ASSESSMENT FOR THE CHANGING NATURE OF WORK:

IT NETWORK ENGINEERS

Helen Bound
Annie Karmel
Arthur Chia

October 2016

institute for adult learning singapore

Centre for Work and Learning

Publisher's note

The views and analysis presented in this document are those of the authors as researchers. The contents are intended for discussion and generating ideas, and are not necessarily the views or policy prescriptions of the Institute for Adult Learning or the Government of Singapore.

This publication should be attributed to Institute for Adult Learning (2017). *Assessment for the changing nature of work: IT Network Engineers.*
Helen Bound, Annie Karmel and Arthur Chia

Published by the Institute for Adult Learning, Singapore
Research and Innovation Division

CWL

Centre for Work and Learning (CWL) is a research centre of the Institute for Adult Learning. CWL specialises in research on continuing education and training system design and practices. Our research employs a range of methodologies designed to deepen understanding in the challenges and opportunities for learning and development in and across different settings, particularly in relation to work and work environments.

Address
1 Kay Siang Road
Tower Block Level 6
Singapore 248922
research@ial.edu.sg

For more information, see http://www.ial.edu.sg/

CWL-2017-06

Contents

Figures and Tables

Preamble

This is ONE of the six cases on assessment practices and the changing nature of work, undertaken by the Centre for Work and Learning (CWL). Each of the six cases highlights different aspects of innovative approaches to assessment, their possibilities and the challenges involved in assessment for, through and at work. Each case suggests different strategies, tasks and/or practices in assessment that can enable **meaningful** and **engaged learning.**

Figure 1: Learning and assessment are entwined

Source: http://www.123rf.com/photo_3706214_stock-photo.html

We think of assessment not as the "test" of what has been learnt at the end of a learning programme, course or set of experiences, but as **judging performance**. We go back to the original meaning of assessment which is "to sit beside". This means that we can think of assessment as working *with* our learners to guide them to meet the required performance. If we understand assessment like this, then learners also need to understand, to know what that desired performance is. In other words we do not hide from them the criteria or expected performance standards. So in other words we are talking about formative assessment – assessment *for* learning. We also acknowledge that assessment of learning – summative assessment – is necessary for accreditation and certification. The question is how we weave these two forms of assessment together. Examples are provided in some of our six case studies. We also discuss this in detail in our full report:

"Assessment for the changing nature of work", available at <url>, as are copies of the other case studies.

In addition to summative and formative assessment we introduce another kind of assessment – sustainable assessment. Sustainable assessment equips learners not just for meeting, but preparing them for what might be required in the future, beyond the course and/or training. It includes "the capacity to evaluate evidence, appraise situations and circumstances astutely, to draw sound conclusions and act in accordance with this analysis" (Boud & Soler, 2016, 402).

These three purposes of assessment and the fact that we investigated assessment in the light of the changing nature of work, mean we also need to think of learning and assessment differently. Assessment serves different purposes including the testing of knowledge and learning yet "testing" need not be the sole purpose. When we think of assessment as only a test of the learning and/or something that happens (sequentially) after the learning, then we are separating assessment from learning and ignoring the fact that learning and assessment are very much in a "dialogic relationship" or entwined together. Figure one metaphorically illustrates this entwinement.

In the case studies, we describe what the course/programme/training is about and examine assessment in relation to curriculum design, implementation and the ways in which understanding, accomplishment and performance are achieved. We hope the case studies provide a glimpse into the different ways assessment has been carried out in design, planning and implementation for practitioners, researchers and policy makers. We hope that they highlight possibilities and contribute to new ways of thinking, designing and implementing assessment of, for and as learning. Different

conditions and situations (context) will offer different kinds of opportunities for meaningful assessment.

The six case studies are:

- Workplace learning facilitators
- Firefighting: Rota commander course
- Menu change in the food and beverage sector
- Resident doctors
- Aircraft engineering programme
- IT network engineers

1. Introduction

This report is an analysis of a five-day classroom-based, instructor-led course that has authentic work-based assessment designed into formative and summative assessment. An important feature of this course is that competencies are written at the higher levels of Bloom's taxonomy; they are not about specific tasks, but *ways of thinking*, important for IT Network Engineers. But outcomes in this course are more than cognitive levels, which only partially represent what professionals are and what they do; it is developing the confidence of the IT Network engineers in their problem identification and solving ability that is integrated into ways of thinking like an IT Network engineer. Another important feature of the course is the authenticity of the learning activities and the assessment tasks. The designers' deep understanding of issues within this industry sector and their thinking beyond tasks, allows them to draw meaningfully on typical network problems within the sector and to provide an overview understanding of networks.

This course builds a foundation of competences that lead to intermediate and advanced level programmes which are grouped into a number of courses of between four to five days each aligned to job role requirements. Each of the courses aligns to a competence framework that has been developed by the Provider in consultation with industry practitioners and the learning and development arms of their respective organisations across the region. The framework is reviewed continuously so that new competence areas can be added through the application of a "descriptor". The descriptor identifies the course requirements, level, who should attend, how it should be assessed and what the learning outcomes are. Each stream is made up of four courses of between four to five days each. This design is important as the provider has mapped the sector to understand common issues and challenges and developed pathways network engineers can take through a series of courses. The designers' philosophy of lifelong learning and self-development is expressed on the competence map as,

> *Learning is a lifelong process and individuals should invest in themselves through a lifetime of professional growth to remain at the cutting edge of their profession – to help you to keep pace with a constantly changing work environment." (Certified IP Associate, 2014).*

In the following section, we outline the course in detail to provide the background for the discussion and analysis of the course and its assessment practices. This is followed with a discussion of the intent behind this design and how this assists in structuring in a number of dimensions of assessment for the changing nature of work (see full report, Bound, Chia and Karmel, 2016). A section on assessment *for, as and of* learning and sustainable assessment follows and finally we conclude with possibilities for the future for this course in relation to assessment for, as and of learning.

1.1 The course

The course aims to develop the confidence and skills of these engineers in identifying and analysing faults in networks involving typical network environments built using the Internet protocol (IP). As indicated above, the training provider who developed the course situates it as an introductory course in their "IP Competence Development Steam". Sam, the trainer, explains the outcomes of the course in relation to assessment as, "*How good people are at problem solving, analysing situations, how does it build their confidence*?"

Participants in the course were all from a major telecommunications employer in Singapore, hereafter referred to as Telco. Learners include recent graduates and those who have been in the sector for some 20 years. They were from a range of different divisions within the Telco. Some participants were directly engaged in finding and identifying faults in networks, others either worked with those who did, or their work involved them communicating with sections in Telco that did this work. These latter participants needed some knowledge of processes, ways of analysing problems and how to read the symbolic language involved in identifying network problems in order to communicate meaningfully with their colleagues in different sections.

Each participant was issued with a workbook of approximately 100 pages that contained background information, explanations, the PPT slides, exercises to complete, and a problem solving heuristic. They brought their own computer or were provided with one. Using a bootable device from the provider, they booted their computer into an environment for the training in which all the necessary configurations and tools had been set up. In the front corner of the Telco classroom, opposite the teacher's desk, was a server rack of relevant equipment that was designed and installed by the provider allowing them to show a range of different types of network problems and to provide participants with different exercises across a range of platforms. Long desks, three across took up the remainder of the room; they all faced the board.

The first three days of the course covered basic knowledge content delivered through various combinations of PPT, question and answer, examples and stories with a range of "*building block*" (Sam, designer, trainer, assessor) practical activities. As noted by Sam, "*A key aspect of these first few days is to familiarize participants with "how a network works*" but essentially to ensure each of the participants is comfortable with using the network analyser and other tools. Participants start on the practical scenarios on day one. The provider's philosophy is that if people can fix a broken network in a methodical manner then they must know how that network functions."

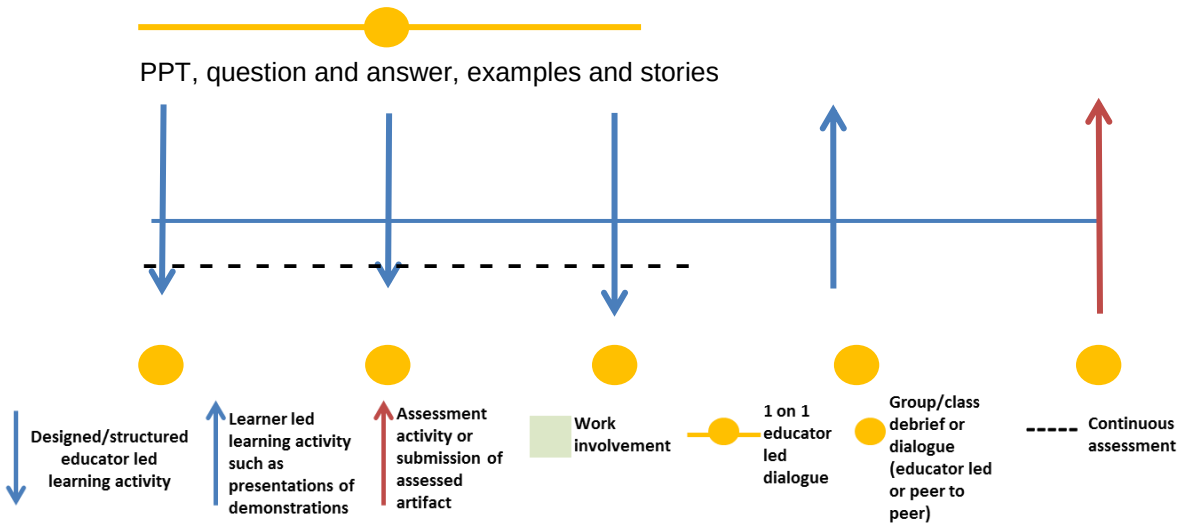
A week later participants returned for the last two days where they recapped and then moved onto more detailed exercises involving identification of network problems using the tools they had learnt. This experience was well scaffolded starting with simple problems, moving to more and more complex problems. Participants were provided with the heuristic mentioned above; a decision flow chart. The intent stated multiple times and in multiple ways, is that the heuristic becomes a way of thinking analytically about how to approach network problems to identify the issue. All understood it as a guide; a guide to decision making and pattern identification and that it would not be available in the assessment. Using the heuristic for the first time, the first simple problem took participants some 20 minutes to solve, but the next took only four to five minutes. The following more complex problems took less and less time. By this stage participants were moving around and talking to and helping each other, much like they do in work settings. There was energy and a buzz in the room.

The summative assessment had two parts; one undertaken through observation of basic competencies on the part of the facilitator over the first three days; the second series of summative assessment took approximately half a day at the end of the course and had three components: a short verbal test, a short answer written test and a practical test.

Course participants were well placed to undertake the test, not only because of the practice opportunities built into the course, but also because over the first three days the trainer observed and listened to participants noting and confirming their basic knowledge. It is a given that participants are or will be competent in the basic know what and know how; on the reporting form these competences are already marked as competent. However the trainer confirmed this through observation and discussion.

There are a number of exciting dimensions of learning and assessment in this course that are expanded on in the following sections; they include authentic and holistic assessment. Figure 1 is a diagrammatic representation of the course and its assessment points.

FIGURE 1: THE CERTIFIED IP ASSOCIATE COURSE



Source: Certified IP Network (2014)

2. Intent and its relationship to assessment design

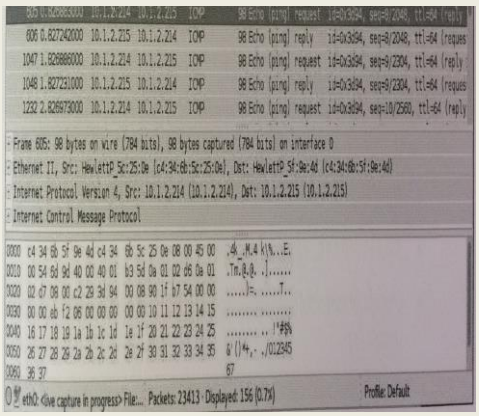
Through the course designers addressed typical misunderstandings and gaps in knowledge that course participants had; this approach comes from the Provider's deep understanding of and experience in the sector. The following dot points capture the designers' description of the sector to us:

- The increasing emphasis on service delivery and less emphasis on equipment
- Networking equipment must work according to a well-defined set of protocols to allow inter-communication, hence "Internet" – *between networks*. Despite this each platform, or brand of equipment has its' own specific command sets for configuring this and associated training in these commands. This leads to knowledge of specific platforms, but engineers are often unable to operate across multiple platforms or apply their skillsets between platforms providing the same function but from different manufacturers. As a result, knowledge is silo-ed.
- Prior to this course and also currently in the sector, training tended to be focussed on a platform and thus tied to equipment manufacturing courses, so those working on the networks were often unable to apply what they learnt to other platforms.
- As a result engineers and others working on the networks "*typically escalate[s] issues too fast due to lack of confidence, etc.*" (Sam, designer, trainer, assessor). This has a cost impact on the organisation since escalation to external vendors is expensive, it also takes longer to troubleshoot and thus has an impact on customer service.
- In addition, there is a lot of "of hacking, of just, "Oh, I will try this. That didn't work. I will try this. That didn't work… So, there's a tendency that something goes wrong, they can be panicked because in the real network, there's going to be lots of shouting. There's going to be lots of complaints. So, people can end up flailing about. Try this, try this, try this, rather than take a step back and take a structured approach to it." (Sam, designer, trainer, assessor)
- This can also result in a fear of changing settings or optimising equipment performance, as the engineers are concerned about what might go wrong.
- As a result, there can be longer disruption to service, yet Telco's have "*based their infrastructure on reliability and availability*" (Sam, designer, trainer, assessor).

The official intent or purpose of this course is captured in the opening pages of the course book all participants were issued with.

> *The purpose of this course is to familiarize the participants with the fundamentals of networking. In particular the IP family of protocols which is now the most widely used networking protocol and also the protocol of convergence for the telecoms industry. We will also examine the underlying transport mechanisms, and explain the operation of the Ethernet protocol which is widely used to carry IP… This course will address the fundamental concepts, basic architecture and implications for the LAN, WAN and Internet environments. (Course book, p.9)*

Example of network analyser



Broad or task-based competencies

Competencies that are broader are more like learning outcomes; they are more holistic and relate to developing understanding of the *work* as opposed to tasks within the work. Understanding of the work requires a holistic knowledge and understanding of where the work being done fits into the organisation, the profession and the industry sector.

Task-based competencies break down the work into small bits. These 'bits' then become the focus of the curriculum design. This means it is less likely that understandings of the whole and therefore of how to contribute will be developed. Rather this knowledge is totally dependent on the enacted curriculum through the skill of the facilitator.

The list presented here includes know-what, know-how (family of protocols) and know-why (fundamental concepts). As with much official course documentation it does not capture the wider and deeper aspects of what is actually taught and for many participants, what is learnt. However before exploring the wider, deeper aspects, it is useful to take a closer look at the extract above.

There is reference to "a **family** of protocols", "**underlying** transport mechanisms" and "**fundamental** concepts". The bolded terms suggest that the course moves well beyond a list of tasks, to holistic understanding appropriate to this introductory level; laying the foundations for *ways of thinking* within the discipline of IT network engineering. Ways of thinking are important as they develop the ability to know what to look for, what to select, how to make decisions (Meyer & Land, 2006) and why these decisions are made, that are pertinent to the disciplinary field.

A strong base is enabled because the provider has mapped the sector to understand common issues and challenges. This deep understanding of the work, and of the issues the sector is experiencing and will continue to experience into the future, is an important feature of the strong authenticity of the course. This is despite delivery being entirely classroom based. The wider, deeper intent of the course is summed up by Sam, the trainer as, *In particular, with the disciplines we are teaching, we tend to look at confidence, problem solving, analysis, troubleshooting" (Sam, designer, trainer, assessor)*

This emphasis on broader competencies, rather than task-based competencies creates possibilities to better mirror the work and its challenges as opposed to a focus on separate, seemingly unrelated tasks. Instead, there is an emphasis on performance. Critical elements of performance in this instance have been identified as "*building confidence, problem solving, analysis, trouble-shooting*" through a "family of protocols" and fundamental concepts." As a result, course participants are taught to seek patterns as they trouble shoot, they are provided with a heuristic to assist them in seeing patterns and to think as an IT network engineer. Organisations benefit from this as these elements provide 'transferability' (or ability to apply across different environments) and agility outside of the specific domain in which they are developed. Sam informed us that between their experience and knowledge of the sector and wide ranging discussions with customers and other stakeholders in the sector they developed

these approaches to the design of their courses. In relation to the course under discussion, Sam comments,

> *Getting the feedback from the customer where they were facing issues, from a broader level, allows us to build the curriculum to say we are not focussed on the specifics. What we will do is we will tell them, "Okay, this is how you would do it here but if you did it on a different manufacturer's equipment, can't you see? The commands here and the commands here are very, very similar since you've got the same fundamental things you are required to configure… building it up that they can see the similarities, drawing a thread across different platforms. Whereas if the equipment is only the tool to get the outcome and they got the confidence to say, "Well I know. In this manufacturer's equipment, I've got to do this. So, if it's the same end-to-end, then if I get this one, there must be a same way of doing it in here. So, I can find out how to do it. I know what needs to be done. It's just the how that I need to figure it more." (Sam, designer, trainer, assessor)*

To be able to assess performance, course participants also need to understand the big-picture of how devices are connected to each other and why. How devices are connected to each other is explained by Gaffar, one of the course participants. Gaffar expressed pleased surprise about understanding why and how devices are 'talking' to each other when Sam (designer, trainer, assessor) asked him to think through why you checked if devices are talking to each other through a process called, ping the IP address. In talking to us, the researchers, Gaffer summed up his observations as,

> *He taught us how computers communicate to each other, how equipment from one end of the data cable to the other end, how they are talking to each other. (Gaffar, course participant)*

This is one of many comments made by the learners on the range of know what, know-how and know-why that they learnt. Broader conceptualisations of course intent, goals and learning outcomes assume specific knowledge is also attended to as higher order operations cannot be undertaken without this knowledge. An example is learning to read the output from the network analyser that encodes a language telling the IT network engineer what is happening in the network. The learning of this symbolic language can be likened to a musician learning to read notes on a stave.

3. Assessment *for*, as and *of* learning and sustainable assessment

3.1 Assessment *of* learning (summative assessment)

Assessment *of* learning is summative assessment, used for credentialing and other official purposes.

The 10 core competencies were assessed during the first three days through observation to, "*ensure that they [competencies] are achieved as a base level*" (Sam, designer, trainer, assessor). Observation became formative assessment when Sam provided feedback; yet it was also summative assessment as he confirmed that all knew these basics and this was recorded. In fact this part of the reporting form was prefilled as it was an expectation that everyone would reach this level. It was the responsibility of the trainer to ensure that all participants' had indeed reached the required level. The competences were written not as knowledge competences requiring recall or understanding but as higher cognitive and skill level competences which implicitly require knowledge and understanding in order to be able to perform at the required level. Pre-fixes to these competences are:

- Is able to use…
- Is able to identify…
- Is able to configure…
- Is able to interpret…

This wording is indicative of basics for performance, not just recall but a combination of understanding and doing.

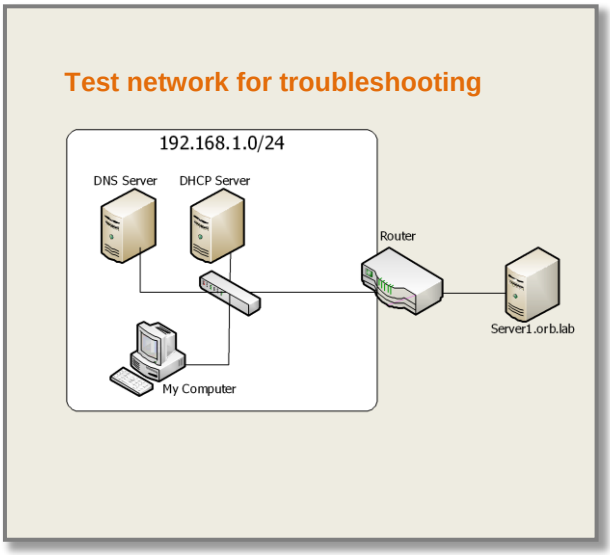
The last two days of the course were dedicated to analysis and trouble-shooting using real work-based examples and tools. Summative assessment took up half of one of these days when participants sat an oral test, a short answer test and a practical test. The practical test, like the examples being worked on in class, was typically the sort of faults found within the organisation.

- A short answer test

- The oral test: was where participants were asked about types of protocols used, what the protocols do, the types of equipment and what the implications were of using particular types of equipment. Ben, a participant explained, *What's the length and which is important? Especially for wiring. A wire like that, it can be Cat 5, Cat 5B, Cat 6, 7, 8, the blue colour wire. It looks exactly the same. If you can't identify it, it makes a lot of difference. You hook up a Cat 5 to a Cat 5B system, it will not go more than 100MB. And now you need, 1GB, you need to have one 6A and so forth. (Ben, course participant)*

- The short answer test: required application of the logic behind the analytical and trouble-shooting competences

- The practical test: In this test, participants were expected to demonstrate their skills particularly related to the trouble shooting and analysis competences. The test included for example, a fault placed on the network and participants had 20 minutes to diagnose and document it. This emulated the real-world experience where they would be in a similar situation in having to resolve problems (although "*with more pressure*") (Sam, designer, trainer, assessor)). In addition participants had to be able to demonstrate their thinking (to meet the analysis competences). They did this by explaining the steps they used, what were the decisions they took at each step. No one person got the same problem. This possibility was afforded through the provider's server environment at the front of the room. As with the practice exercises, network problems were drawn from problems experienced by the company. However these are also representative of typical problems in the sector.



The assessment design is about performance in relation to "*confidence, problem solving, analysis, troubleshooting"* (Sam, designer, trainer, assessor). Problem solving, analysis and trouble-shooting are evident in the assessment tasks; confidence is perhaps less evident. Confidence is expressed through knowing –what, how and why, through being able to perform. The following quote from Nadira, one of the learners, illustrates how confidence grows with appropriate knowledge and ability to apply it.

> *This is not something I do every day, it's not part of my core job. But I do liaise with some departments which need to do this so I'm able to understand the jargon better, and when they give back some feedbacks related to network issues, I'm able to relate to it better to solve the issue at my end. To execute my job, I liaise with say five stakeholders, and one of my stakeholders is the department which takes care of the networks or the troubleshooting, so I think now that I have the knowledge of their job, I'm able to kind of speed up the process, kind of understand where things need to be fixed there so that we could speed up the end to end flow. That has been the value-add for me. (Nadira, course participant)*

Holistic assessment design and process

The design of the assessment is holistic, and to some extent future oriented. An important aspect of holistic assessment is that aspects of 'ways of being' an IT network engineer are included. Examples include, analytical thinking for problem solving, developing understanding of whole systems – global, national and organisational and in-between are included. The following quotes from learners illustrate their appreciation of and development of some of these 'ways of thinking' like an IT Network Engineer.

> *Writing down the steps… it's not by pure luck you find the answer. So basically by writing down the steps, they will know that you know what you are doing… the crucial thing is that you know what you're doing and you solve the issue.*

> *It was not just rote-learning and just writing, there was an element of thinking and analysing, which I didn't expect but it was good… Why it is important, because I think it has consolidated my conceptions into critical learning. I think the theory which I've learnt, it never stayed with me because it's more like pass the exam kind, get the degree kind of thing? So, but I think after the practical assessment in the course, I'm able to, it's in my memory now, like I'm able to relate to it."*

> *"I think the oral questions were good, because it was more, it kind of really tested the understanding of telecom scene as a whole.*

> *One part, the hardware part is understanding the basic architecture of a system and its protocols.*

Sustainable assessment

Sustainable assessment equips learners not just for meeting but preparing them for what might be required in the future, after graduation. Sustainable assessment includes 'the capacity to evaluate evidence, appraise situations and circumstances astutely, to draw sound conclusions and act in accordance with this analysis' (Boud & Soler, 2016, p.19). The qualities of judgement that need to be developed are similar for students and for teachers; it is only the subsequent ends to which these judgements are put that differ. Key elements of developing informed judgement from the perspective of the students include: (1) identifying oneself as an active learner; (2) identifying one's own level of knowledge and the gaps in this; (3) practising testing and judging; (4) developing these skills over time; and (5) embodying reflexivity and commitment. Sustainable assessment demands that learners make conscious comparisons between self-assessments and assessments by teachers, peers and other stakeholders, and that responsibility for the assessment process must gradually shift from the teacher to the students, because, after graduation, people themselves need to drive their own learning. (Boud & Soler, 2016)

> *Troubleshooting can be approached from many ways, and we were told that this flowchart is not the only solution, it's not the only tool to address the solution. There could be other ways as well. Yes we were told that as well. And after a point in time, there was no need to even follow those steps of the flowchart. After the fourth problem, we would automatically guess which step the problem could potentially be and directly address it. That kind of thought process. Initial times were steps 1, 2, 3, 4, 5 but then after a point in time, when step 2 fails, there's an inherent understanding oh maybe the issue is at step 5 and we directly go there, yeah that's the issue.*

The confidence that comes with these ways of knowing and thinking are expressed by another learner:

> *I think with knowledge comes confidence, so I think the approach, at the back of my mind, there's some kind of "Oh, I know this.*

The outcomes of practical hands-on assessment, and continuous assessment provide feedback to the organisation as well as the individual participant on their capabilities. Organisations can use the assessment results to identify which learners are capable of working independently, those whose work may need checking, and those learners that have yet to meet a minimum standard and require further assistance. This information is critical for organisations such as Telcos where any extensive "downtime" of the network may cost millions of dollars and has an impact on "churn" of subscribers.

3.2 Assessment *for* learning and sustainable assessment

Using **Bruner's spiral curriculum** (1968) Sam (designer, trainer, assessor), followed the design of the curriculum, "*break[ing] the topic off into little segments that can be dealt with on their own so that they can get their heads around*" (Sam, designer, trainer, assessor) and then comes back to the segments in different ways and at a deeper level. The spiral curriculum is one means of building in feedback loops and opportunities for iterative movement between theory and practice and back again, each time at a deeper and more interconnected level. It also enables sustainable assessment (the ability of the learner to judge their performance realistically) as learners get the bigger picture early in the course and can therefore informally judge how they are going, in addition to whatever is deliberately built in to prompt this. Table 1 captures pedagogies that support these different approaches to assessment.

TABLE 1: PEDAGOGIES THAT SUPPORT ASSESSMENT FOR LEARNING AND SUSTAINABLE ASSESSMENT

Assessment for learning (Feedback from multiple sources)	Sustainable assessment
Using Bruner's spiral curriculum enables multiple opportunities for feedback through collecting evidence of learners' developing capability and their strengths and weaknesses	The use of prediction (see box explaining prediction) Bruner's spiral curriculum
Questioning strategies: • Breaking down questions to assist learners identify their own logic • Throwing questions back to learners to get them to think analytically	NA
Knowing and addressing common misunderstandings and gaps in knowledge	

For example, the concept of why and how computers are networked is a key or a threshold concept (Meyer & Land, 2006) where once learners understand this, it enables a leapfrogging in understanding. This understanding and the practices entailed in it involve the ability to be able to read and interpret the symbolic language of networked computers. Participants were given many opportunities to engage with and interpret the symbolic language starting with basics such as IP addresses through to interpreting what strings of symbols mean, what type of information has been asked for depending on the response of the computer, and a range of strategies to connect, identify faults and so on. This is a form of the spiral curriculum mentioned earlier, where learners work on simple exercises to consolidate their understanding, then move to increasingly more complex exercises building from simple to complex interpretations, reinforcing the basics of each iteration and building new, deeper understandings with each iteration. This approach builds in multiple feedback loops. Feedback is from multiple sources:

- The response – symbolic language - received when they try an action in the practice examples given
- Participant's own interpretation of this response to their action
- Peers when they help each other and ask questions
- Sam the teacher as he circulates around the room assisting as required
  Using questions: Breaking down participant's questions and throwing the question back to the participant to assist them identify their own logic is a pedagogical strategy that:
- Contributes to participant's becoming aware of what it is to think like an IT network engineer

Hands the responsibility for participants to constantly reassess their previous understandings. A specific example, (one of many) is when Sam responded to a participant's query with, "What happened when you queried EBAY?" On the learner giving the response Sam asked, "So what does that tell us?" The participant was essentially being asked to answer his own question, and in the process he might recognise not only that he could work out the answer but that in working out the answer there was a particular logic, a way of thinking that could assist with other queries he might have.

Sam describes the process he used:

I tried to get people to answer their own questions or at least attempt to answer their own questions or break their own questions down into a couple of things, rather than me giving them the answer. … Okay, some questions, direct answer but if it's something that they should already have the building blocks to, try to get them to discover the answer. Say, would you look at that and…Okay, this didn't work but it should have worked. Why didn't it work? Which bits worked? Which bits didn't work? And get them to break it down into components where they know parts, so they can hopefully make the leap to the bit that they don't know. (Sam – developer, trainer, assessor)

Scaffolding

Scaffolding is not necessarily a teacher, or an expert, providing knowledge; rather it is about the co-construction of knowledge and know*ing* through dialogue, relevant and meaningful activity using artefacts, tools, ways of thinking appropriate to what is being learnt. The term, scaffolding was first introduced by Wood, Bruner and Ross (1976) as their way of operationalsing Vygotsky's zone of proximal development (ZPD) (Verenikina, 2008). In the ZPD responsibility is gradually handed over to the learner as the learner(s) moves increasingly closer to the desired goal of the learning (Wells, 1999). This suggests a collaborative approach between teacher and learner in developing skill, constructing knowledge and developing capabilities to become lifelong learners. The process involves teachers breaking down tasks into smaller, achievable pieces that still provide challenge, requiring strong engagement of the learner (Verenikina, 2008).

In the process Sam is gathering information about what the participant knows and understands and what they do not; he adjusts his questioning and degree of scaffolding see box on scaffolding) accordingly. Within this questioning process there is feedback, albeit through a small, informal process, from the teacher to the participant. The participant comes to realise what they know and what they need to better grasp.

LiSu, a participant in the course reported that he found this practice "*quite helpful*". An added benefit of this interaction is that it models ways in which learners can assist each other, an important feature of sustainable assessment.

Knowing and addressing common misunderstandings and gaps: There are a number of common or typical prior gaps in the knowledge of participants who attended this course, already referred to in previous sections. These gaps and misunderstandings include the all-important issue for this course, how computers are networked together. The reasons for computers being networked together and how they are networked and can be identified

through their IP address are two aspects of this gap in knowledge that the course addresses. By teaching through drawing on common misunderstandings and gaps, a space is created for participants to be actively engaged in reassessing their understandings and filling in 'gaps' in understanding. Gaffer, one of the participants in this course explains his new understanding of how computers are connected to each other:

> *Before this course, I thought everything was in one (grid) ecosystem, one big network. But then from this course, I learn that most of my equipment are segregated in different levels.*
>
> *And … that's why your Google, wherever you go, you'll be connected to that [Google] google.com.sg because that's the nearest server to you. Then from my understanding, I can understand why there is a lot of servers because I bet you every single day, billions of people connect to Google. To google.com especially. If you only have one domain or one server only, and maybe 2 billion people log in to Google at the same time, the system will lag and fail. That's why they need more (deeper) servers talking to other Google servers all round the world. So he was trying to explain in that way, that servers are very important to collect data, to store data. Then that's one thing that I learnt. (Gaffar – course participant)*

He also commented that before the course he was always wondering about the IP address.

> *Then I was still wondering, why is it .18, why can't it be like .172 for example, the IP addresses. Then that's why this course is very useful for me, so I know how companies segregate their networks. (Gafar, course participant)*

Clearly this is basic knowledge for IT network engineers. Using common misunderstandings through a combination of teacher led examples, stories and then posing of questions and posing problems engaged learners in actively rethinking their misconceptions. This rethinking is very difficult to collect data on, but comments such as Gaffar's above suggest that because coming to understand how things work is highly relevant, he is rearranging and redefining his understandings. We can think of this process as an internal feedback loop prompted by the pedagogical strategy of using misunderstandings and addressing common gaps in knowledge. LiSu, a course participant, explains his change in approach and understanding as,

> *It helped me to see things differently in my work. Means that I will be more alert to the testing that I did. Because after I attend this course I find that there is still a lot of things that I don't know. So when I do testing that time I'll be more alert on small minor thing that might help me to... Because when I do this testing, some of the testing does not show any fault. But the fault is there, just that you did not see it. So it make me do more testing, try different method. This improves how I work. (LiSu, course participant)*

Prediction

Prediction is a commonly used strategy in developing reading skills but has been used in many other discipline areas to great effect. It is a powerful strategy as it develops understanding and identification of clues through asking learners to anticipate what comes next, what the response might be to particular actions.

- Learners need to read and understand the clues that are given
- Learners draw on prior knowledge and experience to anticipate and interpret clues
- Learners are therefore making inferences and drawing conclusions and in the process assessing their previous understandings.

In combining the questioning strategies, using Bruner's spiral curriculum and working with common misunderstandings and gaps, a range of opportunities for feedback are provided; feedback that is from Sam the teacher, feedback from peers and feedback from thinking though answers to questions and reconceptualising previous misunderstandings and self-feedback from completing the practice exercises throughout the course.

All of these forms and sources of feedback are aspects of assessment *for* learning (formative assessment), where participants identify what they are uncertain about, do not yet understand and are helped by others to bridge the gap in their understanding.

Prediction is structured into the curriculum. For example, in a worksheet where participants were trouble shooting with *ping*, they were required to write down what they think will happen across four different network scenarios, then work in pairs to troubleshoot and compare their findings with their prediction. As indicated in the box on prediction, prediction engages students, requiring them to think at quite high levels. They are actively and strongly engaged in sense-making and prediction of patterns. In the process they are constantly re-assessing their own understandings; this is another key feature of sustainable assessment.

Feedback

The focus in more recent work on feedback is on "the contribution of others to learning through assessment, and repositioning the notion of feedback not as an act of information giving to students, but as a co-productive process in which both students and others have key roles to play.(Boud & Soler, 2016, p.403)

By drawing attention to what are essentially meta-cognitive processes (an important aspect of assessment as learning and sustainable learning) educators can better enable learners to develop sustainable meta-cognitive capabilities, key to learning to learn. The opportunities in this course to do this were quite rich, tending to be implicitly integrated into the programme rather than explicitly identified. The exception is in the use of the heuristic.

The heuristic: The heuristic is a decision tree flow chart that captures the logic of thinking like an IT engineer. Participants were introduced to it on Day 4 as they were given practice scenarios in identifying network problems, starting with simple and moving to complex networks. Participants were told that they were expected to know this process; the flow chart would not be available to them in the exam. Sam shared the purpose of the flow chart with

participants by saying, "*So we are looking for the thought process, the analysis, the logic. The first one will be a bit confusing but gradually you will get more confident*." Just as Sam had warned them, the first network problem took much longer than the following problems. In doing this, Sam was managing fears and reassuring participants. As participants became familiar with this way of thinking, Sam stressed that the flow chart was not the only way of solving the problem. In discussing this with him, he explained:

> *They can start to make a judgement call based on not the full picture, but some evidence. They would say, "Well, on my judgement, I don't need to pursue this line of enquiry. I haven't checked all the things but the first thing I've checked has a strong indication that it won't be there. So, I will go this way instead." So, it speeds up the decision tree a bit in terms of how long it takes them to control resolution and those are techniques that, I think, are pretty transferable into other domains. (Sam, developer, trainer, assessor)*

The idea that this way of thinking is "*pretty transferable into other domains"* is an important point. In this course, participants are being taught basic skills pertinent to the discipline of engineering, and potentially beyond the field of engineering. This is an example of a lifelong learning capability being developed as an intrinsic and critically important part of the course. There is opportunity to more explicitly label this process to enable participants to 'see' their meta-cognitive patterns in relation to learning and thinking like an IT network engineer. Such capabilities are potentially carried by the participants into other domains.

4. Possibilities

The design of this course is quite strong in supporting assessment for and of learning. However there is always room for further development and the following two suggestions are offered for consideration.

1. Make the most of existing opportunities to develop the sustainable assessment capabilities of participants. This can be achieved, for example, through:

    a. Naming the heuristic as a means for developing or building on the capability of thinking like an IT network engineer. Having done this, establish structured opportunities for learners to critique each other's thinking, using the heuristic as a benchmark while understanding that it enables pattern recognition.

    b. Build in structured opportunities for learners to provide explicit feedback to each other, for example a short session working in pairs or threes, on key concepts and their applications as they are covered during the course.

2. Provide another reporting period where the summative assessment is confirmed or changed, through discussions with the participant and with their supervisor. This would require one or more visits with the learner and their reporting officer some time after the completion of the course. An addition such as this is an opportunity to:

    a. Engage the participants in further reflexive thinking about their progress

    b. Provide further feedback on the participant's approaches to IT Network identification of problems and their solutions

    c. Confirm or change the 'summative' assessment achieved at the end of the course

    d. Discuss with the participants and their reporting officer possible next steps – formal and informal

Such a strategy is educationally sound but may not make good business sense for the provider unless the Telco is agreeable to supporting the additional time and resources this would require.

References

Berry, R. (2008). *Assessment for learning*. Hong Kong: Hong Kong Univerity Press.

Boud, D. & Soler, R. (2016) *Sustainable assessment revisited*, Assessment & Evaluation in Higher Education, 41(3),pp. 400-413.

Bruner, J. S. (1968). *Toward a theory of instruction.* New York: W. W. Norton.

Colley, H., James, D., Tedder, M., Diment, K. (2003) "*Learning as becoming in vocational education and training: class, gender and the role of vocational habitus*" in Journal of Vocational Education and Training, 55(4), pp. 471-496.
Gardner, J. (Ed.). (2012). *Assessment and learning: Introduction*. In Assessment and Learning, second edition, (pp.1-9). London: Sage publications.

Meyer, J. & land, R. (2006). *Threshold concepts and troublesome knowledge*. An introduction. In J. Meyer and R. Land, Overcoming barriers to student understanding. Threshold concepts and troublesome knowledge, pp.3-18).Oxon: Routledge.

Verenikina, L. (2008). *Scaffolding and learning: its role in nurturing new learners*. In P. Kell, W. Vialle, D. Konza, and G Vogl (eds), Learning and the learner: Exploring learning fore new times. University of Wollongong.

http://ro.uow.edu.au/cgi/viewcontent.cgi?article=1043&context=edupapers&sei-redir=1&referer=http%3A%2F%2Fwww.google.com.sg%2Fsearch%3Fclient%3Dsafari%26rls%3Den%26q%3Dscaffolding%2Bin%2Bthe%2BZPD%26ie%3DUTF-8%26oe%3DUTF-8%26gfe_rd%3Dcr%26ei%3D0bZFV5qLA42AoAPot66AAg#search=%22scaffolding%20ZPD%22

Wells, G. (1999). *Dialogic Inquiry: Towards a Sociocultural Practice and Theory of Education.* New York: Cambridge University Press.

Wood, D., Bruner, J. & Ross, G. (1976). *The Role of Tutoring in Problem Solving*. Journal of Child Psychology and Psychiatry, 17, pp 89-100.