Title page:

‘Here’s the iPad’, The BTEC. Philosophy: How not to teach science to vocational students.

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Biographical Note

The author has over 20 years as a Further Education (FE) teacher, teaching science subjects that range from 'O' Level to GCSE, 'A' Level Biology, BTEC Health and Social Care, BTEC Sports Science, A Level PE through to GNVQ Science amongst other vocational areas such as Medical Laboratory Science, Catering Science and Hairdressing Sciences.

Since 1994 she has been involved in teacher education with both City and Guilds and University based courses. Teaching was delivered on behalf of the awarding institutions at two FE colleges, one of which supported a Doctorate in Education that looked at the changes in knowledge within Further Education Initial Teacher Training (FEITT) between 1945 (McNair) and the demise of the FENTO Standards (Further Education National Training Organisation) in 2007. This was entitled:

> The Lost Disciplines: An examination of the changes to the knowledge content of Further Education Teacher Training (FEITT) between McNair (1944) and FENTO (2007).

Since 2010 she has worked in a higher education institution where she has maintained this research interest in the role and place of knowledge within vocational subjects. As a result of the growing government interest in the notion of 'Vocational Pedagogy', she has been researching the changes in the place and delivery of science to vocational subjects.

Abstract

This research examines the delivery of scientific knowledge in vocational BTEC courses in terms of the concept of Vocational Pedagogy. It draws on empirical data from observations of teaching, semi-structured interviews and a documentary analysis of syllabuses from both 'A' Level and BTEC examining boards. Theoretical concepts of Pedagogical Content Knowledge (PCK), Content Knowledge (CK) and General Pedagogical Knowledge (GPK) drawn from Shulman (1986), as well as newer concepts of Technological Pedagogical Content Knowledge (TPCK) (Koehler and Mishra, 2009), are used to investigate the way that technology is used in the teaching of scientific concepts in these vocational contexts.

The initial hypothesis drawn was that the Further Education Learning Technology Advisory Group (FELTAG) established in 2013 was creating 'shallow learning' through the ineffective use of technology. As a result there was emerging a 'BTEC Philosophy' of teaching science to vocational learners using Learning Technology (LT) as a 'quick fix' approach.

However as the research progressed it became clear that one of the colleges involved had embraced the pedagogical uses of LT in an innovative way and that what was really lacking were strong 'Bodies of Knowledge' within the curriculum of vocational courses that had science within the curriculum.

Key words

Vocational pedagogy, Pedagogical Content Knowledge (PCK), Content Knowledge (CK), Learning Technology (LT), Technological Pedagogical Content Knowledge (TPCK).

Introduction

This article interrogates evolving pedagogical issues within the delivery of vocational education and training at two Further Education (FE) colleges, the role of specialist subject knowledge of science and 'Bodies of Knowledge' (Lucas et al 2010), alongside emerging policy initiatives for the increased use of Learning Technology (LT) for teaching in this sector. Definitions of pedagogy are changing as technology and theories of learning advance and alongside this are government policy drivers that advocate the increased use of LT in curriculum design, the most recent of these being the Further Education Learning Technology Advisory Group (FELTAG) established in 2013, one aim of which is that 'effort needs to be made to engage and empower learners' use of digital technology –and – the use of their own devices – in the learning process' (pg.5).

This research examines literature regarding current thinking about vocational pedagogy as well as the use of technology and e-learning and uses qualitative data arising from the process of undertaking three separate teaching observations carried out between 2014-6 with trainees on a fulltime post compulsory Post Graduate Certificate in Education (PGCE) run at a University. Two of these observations took place at different campus sites of one large Further Education College that provide placements for fulltime trainees. The other observation took place at another large FE college in the local area. Two of the observations was graded according to the 2014-5 Ofsted Criteria for this sector and each was awarded a Grade 3 with significant improvements required. The final observation was ungraded due to recent changes in inspections for this sector. The lessons observed in 2014-5 were both BTEC National Diploma Level 3 Sports Science which involved the theoretical aspects of that subject rather than the practical. Each observation took place within a typical classroom environment but with different IT facilities. The final observation in 2016 was a science lesson delivered to a group of BTEC Health and Social Care students.

Following these observations semi-structured interviews took place with key members of senior management staff at the one of the colleges involved. The purpose of these was to ascertain relationships between policy and practice in terms of the FELTAG recommendations. Finally documentary analysis was undertaken using an 'A' level Biology syllabus and a BTEC Unit to see if the information presented here had any relationship to the 'Bodies of Knowledge' as advocated by Claxton, Lucas and Webster (2010).

Underpinning concepts

The key theoretical concepts underpinning this research are those of Shulman (1986) and his theories regarding Content Knowledge and Pedagogical Content Knowledge. Shulman refers to expertise in content knowledge as being the way that teachers understand the various means by which the discipline or subject can be organised. The discipline referred to in his work is highly relevant as all three observations involved the teaching of biological sciences. According to Shulman, the 'well –prepared biology teacher' will be able to select the appropriate form of knowledge organisation that suits the learners. Shulman noted that Pedagogical Content Knowledge (PCK) in teaching was where the teacher was able to recognise that the learning of specific topics was easy or difficult for specific learners and as a result was able to organise the curriculum content accordingly.

The most relevant policy directives such as FELTAG advocate that LT can, when used 'astutely' by teachers, enable learners to reach their learning potential (pg. 6). It could be argued that the use of learning technology is one aspect that can be used as a measure of teachers' general pedagogic knowledge and the way that it can be used to maximise learning. As Koehler and Mishra (2005) note, what is important is that teachers recognise what technology can do for them as teachers, rather than a view that what technology can do and this gives rise to the importance of TPCK as the way that technology informs the learning and pedagogical process.

A final strand to the research lies in the philosophy of the colleges with regard to vocational teaching and learning. One of the colleges involved was mentioned in Pullen and Varley-Winter's (2015) work on coaching, culture and collaboration, a paper that looks specifically

at how digital technologies can enhance and change the role of the teacher with clear benefits to the learners. In order to unpick the philosophy behind the college in relation to the use of learning technology and vocational teaching practice, interviews were undertaken to obtain senior management views of current practice and the training of teachers in the sector. These were structured around the same themes used to analyse the observation data as well as questions designed to interrogate the philosophy behind the vocational pedagogy being used.

Vocational pedagogies

Recent literature refers to the term 'vocational pedagogy' in a way that can be perceived as raising the status of vocational education and training with a 'strong VET system to support…. businesses, and to recognise and nurture entrepreneurial talent' (CAVL, 2013, pg.11). The key concepts identified with this relatively new notion are a 'two way street' and a 'clear line of sight to work', (CAVL, 2013, pg. 7) and recommendations that the VET (Vocational Education Training) system should operate as a two-way partnership that uses employers as the main driver for enhancing the curriculum. Lucas et al (2012), in examining how to teach vocational pedagogy, also provide recommendations as to how the 'flipped classroom can be applied in vocational education' (pg.120) and that by developing maps and scaffolding for practitioners in designing vocational education, as well as learning from other disciplines, are pivotal issues in raising the status of vocational pedagogy. The notion of knowledge and theory are raised in this literature but as Hobley (2015) argues, they both fail to fully address the actual theoretical knowledge within vocational subjects. In support of this Wheelahan (2007) argues that much vocational teaching has resulted in a 'delocation of knowledge from the disciplinary frameworks that give knowledge its meaning' (pg. 6) and that when such courses 'face one way' only to the workplace, students are subsequently unable to relocate that knowledge within any context let alone the vocational one being studied. Interesting concepts discussed by Pullen and Varley-Winters with regard to the notion of learning technology in teaching are also the notion of 'flipped classrooms' and pedagogic practice. In order to research these concepts the following is an overview of some pertinent literature.

Flipping the lost disciplines

Claxton, Lucas and Webster (2010) in 'Mind the Gap' go some way to unpicking important concepts regarding the role of knowledge in vocational education and they demand a 'urgent need' to relook at the role of knowledge in this context. A second report Bodies of Knowledge, by Claxton, Lucas and Webster (2010) develop these ideas further with reference to the need to explore how the sciences of learning can contribute to raising the esteem of vocational education and training. These authors identify tensions between academic and vocational education vocabulary and they claim there is a need to:

> reappraise the role of explicit knowledge, theory and understanding in the context of PVE. As educators, we need a better understanding of exactly where, why and how a knowledge of human physiology makes someone a better sports masseur, knowing a little about the chemistry of bleaching makes someone a better hairdresser, or a knowledge of Ohm's Law makes them a better electrician. (pg. 65)

The full quote is reproduced here as this aspect of science within vocational teaching is seen as vital and one that is sometimes forgotten in the recent literature about vocational pedagogy. A personal view is one that sees the 'teaching of science' as an important and neglected aspect of vocational pedagogy. As a teacher educator for many years and as a past science teacher to several different vocational areas, the teaching of science is regarded as significant in recognising both the importance of the subject knowledge and the pedagogical practice that go within an organised learning environment.

In support Wheelahan (2015) is critical, as she was in 2007, of the loss of knowledge in the curriculum and she rightly argues that students have a right to access theoretical knowledge that is relevant to their occupational fields. She argues that whilst student's experiences, pedagogically, are the key aspect of teaching, the objective of learning needs to 'help them access higher order concepts in disciplinary systems of meaning' (pg, 757). She draws on research that indicates that by involving students who are academically weaker into 'inquiry based' projects requires a pre-requisite understanding of the knowledge as opposed to

students taught with traditional disciplinary teaching**.** Wheelahan argues that the VET curriculum needs to return to a knowledge based curriculum as a means of social justice that enables students a voice and engagement in society that the current knowledge poor curriculum offers. These conclusions echo those of Bathmaker (2013) who views access to knowledge as a means of social justice and the need to rethink the place of theoretical knowledge in vocational curriculum.

Claxton et al (2010) advocate that the 'language of learning' is important and that the language of learning in both academic and practical learning should be the same. FELTAG, on the other hand, claim that more needs to be done to harness digital technology in the learning process. Their proposals suggest that teacher education should create 'benchmarks' with regard to the use of learning technology which would allow a teacher to improve students learning in order to reach their learning potential.

Consensus is therefore given to the importance of theoretical knowledge and the use of learning technology in supporting the teaching of vocational subjects but apart from Claxton, Lucas and Webster few formulate concrete ideas regarding it. What most of the literature concentrates on with regard to vocational pedagogy is the way that technology can help vocational learners to access the 'theory' of how to do things rather than knowledge (Pullen and Varley–Winters, 2015). This concept of how the use of digital tools help students' access knowledge is under scrutiny in this research.

Technological Knowledge

Shulman's original definitions of teacher knowledge therefore need revising in the light of advances in technology and the rise of this within a teaching and learning context. Hence a different dimension has been added to these concepts, that of Technological Pedagogical Content Knowledge (TPCK). Koehler and Mishra (2009) and Harris, Mishra and Koehler (2009) discuss this at length and define the term as the effective use of technology in teaching and learning. The concept rests on the interaction between established Content Knowledge, Pedagogical Knowledge and Pedagogical Content Knowledge as advocated by Shulman together with new dimensions of Technological Knowledge, Technological Content

Knowledge and Technological Pedagogical Knowledge creating a framework that the authors agree present different challenges to teachers today.

They note the difficulty of teachers who gained their disciplinary content knowledge at a time when technology was not as advanced, and argue that the 'one size fits all' approaches to the training of teachers in relation to using technology are difficult given the diverse nature of the contexts and indeed the curricula requirements of the subject taught. Harris et al (2009) also recognise the importance of leadership and vision in integrating technology and note that there can be a 'mismatch' in vision as to how practitioners use digital artefacts to promote effective learning. They draw on previous educational reforms in the United States and argue that different approaches to the vision of using technology such as Technology-based educational reform efforts and Software-focused initiatives fail to address fundamental issues of student learning. They are in their words, 'technocentric' and that these initiatives were not addressing fundamental content and pedagogy. Pullen and Varley–Winters on the other hand do acknowledge pedagogy where they conclude that practitioners should reflect 'on their own pedagogy' and that they should consider 'how to incorporate or adapt digital technologies to best fit with that pedagogy' (pg.43)

Methodology

Given the view that vocational education should become more knowledge based whilst taking on board government initiatives for the use of digital technology, the following research questions arise.

- How is technology being used in the teaching of science to vocational learners?
- Does the use of these tools allow learners to access this complex knowledge?
- What are the college policies for the use of digital tools in vocational lessons?
- How are staff using these tools for effective learning?
- What are the colleges doing to support staff in both their own subject knowledge and their technological knowledge?

Based on these the documents of the observations of the three vocational lessons were analysed according to the following themes:

- Pedagogical content knowledge
- Content knowledge
- Technological pedagogical knowledge (use of resources and LT)
- Student learning and outcomes of assessment

Semi-structured interviews with two senior managers took place with a view to interrogate the college policy with regard to both staff training in technology and the use of technology in vocational subjects. Finally the BTEC syllabus for Sports Science was compared to an A Level science and analysed for the way that knowledge of science was framed, classified and documented. This took the form of triangulation but more importantly was an attempt to answer the questions that remain as to how a vocational curriculum can become knowledge rich.

Observations

Two of the sessions observed were BTEC Level 3 Sports Science. One session was about the different energy systems, phosphagen system, glycolysis and the aerobic system with the other covering cardio vascular systems and adaptations as a result of exercise. Both of these are complex subjects. In both sessions the teacher were asking the learners to use iPads to do their own research in groups with the aim of presenting their findings to the group, in each case through a poster. The third lesson observed was a Health and Social Care level 3 class and was covering homeostasis in biological systems. This session was a mix of tutor led and student group research using Chromebooks. In each case the observation feedback was written as a narrative of what was seen with many questions relating to the way that the lesson was going in terms of student learning and activity. Each set of feedback notes has been analysed in terms of the above questions and themes.

Pedagogical content knowledge

Shulman defines this as when a teacher uses the most useful forms of representation, analogies and examples. He goes on to define it as an understanding of what makes learning of specific topics difficult and a 'wisdom of practice' as to what works and how. Neither of the sport science teachers used analogies or any form of representation of the complex topics being covered. In one lesson learners were asked to research three different energy systems and to present their findings. What happened was predictable to an experienced science teacher with comments such as:

- *Use of IT seems to allow students to regurgitate information without understanding*

- *Not a good idea to get students researching on phones- this leads to a superficial recall knowledge Students are researching, but what are they learning about the process?*

- *Too much reliance on computers can lead to copying without really comprehending the subject and process*

The resulting presentations were poor in spite of the teacher giving a set of questions that 'structured their research'. At one stage one student copied perfectly the Krebs Cycle on the board, but when challenged by the teacher to explain it, merely stated that *'I don't know, I just copied it'*.

The second sport science tutor gave no detail to her class other than to produce a poster as to how the cardio-vascular system adapted as a result of exercise. Previous knowledge about each system appeared to be missing in this session. However it must be noted that as observations are only a snap shot of learning, this may have been covered elsewhere. However the feedback here notes issues of this lack of linkage and ordering:

- *How does the presentation link into the process of respiration?*

Similar comments about structuring and ordering were seen in both sports lessons:

- *Have the students had a chance to discuss how they will present the information to show how it links together?*

- *How does this link back to their holistic understanding of how the energy systems interrelate in movement?*

On the other hand, the biology graduate presented some complex concepts such as positive and negative feedback as well as getting the learners to research specific hormones using Chromebook technology. However feedback here relates to the structuring of the activity where all the groups were researching different hormones and as a result of their poor presentations did not allow the students to learn anything about the other hormones. Feedback here notes that she should:

- *Maybe next time go through one system yourself and show how a flow diagram should be constructed then get them all researching the same, followed by another demo of the third.*

All of these comments from the observation feedback indicate that doing research on the internet require structure to it in order for students to organise their work as well as allowing linking and ordering of difficult concepts.

Content knowledge

Here the knowledge of the teacher is important and Shulman notes that teachers must 'know the rules' of syntax or 'truths' within a discipline as well as the substantive structures of organisation. Using Biology as an example, he explains that the teacher will recognise the varying ways of organisation, for example, from small molecules to large, from the larger picture to basic cellular structures so that he or she can select the most appropriate way to explain it to differing learners.

In the case of the Health and Social Care group, the teacher had a Biology degree and hence had this content knowledge. The observation was however for a vocational Level 2 group. In this observed session the feedback did not question the teacher's subject knowledge and there was good evidence that she was well qualified. On the other hand the Sports Science teachers had themselves come up through the BTEC route, and whilst had degrees did not have such a strong core knowledge as the biology tutor. Their main interests lay in the practical aspects of coaching and exercise rather than the hard science. Hence comments made in the observations were:

- *You seem more comfortable with this (sport performance rather than energy systems)*
- *Good type of consolidation to sport and performance, not clear how this relates to energy systems?*
- *This seems a useful activity that relates to sports performance (using phones to search conditions of sport performance) but not with energy.*

These comments do seem to indicate that one tutor was not comfortable with teaching the subject and that both had difficulty in explaining the key principles behind the respiratory system and the different energy systems. Both tutors used the iPads to get students researching broad topics with limited direction. The Biology degree qualified teacher however also used Chromebooks as a research tool and here the issue of research was made complex by the students doing three different systems as noted above under pedagogical content knowledge. Here the issue seemed to be with controlling the learners rather than issues with her own content knowledge.

Technical pedagogical knowledge (use of resources and LT)

This refers to the teacher's knowledge about the process and practice of teaching and learning (Koehlar and Mishra, (2009) as well as the way that students learn and construct knowledge. Comments from all the observations indicates an over reliance on the use of technology for research as the feedback shows:

- *Copying from the internet*
- *4 times in one hour students doing research using iPads*
- *Take iPads off the students, they are playing with them*

These comments show the amount of time spent on devices which were used in an unstructured way to provide information only.

The Biology teacher did provide some structure in the form of a handout to guide the students but here the issue was different as the following comment notes:

- *Start with the disease, this engages vocational learners more than facts*

What this novice teacher needed to do was to relate the learning to the student experience of health and care rather than just solid facts.

Student learning and outcomes of assessment:

This theme was chosen as the outcome of the learning for the students as well as the ability of the teacher to check that learning has taken place. Whether or not the teaching was good, whatever the resources used were, assessment is a vital aspect of learning. In all cases this was seen as a major issue, however it must be said that most novice teachers have a similar issue. Here feedback to all the observed sessions related to the lack of questioning.

- *Are all student able to recall the process of phosphorylation rather than just one student reading it out?*

- *Are you really testing 'listening' skills or knowledge and understanding of the key energy systems and the way that they interrelate in sport and performance?*

- *Use of an app as a quiz, questions relate to the energy system, how do students know if they have the correct answer?*

- *Lack of checking presentations for learning rather than copying off the internet*

It could be argued that these comments relate to pedagogical knowledge as well.

Interviews

A senior manager was interviewed in order to gain a college wide perspective of the use of technology in vocational areas. Whilst this was useful to provide the overview it was not possible to drill down into the way that technology was being used specifically within the teaching of science to vocational subjects. She was able to direct the research towards the Leaning Technology Manager whose role in the college was to disseminate good practice here. She stressed that she regarded teaching and learning as paramount and that the technology came next and the staff were being encouraged through 'bite sized sessions' on how to use it effectively to enhance lessons. The FELTAG policy was being taken up with a drive towards a mix of blended and on line material and that some curriculum areas were more advanced than others. Management here had invested in updating Wi-Fi infrastructure to enable cloud based platforms to operate and that most departments had Chromebook and other mobile devices. Interestingly she noted that the training in the use of technology also extended to the students as many learners did not see this as a form of learning. Students here were inducted into the ground rules and the professional approach to using technology for learning.

She also commented that as an Ofsted Inspector herself, she had been engaged in a debate as to whether the research done in class using technology was actually a good way to use the time, a comment which resonates with the observation data that shows a lot of 'research based' activities in a one hour session.

Following this the Group Learning Technologist Manager was interviewed to see his deeper perspective on the use of technology in vocational areas. The questions used here were to see if there was any difference in the use of technology between A Level and vocational tutors, how effective the use of technology could be in helping the students learn difficult concepts and processes, its part in scaffolding learning and finally if there was a link between the use of technology and subject knowledge.

His responses were interesting, he was a photography teacher who had become interested in how technological tools could help teachers. His responses therefore structured around the way that these tools could be used generically to order and structure information rather than as a research tool. Here he mentioned web based software that was being introduced to teachers that allowed learners to do this important scaffolding. Examples given were biblio.org and Bundlr, both useful web collation tools, and he describes these as possibly being very useful for students and staff as a way of collating their research sources. Both of these sites allow students to order and present information after an initial searches. He stressed the need for students to be able to review their searches and to be able to collate the information in a structured way. His role at the college was to find these tools and disseminate their use with the teachers through staff development. This was useful as it presented a different approach to the use of technology as 'advanced organisers' rather than simply information gatherers.

Documentary analysis of a BTEC Higher National Diploma in Sports Science and A Level Biology

The final strand of this research was a documentary analyse of a BTEC Unit and an A level syllabus. This quote was taken from the Unit entitled Unit 20: Biochemistry of Exercise, Unit code: J/601/1868 where the aim was to give 'learners an understanding of the biochemistry of cells and homeostasis'. It also 'explores energy production and how it is

affected by participation in exercise' (pg. 101). On page 104 of the Unit it states categorically that 'There are no essential requirements for this unit'. Nevertheless learners will explore 'metabolic processes including the energy systems – both anaerobic and aerobic energy systems which are covered together with the biochemistry of the different stages involved in energy production' (pg, 101) as the abstract explains. The word understand is used eight times in relation to the learning outcomes (LO's), for example, LO3: Understand the metabolic processes that provide energy for exercise. The following are examples of 'knowledge' that learners need to 'Understand':

> Energy production: anaerobic energy production eg phosphocreatine system, lactic acid system (anaerobic glycolysis), capacity; limitation; aerobic energy production eg aerobic glycolysis, Krebs Cycle, electron transport chain; by-products; capacity; limitation metabolic processes: anabolic and catabolic processes; oxidation-reduction reactions; control of metabolic activity by (co) enzymes – regulation and rate of activity; hormonal effects; effects on cells. (pg.102).

Nowhere in the whole of the unit were learners required to look at the fundamental aspects of physiology that tie together the working of the cells, that is the respiratory system that gets oxygen to the cells BEFORE any form of metabolic process can take place and which removes waste. Similarly no mention is given to the chemistry of the complex molecules and compounds that the learners are required to 'understand' (LO3).

In contrast an A level syllabus also covers the same topic, 3.5.2 Respiration (A-level only) (pg.36) which is covered in year 2 of the qualification after students have already looked at the general features of respiratory surfaces and the structure and function of the respiratory system, core content: 3.3.4 Mass transport (pg. 28). Structure of the cells is also seen as a pre-requisite of this knowledge whilst in the BTEC unit, this knowledge is simplified to the following:

> LO1 Understand the structure and function of human cells
> 1.1 discuss the structure of different types of human cells
> 1.2 discuss the function of different types of human cells. (BTEC Sport and Sports Exercise, pg, 103)

The rest of the unit looks at homeostatic processes such as pH, osmotic control and temperature control which are to be 'understood' followed by further understanding of the different energy systems. Included in the whole make-up of the award however is a mandatory unit called Anatomy and Physiology for Sport and Exercise in which the basic physiological systems are covered. However the two units do not overlap in any way and are seen in the syllabus to be distinct knowledge topics that are not interrelated.

Discussion

In terms of technological content knowledge, all the trainees seen in this research were young and had only just graduated from university. Hence one would expect that their skills in using technology to be up to date. However they were all trainee teachers who were learning the pedagogical skills of using that technology in teaching and learning as well, what Koehler and Mishra refer to as Technological Pedagogical Content Knowledge. However their mentors as subject specialists should have a greater knowledge of using technology within their subject given their greater experience, which could be passed on during their mentoring. However, this research did not look at the mentors in relation to the support given here.

The main theme emerging from the data seems to be that of ordering and structure of material. Observation data shows the lack of linking and relationships of topics as does the overarching BTEC syllabus. This is the very notion of pedagogical content knowledge that Shulman refers to as being the skill of a subject teacher. Interestingly the Learning Technology Manager noted these concepts and was pointing teachers towards software that could be considered as 'advanced organisers' that enabled learners to structure and organise. He saw this as the power of technology in teaching, what he is referring to here is exactly what TPCK is about. His role in this college was to help teachers find these tools or advanced organisers in order to help learners structure their research well in order to assist their learning. What was missing here however was an opportunity to see an experienced Science teacher using these very tools in their lessons.

In terms of the documentary analysis what was very interesting is the very same aspect of structure and ordering. For example the analysis of the A level syllabus showed more coherence in terms of structuring learning and key concepts of framing and classification,

(Bernstein, 2000), which he describes as being a means of structuring 'vertical discourse' or knowledge. According to Bernstein, classification refers to the way that knowledge is divided, in other words 'the relations [*my emphasis*] between categories' (Bernstein, 2000, pg.99). In terms of formal education this involves the syllabi or curriculum. Framing, on the other hand, is the way that knowledge is structured. According to Bernstein, framing refers to the 'locus of control over the selection, sequencing, pacing and criteria of the knowledge to be acquired.' (2000, pg.99). This appears to be similar to the notion of Shulman's Pedagogical Content Knowledge.

One the other hand the BTEC Units appear to be simply a collection of artefacts relating to modularised aspects of science with little or no integration between the knowledge required to scaffold students learning. This is just one example where the vocational syllabus has 'fragmented' knowledge. The concept of modularisation is not part of this argument although it undoubtedly has had a significant influence on curriculum design as have the different stakeholders who according to Bathmaker (2013), in vocational subjects, seem to avoid the issue of knowledge, and 'an erasure of those stakeholders who might contribute to deeper understandings of knowledge in specialist subject/occupational areas.' (pg. 102). She notes the difference with 'some 'academic' qualifications, where there are examples of higher education subject specialists, teachers, awarding bodies and others working together to develop and revise qualifications in the light of new knowledge' (pg. 102)

Conclusion

The value of technology as a resource for learning is obvious and FELTAG aims here are valued. However what was seen in three of the observations indicate a philosophy of using technology simply as a research tool without any guidance. Here the vocational learners were simply cutting and pasting information without any guidance or structuring resulting in shallow or no learning when the technology was not used with pedagogical principles and 'scaffolded' knowledge as well.

From the outcomes of the qualitative feedback recorded following the observations it is argued that what was seen in each is typical of what can be referred to as 'BTEC philosophy' when teaching theory to vocational students. 'Here's the iPad' was noted in three of the observations and seems to be symptomatic of how vocational pedagogy together with the

impetus of FELTAG may be forcing teachers to use technology 'just because it's there'. However it is heartening to hear senior manager views on a more holistic policy for students and teachers with new posts emerging such as Learning Technologists who are firstly teachers rather that technological 'geeks'. This college was able to teach-the-teachers how to design on-line learning materials on their own using open-source packages and the use of LT and its effectiveness in teaching science was seen by the powerful web based software that the Learning Technologist was introducing into the college. He kindly allowed access to his blog which had a lot of different free and easily accessible applications that was formidable in terms of their pedagogical usages. All teachers at this college had access to this and also had training in the pedagogical use of the applications. This college seems to have got to the heart of TPCK and the importance of pedagogy in using technology effectively. However, it would have been useful to have seen experienced science teachers using these tools effectively as a contrast to the vocational groups that were observed.

However a more dangerous problem seems to emerge from this small study, that the vocational teachers who have come up through a BTEC route themselves rather than 'A' Level Science, lack that strong underpinning subject knowledge that Shulman refers to as Content Knowledge that with training in pedagogical principles can be moved towards Pedagogical Content Knowledge. The Biology teacher did have this knowledge and showed some attempts to teach the students the 'vertical knowledge' needed in homeostasis, what she lacked was the way to change the focus of this knowledge for more vocational learners. Wheelahan (2015) calls this 'facing one way', and Barnett (2006) notes that a 'teacher involved in 'boundary-crossing' pedagogy needs reasonable familiarity with the 'discourses' on either side of the divide, and the recontextualisation strategies that have been used to create the new 'pedagogic discourse…' (pg.155). He stresses importance of 'facing both ways' within vocational education and training. It is argued that with further development in pedagogy, this teacher will achieve that skill.

Finally, the documentary analysis and observations suggest that teachers who themselves have been taught through the fragmented approach of the BTEC syllabus lack that important 'linkage of knowledge' that is of importance with regard to Pedagogical Content Knowledge. Without a structured and ordered Content Knowledge a vocational teacher may flounder in teaching the subject effectively even with technology as a useful resource. One key aspect emerging is in the way that knowledge is structured within curricular and ordered by the

teacher. Technological tools that can act as organisers are useful as long as the teacher provides the underpinning knowledge first. Claxton, Lucas and Webster (2010) note that 'Students used to be taught about the body's three control systems – the endocrine or hormone system, the immune system, and the central nervous system – as if they were separate. They aren't.' (pg. 15), however it is argued that what a good vocational teacher does is to link these, something that was not seen in either the BTEC syllabus or the teaching by the vocational teachers brought up on a fragmented syllabus themselves. In the past the science of different vocational subjects was taught by the college science departments, with the introduction of the National Vocational qualifications (NVQ) in the late 1980's this changed and the vocational tutors took over the teaching of this vital aspect of the vocational subject. This work argues that as a result of the loss of structured and linked knowledge within the curriculum, no amount of technology in the form of 'advanced organisers' or indeed 'curated spaces' that McEneaney, (2015) advocates will help finding knowledge on the Internet, without the teacher having access to 'powerful knowledge' that is connected, linked and ordered themselves. Hence vocational pedagogy in the form of the teaching of science will remain fragmented as long as the vocational teachers themselves remain 'facing one way', to the practical world of work. Without strong disciplinary knowledge themselves, working to syllabi with seemingly disconnected knowledge, they have no chance of really getting to the core of Pedagogical Content Knowledge and hence there is no hope for the learners to access knowledge in any form, technology or not.

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