HO Chung-tai (2016:1):

*As stated in the report 'Commission of Inquiry into Excess Lead Found in Drinking Water', it is disclosed that a Licensed Plumber (LP) is not a Plumbing Worker in large scale projects. LPs are supervisors or engineers for the projects. As suggested, legislative requirements should be revised to comply with the actual needs. In future, Plumbing workers will be properly trained and authorized by the Construction Industry Council (CIC). The workers will be assessed to ensure that their skills meet the contract's requirements. LPs can still play the role of supervisors or even Plumbing Engineers.*

The substantive evidence also presents wider concerns because it is highly likely that poorly made copper plumbing joints similarly exist on many plumbing systems around the world.

### 3.2.4 The risk in the English context

It is plausible to suggest that the same bad workmanship on copper jointing may be true for some English systems. In an interview with Dr Henry Hung, he said that Hong Kong had only taken up lead-free solder about ten years ago. In contrast, leaded solder for wholesome water supplies had been outlawed in England since the 1980s. However, it is argued here that there are still serious risks to be considered in regard to English plumbing systems, which may contain lead. The Water Research Centre (WRc) (in Potter, 1997: 16) highlighted the possibility that owing to galvanic action between copper and lead solder “combinations of lead and copper pipework may actually lead to higher concentrations of lead in drinking water than lead pipes alone”. Therefore, Dr Oliphant (cited in BBC, 2000) at WRc, considered leaded solder with copper pipe, “potentially more dangerous than lead pipes themselves”.

Existing English hot and cold wholesome systems with imperial sized  $\frac{3}{4}$  inch copper pipe, which is known (by age) to most likely have joints containing leaded solder, are often extended or joined onto during contemporary plumbing alterations. Despite this explicit risk of jointing onto existing imperial copper with lead solder joints, the detail below shows a Water Regulations Advisory Scheme (WRAS) ‘approved fitting’, currently on sale, which is manufactured to do such a job:

WRAS approved, EN 1254/BS 864, for use on hot and cold systems



*Figure 21 Imperial to metric adapter  $\frac{3}{4}$  inch to 22mm (Screwfix website, 18 Nov 2016)*

In the English context, many dwellings have imperial copper systems with lead joints, which were installed before the 1980s. However, clients may be suspicious of a plumber’s quote to re-plumb an imperial copper-plumbed house because the general belief is that only lead pipes are dangerous to health. Re-plumbs are usually recommended by English plumbers when systems have lead pipes. Anecdotally, it is unlikely an English plumber would recommend a re-plumb if imperial copper pipes already exist in the dwelling. Many English plumbers will have paid little attention to the risk of lead being leached into the drinking water supply from existing copper soldered fittings. In England, the matter of lead joints in copper fittings has received little if any attention, yet there is still a significant proportion of systems with such joints (based on sales demand for imperial  $\frac{3}{4}$  to metric 22mm adapters).

My literature search revealed an interesting article, published in the Heating & Plumbing Monthly (Hill, 2014), about the dangers of lead solder. Following a lead contamination incident in the UK, Hill (2014) described events in an isolated incident:

*In 2013, the Drinking Water Inspectorate received reports from water suppliers of 11 routine drinking water quality check samples exceeding the permitted amount of lead. In a recently-built luxury apartment block investigated by one water supplier, tap water samples contained more than 12 times the permitted amount of lead. Five or six joints on short lengths of distribution pipe entering each apartment had been made using solder containing lead. Enforcement notices under the Water Fittings Regulations required the developer to replace every suspect joint – at his own cost.*

If only five or six joints can cause such a significant contamination, then concern must be raised for the number of dwellings in England that have imperial copper pipes with joints made with leaded solder. An educational bulletin from WaterSafe (2016), a UK water body, has provided the following question and response about the possibility of having lead in the water supply without lead pipes:

**Is it possible to have lead in my water without lead pipes?**

The installation of lead pipes to supply drinking water and the use of lead to solder to join pipes has been banned in the UK for more than 25 years. However, it is still possible to buy lead solder and case of high lead in the drinking water are still being recorded following its use by DIY enthusiasts or unqualified plumbers who are unaware of the danger.

Using lead-free solder to joint copper pipes which are used for drinking, cooking and washing isn't just a legal requirement, it safeguards your drinking water. Under the Water Fittings Regulations and Bylaws, the use of lead solder for jointing copper pipes is prohibited in plumbing systems which supply water for drinking, cooking or bathing. Solder containing lead can only be used on water installations not used for drinking, such as closed circuit central heating systems.

Water suppliers recommend households and businesses use WaterSafe to find approved plumbing businesses whose plumbers have undergone specific training in the Water Fitting Regulations and Byelaws (WaterSafe, 2016).

However, there is no mention or warning in WaterSafe's (2016) online information about dwellings presenting a health risk owing to imperial copper pipes with joints made with leaded solder (installed before 1980s).

### **3.3 Importance of high-quality training and progression opportunities**

The Hong Kong construction industry standards, which included health and safety, appeared to be similar to those observed in England. The small sample in this study is not representative of the Hong Kong population. Nevertheless, the data allows a snapshot of empirical reality to bring meaning to the emerging narratives associated with the importance of experience in education, high-fidelity simulations for teaching, learning and assessment, skills shortages and sharing good practice.

### 3.3.1 Importance of a 'quality' experience in vocational education

*To teach a person to swim they must get into the water* (Shade, 2013).

The HKPolyU preferred to train inexperienced professional construction students (degree level) in safe and predictable college contexts first before progressing them onto the reality and challenges of the work context. At the Hong Kong PolyU, professional construction students experienced building a typical Chinese apartment along with managing the project in teams. Pedagogical effort was made by teachers to integrate practical experiences with aspects of the theoretical curriculum, learned in the profession.

Work experience that was continually supervised and corrected by professionals was found in Reddy (2014) to be of key importance to plumbing apprenticeship learning in England. Apprentices admired their work supervisors' and lecturers' rich biographies of plumbing experiences and their ability to do the job well. The plumbing lecturers in Reddy (2014) also valued their own practical biographies, and employers seemed to explicitly link length of training or work experience with notions of quality. However, apprentices' accumulated capital in supervised work experience was found in Reddy (2014) to count for little in English plumbing qualifications. The disregard for experience was found to be widespread and arguably perpetuated by Trailblazer apprenticeship groups representing employers, English awarding bodies, colleges and training providers. Trailblazer documentation (HM Government, 2015: 11) defined "the core principles of quality for an apprenticeship that must be adhered to" omitting the need for work experience and supervised training in the work context (HM Government, 2015: 11). Although the Trailblazer standard states that apprenticeship "requires substantial and sustained training, lasting a minimum of 12 months and involving at least 20% off-the-job training" it does not specify that this training must take place at work, therefore 100% of apprenticeship training could be done in the simulated college context (HM Government, 2015: 11). It may be argued that apprenticeship brings social and economic benefits to a nation like England because opportunities are provided for the unemployed, military resettlers and career switchers to train for work and progress through enterprise, self-employment and new careers. However, these flexible and inclusive qualification benefits for adult students work less well for English apprentices, who see their training and progression opportunities undermined and diminished in value compared to the more protected status and assured progression of Hong Kong plumbing apprentices.

The Hong Kong approach to training bore many similarities to the UK system in terms of its pre-apprenticeships and training and assessment structure, but Hong Kong differed in its acknowledgement of the important relationship between training location, duration and the quality of the student experience. In Hong Kong, three years of mandatory time-serving is required for licensed plumber status, but in England there is no time-serving required in apprenticeships and no license to practice for plumbers (except for those who undertake gas work which needs a licence).

### 3.3.2 High-fidelity simulations for training and assessment

The vocational teachers at the VTC delighted in demonstrating their firefighting equipment in a live sprinkler system rig, linked to working alarms and smoke detection equipment. Tutors used these models and high-fidelity simulations to help

students garner a deeper understanding of classroom learning than if they were just using books and being taught by PowerPoint.

In contrast, Reddy (2014) revealed that English college plumbing simulations were low-fidelity and that tutors rarely used the workshop models or simulations for teaching theoretical aspects of the course. Moreover, the curriculum was not designed to support tutors in this endeavour. Reddy (2014) observed that the vast majority of workshop training and assessment simulations across three large FE colleges hardly replicated the workplace at all. This English qualification process was identified as dangerous because colleges did not create the real-world environment required for authentic kinds of assessment, such as those for safety specific occupational competence qualifications (Reddy, 2014).

In Hong Kong, apprentices progressing to licensed plumber status were required to pass two rigorous assessments and have a minimum of three years' work experience. Conversely, the English Trailblazer plumbing qualification is ambiguous about a fixed standard for the duration of plumbing apprenticeship work experience (see Appendix):

*Duration: Typical completion time is likely to be 48 months. This may reduce if an apprentice has gained previous relevant knowledge and skills, which is recognised as Accredited Prior Learning (Trailblazer Plumbing Standard in Reddy, 2016c).*

Without a specified location for mandatory apprenticeship training (college or work) and ambiguity surrounding duration for time-serving, it now appears that some English plumbing apprenticeship qualifications can be completed in a matter of weeks just by passing an end-test in a college (Reddy, 2014, 2015b, 2016c).

### **3.3.3 Strong sense of professionalism in the Hong Kong plumbing community**

As previously mentioned, high-status professionals were visible amongst construction students at entry level basic training. In addition, engineering doctors, chartered engineers and a variety of high-performing, high-status plumbing industry experts were invited to talk on CIPHE professional courses at HKPolyU. The lecture given at the University of Hong Kong on routes to CIPHE Chartered Engineer status attracted around 300 people, including leaders of industry, who were keen to mix with CIPHE members and education and research professionals.

In England the strong sense of community amongst plumbing professionals seems to have waned in recent years, which may be reflected in the decline in CIPHE membership. Hence, there is much to learn from the Hong Kong approach to professionalism and their willingness to develop a professional culture amongst ordinary plumbers and installers and help them to progress to higher levels. In Hong Kong, a Registered Plumbing Worker (registration with Construction Industry Council) can progress to Licensed Plumber (supervisory role). Plumbing professionals formed in Hong Kong include Engineer (Registered Professional Engineer in Hong Kong). Plumbers who may have their experience recognized by expert peers can achieve Chartered Engineer status through organisations such as CIPHE. Although some of these progression opportunities are also available to English plumbers, it seems the professional networks required to help ordinary plumbers in England progress are scarce. The Hong Kong training professionals in BSE operated at every level compared to the more dichotomous approach in England where HE professionals are separated from FE technicians/operatives. This

may be a key factor affecting the continuing low status of English vocational education.

### 3.3.4 Skills shortages

In regard to the English apprenticeship situation, Steedman, Gospel and Ryan (1998) reported a need to address the growing problem of youth unemployment at the time by advocating high-quality preparatory training and an expansion in the number of apprenticeships. This highlighted the ‘serious skill shortages and enduring skills gaps at the skilled crafts, technician and associate professional levels’ (Steedman, Gospel & Ryan 1998: 7). They warned that skills shortages had a number of macro-economic consequences in ‘contributing to wage inflation and making macro-economic policy management more difficult by pushing up wages and lowering productivity growth in the longer term’ (1998:7). The ‘strategy for growth’ they drafted aimed to address inflationary wage pressures caused by skills shortages in sectors such as construction by exploiting the potential of apprenticeships. The authors suggested ‘limiting apprentice pay’ to ‘reduce the costs of training to employers and facilitate the offer of more places’ (1998: 13). Further, they proposed that increasing the number of apprenticeships would contribute to the nation’s stock of intermediate qualifications and, in turn, increase productivity, lowering youth unemployment and deflating craft wages to reduce the risk of macro inflation in the wider economy (Reddy, 2014).

At the time of writing, there is sufficient evidence to support Steedman, Gospel and Ryan’s (1998) predictions, in that wages in the UK have fallen during the period of time that has witnessed large increases in the numbers of apprentices:

*The TUC found that between 2007 and 2015 in the UK, real wages – income from work adjusted for inflation – fell by 10.4%. That drop was equalled only by Greece in a list of 29 countries in the Organisation for Economic Cooperation and Development (OECD) (Allen & Elliot, 2016: 1).*

The falling wages in the UK reported by Allen and Elliot (2016) arguably oppose the existence of skills shortages because in a skills shortage situation, wages should increase due to a high demand for a sparse labour supply (see Zhu, 2015). Moreover, skills shortages in plumbing would arguably indicate high progression rates from colleges to work because there is a high industrial demand (i.e. job vacancies). The table below shows how evidence of skills shortages is comparatively weak in the UK compared to Hong Kong, where wages are rising and progression rates between college and work are high, which is indicative of a strong skills shortage.

	<b>Weak England Skills Shortage</b>	<b>Strong Hong Kong Skills Shortage</b>
<b>Construction Wages</b>	<b>Construction industry in decline</b> and wages relatively low and falling (Thomas 2016; Allen and Elliot, 2016)	<b>Construction industry expanding</b> and wages relatively high and rising (Zhu, 2015)

<b>Progression into Work</b>	<b>Low progression rates</b>  Between FE college and work = 46% (Burke, 2016)	<b>High progression rates</b>  Between college and work = 100% and 90% (based on FE colleges observed in this study)
<b>Marketing of Apprenticeships</b>	<b>Misleading marketing</b>  Apprenticeships linked to 'rich list' high wages and football/TV celebrity lifestyles - signs of dubious marketing (City & Guilds, 2011; Vergnault, 2016)	<b>Fair marketing</b>  Government and employers coming good with relevant employment opportunities based on promises made (Zhu, 2015)
<b>Cost of College Training</b>	<b>State and Self-funded</b>  Unemployed adult students and career switchers often take out loans for occupational training in colleges and then apply for jobs hoping their new skills are competent, relevant and in demand (Reddy, 2015)	<b>State and Employer-funded</b>  Unemployed adult students are paid to attend college for pre-work training and progress straight into a job they have competently trained for
<b>License to practise</b>	No	Yes
<b>Do it yourself culture (DIY)</b>	Yes	No
<b>College based vocational qualifications and finding work experience</b>	FE colleges buying houses for students to gain authentic vocational training and assessment owing to weak demand from industry. Progression more difficult because college has generated the demand for training adding to over-supply problems (Reddy, 2016b)	House build simulation in college context, rather than buying real houses to train students, because Hong Kong considers it safer. It is argued in Hong Kong that college buying houses conflicts with wage legislation and puts college in competition with local construction firms.
<b>Visible Professional Culture</b>	No	Yes

*Table 1 Skills Shortages: Comparisons of England and Hong Kong*

In order to get young people interested in low-status, low-paid apprenticeships, some English institutions have relied on irresponsible marketing. In one instance, the Advertising Standards Authority (ASA) (2006) upheld a complaint against a training provider known as OLCI, which delivered recognised City and Guilds qualifications, for misleading claims made in the national press regarding plumbers' earnings and career opportunities. Despite heavy criticism of these types of unethical marketing campaigns, they are still being used a decade on by reputable institutions to entice young people, unemployed adults and career switchers onto plumbing courses. The Plymouth Herald (2016) reported:

*One of the UK's top accredited providers of compliance, technical and safety training in the utility sector has warned that gas, water and electricity workers could demand Premier League-level salaries if the skills shortage in the utilities sector isn't dealt with by the government and employers.*

The prospects of steady employment and high pay have been key selling points for apprenticeships, with respected organisations such as City and Guilds (2011) touting the 'Rich List' and the principle that vocational learning is a gateway to wealth regardless of a learner's background. Sadly, the list consists of a relatively small selection of high-earning celebrities, such as highly paid chefs who once undertook apprenticeships, who are not representative of the general population of apprentices. In contrast to the promise of occupational riches, Booth (2016: 1) reported the reality of the situation for many pursuing the vocational path:

*Michelin-starred TV chef Michel Roux Jr has been paying some kitchen staff at his Mayfair restaurant less than the minimum wage...while charging over £60 for one starter...*

Supporting the growth in apprenticeships, concurrent UK governments have provided financial support to employers. The Department for Innovation, Universities and Skills (DIUS) and the Department for Children, Schools and Families (DCSF) stated:

*We believe that there is scope for moderate growth in Apprenticeship numbers by offering similar direct payment incentives to large companies, so that they can recruit more Apprentices than they need (DIUS/DCSF, 2008: 38).*

This government-sponsored supply-side growth in plumbing pre-apprenticeships and apprenticeships in England was found to be significantly increased by the number of unemployed adults and adult career switchers entering the occupation (Reddy, 2014). My empirical study of full-time plumbing courses and apprenticeships found that apprentices were outnumbered by at least 10:1 by a combination of unapprenticed full-time 16- to 19-year-old students and adult career switchers. In contrast to Hong Kong and many of our European neighbours, English plumbers do not have to serve an apprenticeship to qualify. This is owing to both a lack of workforce regulation and protectionism. In Germany, plumbers have to achieve *meister* [master] status, and in Hong Kong, licensed plumber status is required to operate in a plumbing enterprise. However, the lack of such regulation in England has created excessive competition in the workforce from adult students and career switchers (who can attend full-time college courses to train to become self-employed plumbers) as well as from migrant labour within the European labour market (Reddy, 2014).

With growth in the number of apprenticeships and unapprenticed types of preparatory training, the colleges in my study complained of being unable to find work experience or apprenticeships within the construction industry for all of their students. Indeed, the lack of progression into the construction industry for pre-apprenticeship trainees and adult career switchers entering the plumbing trade was a key finding of my study (Reddy, 2014).

In an attempt to address this issue of finding work experience for full-time students, some English FE institutions have opted for an audacious solution of buying a house to use for construction simulations. In an article published in *The Times Educational Supplement*, an FE college claimed that many employers were reluctant to take students on work placements because of obvious safety concerns and insurance issues related to having inexperienced and unskilled workers on site (Simons, 2016). However, this college failed to mention the lack of demand from industry and firms eschewing their social responsibility to sponsor work experience opportunities for students. The article claimed the college house was 'run exactly as a commercial construction site would be, so punctuality, attendance and professional behaviour are key themes drummed into learners' (Simons, 2016), but it avoided any mention of wages or payments that students could have expected if the project were indeed a real construction site.

While this appears to be a legitimate and laudable strategy from a pedagogical point of view and while it pleases external inspectors, there are some serious practical implications in the scaling up of this initiative for English full-time, traineeship and pre-apprenticeship students that may not have been considered. In Hong Kong, a conflict of interest was revealed when colleges purchased real properties for the purpose of training students. Using free labour presents colleges with an unfair advantage over local construction workers, who are required by law to be paid for their services.

Another possible implication of colleges buying houses is that it creates an artificial demand. Work experience is most likely difficult to secure for English construction students because there is little or no demand for work experience candidates from within the construction industry. If there were, then they would probably be strongly sponsored by English employers, as is the case with apprenticeships. However, in the situation discussed here, the demand for workers does not come from employers but rather from the college institution. The outcome of creating an artificial demand is greater competition among students for jobs, which arguably diminishes progression opportunities while driving down pay (Reddy, 2014). In my English empirical study, the competition for work placements was fierce, and a small minority of students were even found to be working unpaid for long periods of time in order to secure or continue onto an apprenticeship (Reddy, 2014, 2016d).

A final implication of colleges purchasing real properties for students' work experience is that it may lead to a risk of breach of trust if students are working for free and do not attain the future dividends they believe they have been promised, namely a steady well-paid job in the construction industry. There is an implicit deal being done when full-time students or apprentices work for low or, in some instances, no wages (Reddy, 2015a). The deal means that something better has to come for the student at the end of that period. However, rather than English apprenticeships being a gateway to wealth, as suggested by City and Guilds (2011), the evidence suggests the opposite appears to be the case (Reddy, 2015a, 2016d).

### 3.3.5 Sharing good practice

On completion of my PhD in education, I returned to plumbing teaching in the FE sector to face poorly motivated students who were obsessed with their mobile phones. It seemed impossible to get students to ignore their phones for as little as five minutes. In order to address this problem and to deepen the students' understanding of plumbing, I developed Facebook Pedagogy as a research-informed pedagogical practice (Reddy, 2016a).

Facebook Pedagogy harnesses mobile technologies while creating learning communities and networks of apprentices and college staff, including training-provider officers, assessors, plumbing tutors, managers and college directors. It relates apprentices' work experiences to the classroom curriculum and is compatible with e-portfolios. Apprentices respond to the initiative, posting pictures and experiences of their practical work, which many share with pride. Pictures of poorly installed plumbing systems provide some amusement to apprentices while they engage critically to determine what is wrong and develop the skills of problem-finding. Problem-solving skills are also developed through Facebook Pedagogy because apprentices post pictures of plumbing problems (such as boiler faults) that are often impossible to replicate in the college context (Reddy 2016a).

Facebook Pedagogy arguably creates a new type of knowledge in real time, which is 'emergentist' and different to the prescribed 'represented epistemology' often found in college learning (Osberg, Biesta & Cilliers, 2008). Epistemology is the theory of knowledge. This knowledge may be 'presented' at work or 'represented' in college (Osberg, Biesta & Cilliers, 2008). Facebook Pedagogy enables apprentices to participate in meaningful and relevant technical discussions and present ongoing elements of their work through pictures taken on their smart phones.

Through occupational training, apprentices are being socialised as 'objects' into a 'professional identity', or an existing way of being (Lave & Wenger, 1991; Biesta, 2009). Although socialisation is certainly an appropriate aim of technical education (e.g. to train a good plumber), education is not just about producing unquestioning 'objects'. Biesta (2009: 356) argued that education must mean something other than socialisation:

*It is not about the insertion of 'newcomers' into existing orders, but about ways of being that hint at independence from such orders.*

Facebook Pedagogy involves the emergence of the 'subject' apprentice, who has the space to respond by taking pictures at work, posting pictures on Facebook and asking questions in college while being engaged in industry, promoting real-world motivation, collaboration and problem-solving (Reddy, 2016a).

## 4 Conclusions and implications

The World Plumbing Council scholarship has been an experience of a lifetime, and it has been a great privilege to study plumbing and training in Hong Kong. I chose Hong Kong because my dear late father, John Reddy, went there as part of his national service training and following in my father's footsteps has been a lifelong ambition.

The CIPHE-HKB played a key role in organising meetings with a range of educational institutions, consultants and plumbing engineers. The quality of this report owes a lot

to the CIPHE-HKB's careful planning and the network support I received from Kevin Wellman, CEO of the CIPHE. While this trip has provided me with friendship and some quality socio-cultural experiences, there are a number of important implications relating to the key themes that have emerged from the study. These are discussed below with recommendations listed in the bullet points, and conclusions are drawn.

In terms of the public health group of key themes, the SARS outbreak in Hong Kong was a reminder to plumbers worldwide about the important health implications of plumbing and sanitary engineering. This report recommends a mandatory licence to practice for plumbers in England in order to build professional and technical capital in the plumbing and heating industry.

- In England, plumbing must only be carried out by licensed professionals.

Licence to practice would help safeguard apprenticeship status and progression, while helping to protect the public from diseases like SARS in the future.

In regard to the wholesome water supply in Hong Kong and England, this report has some important recommendations to make. The study revealed the pragmatics of the situation in regard to lead contamination at the sites in Hong Kong and understood that running off contaminated water constituted a significant waste of water and energy without treating the cause of the problem. The recommendations given in the Report of the Task Force (2015) appeared unable to safeguard small children, who may be bathed in lead contaminated water. Consequently, children may be at greater risk of accidental ingestion through swallowing, therefore:

- Immediate action is required by the Hong Kong authorities to reduce lead in the water supply to a safe limit at the affected sites discussed in this study.

In addition, a possible risk of lead in the water supply was identified for England (and possibly other countries). It was suggested that some imperial sized copper pipe (pre-1980s) was still in service in the UK and that this copper pipe was most likely jointed with lead solder – a situation argued to be more dangerous than having lead pipes alone. An adapter from imperial copper  $\frac{3}{4}$  to 22mm metric copper, approved by the Water Regulations Advisory Scheme (WRAS), is widely still on sale. This confirms that English plumbers are adapting to imperial copper systems, which are highly likely to contain lead and therefore constitute a significant health risk.

- WRAS must review the approval for the adapter product on sale, and steps must be taken by WaterSafe to warn the public of the risk of dangerous lead joints on imperial copper plumbing in England and other parts of the UK.

This will mean a review of the guidelines that WaterSafe (2016) are currently offering on their website in regard to lead pipes, to include imperial (pre-1980s) copper pipes.

The second group of key themes were organised under the heading of the 'Importance of high-quality training and progression opportunities'. The importance of a 'quality' experience was a key theme to emerge. A minimum period of three years compulsory time-serving was required for apprenticeships in Hong Kong, therefore:

- The Trailblazer Standard for English apprenticeships at Level 3 must specify a mandatory duration of time-serving in the workplace under qualified supervision, with no exceptions.

High-fidelity simulations have been described in this report as practical training situations in colleges that closely replicate the workplace. Some good examples of

this were observed in Hong Kong, which provided a safe and pragmatic approach to vocational training in college contexts. Therefore:

- English colleges need to review their practical training simulations and collaborate with registered plumbers and plumbing professionals to evaluate Trailblazer assessments in terms of their workplace fidelity. Simulations and models also need to be integrated with teaching, learning and assessment to improve the quality of the student experience (as opposed to the student being continually taught in the classroom and distanced from the workshop)

It seems logical to have plumbers who are members of professional bodies involved in the negotiation of the credibility process (e.g. judging the real-world fidelity of college assessments and practical training facilities on a local level), and this should be remunerated. There was a strong sense of professionalism in the CIPHE Hong Kong plumbing community. University professionals were visible to the apprentices and college tutors at each stage of plumbing education, and there was a culture of collegiality and mutual respect for lifelong learning, therefore:

- England needs a cultural shift towards professional status for college teachers and plumbing workers.

More interaction and involvement in curriculum and assessment planning is needed on a local level from a diverse range of members of the plumbing professional bodies and professionals in the field (e.g. Incorporated and Chartered Engineers). There are growing communities of CIPHE professional plumbers on social media (e.g. Facebook, Twitter and LinkedIn), so visibility of industry professionals in the education and training community may improve. In England, the system is divided between HE-level professionals and FE-level technicians/operatives. This separation may be a key factor affecting the continuing low status of the plumbing occupation, apprenticeships and vocational education and training in England.

Strong skills shortages were found to be in existence in Hong Kong, and I recorded experiences and conversations in field notes that rendered a different interpretation of skills shortages than that found in England (see Table 1). The evidence presented in this report supports my argument (Reddy, 2014) that reports of skills shortages in the plumbing industry in England are often based on assumptions and inaccurate predictions, therefore:

- Further research is required into the meanings of skills shortages in England compared to skills shortages in other parts of the developed world

Finally, it was a great honour to share Facebook Pedagogy (Reddy, 2016a) as a way of supporting apprentices' learning, collaborating and sharing of plumbing knowledge through social media. I presented this theory of practice at HKPolyU and the Hong Kong College of Technology, where it was well received by tutors, professionals and postgraduate students. Facebook Pedagogy is also helpful in supporting tutors with a simple platform when they are just getting to grips with social media and educational technology, therefore:

- This report recommends a World Plumbing Council pedagogical collaboration between plumbing teachers on a global level.

Facebook Pedagogy (Reddy, 2016a) presents a type of teaching and learning that is structured around an apprentice response as opposed to an apprentice being continually taught as an object. As such, it facilitates the emergence of the unique

apprentice as subject and as a human being, which bodes well for education in terms of more creative, relational and democratic ways of learning plumbing.

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# Appendix

Country	Licensing	Product Approval/ Testing	Scope of Craft Training	Further Education	Awarding Organisations	Continuing Professional Development
England	No	<p>Yes</p> <p>British Standard Approval</p> <p>Water Supply (Water Fittings) Regulations</p> <p>Water Regulations Advisory Scheme</p>	<p><u>Apprenticeships</u></p> <p>Mandatory 12 months, but 3-4 Years duration for young plumbing apprentices</p> <p>Fast-track apprenticeship qualification options for full-time adult students</p> <p><u>Preparatory Training</u></p> <p>Full-time 2-3 years leading to Apprenticeship end-test qualification</p> <p><b>Experience supervised by employer <u>not</u> necessary</b></p>	<p>Day release from work</p> <p>Levels 2-3</p> <p>Technical Training and Assessment</p>	<p>City and Guilds</p> <p>EAL (unknown acronym)</p> <p>Plumbing and Gas Qualifications</p> <p>British Plumbing Employers' Council (bpec)</p>	<p>Voluntary</p> <p>Both means of progression and industry professionals invisible</p>

<p><b>China, Hong Kong</b></p>	<p>Yes</p> <p>Licensed plumber status</p>	<p>Yes</p> <p>British Standard Approval</p> <p>In accordance with water works regulations</p> <p>Water Supplies Department (2015)</p>	<p><u>Apprenticeships</u></p> <p>3-4 Years for young apprentices</p> <p>No fast-track</p> <p><b>Experience supervised by employer necessary</b></p> <p><u>Preparatory Training</u></p> <p>2 years' full-time for younger students with 90-100% progression to work (colleges in study)</p> <p>Over 18s do 90 days' full-time basic construction skills training for employment (paid by employer)</p>	<p>Day release from work</p> <p>Levels 2-3</p> <p>Technical Training and Assessment</p>	<p>Construction Craft Course Board</p> <p>Construction Industry Council</p> <p>Construction Workers Registration Authority</p>	<p>Voluntary</p> <p>Both means of progression and industry professionals highly visible (e.g. CIPHE CEng Evening)</p>
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*Table 2 Comparative outcomes of research*

