

A critical analysis of the relationship between teacher subject knowledge and effective learning and teaching in the primary school.

What is great teaching? According to Turner (2001, p.10) there is a notable difference between ‘good teaching’, ‘effective teaching’, ‘creative teachers’, ‘veteran teachers’ and ‘even not good enough teachers’. According to Coe et al (2014, p.2) effective teaching is often defined as teaching that leads to ‘improved student achievement’. This has long been up for debate as many would argue that other factors ascertain what ‘great’ teaching is. Teachers constantly endeavour to improve upon their practice within the classroom, in order to provide the best learning environment for their pupils. These areas of improvement can take a variety of forms and what is considered ‘good practice’ is fairly ambiguous within this profession. Rowland and Ruthven (2011, p.2) quoted Kelly (1995) in saying ‘knowledge is the very stuff of education; it is impossible to conceive of, or to plan any education activity without recognising the central role that some knowledge-based transaction must play in it’. This assignment will focus on one particular element that is ‘teacher subject knowledge’ and its relationship with ‘effective learning and teaching in the primary school’. It will take into account both literature that is available on this subject and my own personal experiences when I have been on my teaching practice. My initial teaching practice was carried out in a small primary school in South Wales. This primary school has approximately 240 pupils between the ages of three and eleven. Throughout this assignment, I will not mention any names of students in order to maintain anonymity in line with the ‘British Educational Research Association (BERA) guidelines’ (BERA, 2018, p.18).

Do other factors play a more important role in effective teaching than subject knowledge alone? I will take into consideration these other factors that may have an impact on an individual’s learning. As quoted by Rodrigues (2005, p.57), Harlen (1999) stated that ‘where teacher subject knowledge is weak, confidence levels to teach that subject are low, leading to restricted classroom practices’. A study by Harlen and James (1997) also lead them to state that teachers cannot expect children to engage in activities unless they are familiar with the concept of what they are teaching themselves. However, Cotton (2012) pondered as to why it is that some children struggle to learn when others don’t, suggesting that not so much emphasis is to be placed on the teacher. He considered ‘is it their learning styles; is it right or left brain strengths or defects; is it lack of attention; is it their refusal to take their

medication; is it their lack of motivation; is it their parents not being supportive; is it because they do not do their work, and so on'. These quotes and pieces of research support the idea that subject knowledge does indeed have an impact on effective learning. However, this assignment will consider further research that both critiques and supports this.

Firstly, I will touch upon the current and developing curriculum in Wales today. This is something that is of great discussion within schools at present, in which lots of changes are occurring. It is important for all teachers to be aware and familiar with the national curriculum in order for the children's learning to be optimal. At present, we are at a time where the new curriculum is being put in place and established. Lewis (2017, p.1) states that it is due to be fully implemented in 2022 and rolled out gradually. According to the Welsh Government (2018, p.1) this will include three 'cross curricular responsibilities' which consist of 'literacy, numeracy and digital competency'. As stated by the Welsh Government (2017, p.1), this framework is designed to allow teachers more freedom when teaching within the classroom. They will be encouraged to teach in a way which 'they feel will have the best outcome for learners'. Graham Donaldson (2015) is behind many of the central ideas of the new Welsh Curriculum and he introduced 'four key purposes. These purposes are designed to ensure that children become 'ambitious capable learners, ready to learn throughout their lives', 'enterprising, creative contributors, ready to play a full part in life and work', 'ethical informed citizens of Wales and the world' and 'healthy confident individuals, ready to lead fulfilling lives as valued members of society'. Donaldson (2015) also introduced 'six areas of learning and experience' which include 'expressive arts, health and wellbeing, humanities, languages, literacy and communication, mathematics and numeracy, science and technology' (Welsh Government, 2017, p.1). A key question asked by many is 'why is it changing?'. According to the Welsh Government (2017, p.1) the change came about when it was recognised that 'young people need to be adaptable to change' and teachers need to be given more flexibility when it comes to teaching. The ever changing curriculum still means that teachers have to have more up-to-date knowledge and understanding, particularly when it comes to digital competency. Without their own understanding of subjects such as these, it would be near impossible for teachers to be able to help children learn and develop in these areas. However, not everyone would agree with this statement.

It is widely recognised that teacher subject knowledge can have an impact on their students learning. However, is it just what teachers know that makes them good at teaching, or are there others aspects that should be considered when discussing this? There are different

ways in which teacher subject knowledge can be distinguished and categorised. According to Carden (2018, p.10) Shulman (1987) was one of the first educational psychologists to investigate how teacher subject knowledge could be organised and categorised. He was very influential in this area and key when discussing the relationship between subject knowledge and effective teaching. According to Ohle (2010, p.24) due to the complexity of teaching, Shulman (1987) distinguished between different types of knowledge by creating a 'classification system of seven types of teacher knowledge'. Shulman (1987) described these as 'categories of the knowledge base'. The seven categories are as follows; 'knowledge of educational ends, knowledge of education contexts in classrooms, knowledge of learners and their characteristics, curriculum knowledge, general pedagogical knowledge, content knowledge and pedagogical content knowledge' (Ohle, 2010, p.24). Shulman (1987, p.8) believed that these seven domains would be the minimum of what is required in order to be a successful teacher. Ohle (2010, p.24) states that the latter three domains place more emphasis on 'content' and are believed to 'determine the teachers' performance in the classroom'. However, in contrast to this, as stated by Shing et al (2015, p.49), Grossman (1900) argued that it was important that a teacher to has only four key 'knowledge bases' which include 'pedagogy, PCK, school contexts and subject matter'. This is similar to the ideas of Shulman (1987) but perhaps a more focussed approach.

A lot of Shulman's (1987, p.8) work places emphasis on content knowledge (CK) and pedagogical content knowledge (PCK). These two domains are used when considering teacher ability and pupil outcome and therefore it is important to understand the difference between CK and PCK. As explained by Coe et al (2013, p.91), CK refers to the teacher's knowledge of a subject. CK must be in place before any further teaching can occur and without sufficient CK teaching will not be effective. The teacher must be able to understand what they are teaching and why what they are teaching is the way it is. For example, if they are teaching Mathematics, teachers must know and understand the concepts to a sufficient level. Naturally, teachers CK varies and this can possibly in turn have an effect on pupil outcome. Once CK is in place, teachers can consider PCK. According to Shing et al (2015, p.49) Shulman (1987) first introduced the idea of PCK was due to the fact that teaching is often viewed as a 'non-professional career'. PCK is described to be a combination of both 'general pedagogical strategies and the knowledge about the specific content of a subject' and refers to when CK is transformed in such a way that it can be used within the classroom effectively. It focuses on the teacher's ability to make their knowledge of subject accessible

to their pupils (Shulman, 1987). According to Olszewski (2010, p.14) PCK also includes being able to understand the level of difficulty of a task. It also takes into consideration the backgrounds of the pupils and their varying ages and abilities. As previously stated, CK must be in place in order for PCK to occur.

According to Shing et al (2015, p.49) it has been discussed in depth how teachers continue to develop their PCK as they progress from student teachers to full time qualified teachers. According to Bruer (1994, p.279) Shulman (1987) supports his ideas by making reference to a veteran teacher known as Nancy. Nancy was 25 years of age and she was an English teacher. Accordingly, to Bruer (1994, p.279) Shulman (1987) described Nancy's performance in the classroom as follows; 'She was like a symphony conductor, posing questions, probing for alternative views, drawing out the shy while tempering the boisterous. Her combination of subject-matter understanding and pedagogical skill was quite dazzling'. It was interesting that Shulman chose to compare Nancy to an orchestra conductor. This shows that Nancy had full involvement in the teaching and learning process and she processed more than knowledge alone. Shulman (1987) described Nancy's teaching as 'pedagogical excellence'.

The above ideas and concepts put forward by Shulman (1987, p.6) place a large amount of emphasis on the 'knowledge-base for teaching'. However, it is key to recognise that he argues that there are more components that play a part in teaching than just knowledge alone (Shulman, 1987, p.6). Although Shulman's ideas are influential, they have been questioned in the past. It has been argued as to whether the PCK is a useful construct when discussing the relationship between teacher subject knowledge and effective learning. According to Shing et al (2015, p.51), Abell (2008) who was a science teacher herself, argued in support of the idea of PCK, stating that it does indeed remain useful as 'it helps her to understand teaching processes and generate viable instructional strategies in her method courses'. According to Loo (2008, p.4), Shulman's (1987) ideas have been queried and the seven knowledge types that he presented may have required 'expansion'. It was thought that both 'curriculum knowledge' and 'pedagogical content knowledge' were not thought to be defined clearly enough. It is also thought that treating content knowledge as a 'starting point' meant that new teachers weren't taken into account as they may already have content knowledge in place already from past experiences. Sockett (1987, p.208) also questioned whether Shulman (1987) was right in his way of thinking regarding CK and PCK. Sockett (1987, p.208) believed that Shulman (1987) did not pay enough attention 'to context, as

opposed to content'. It is thought that whilst he took into consideration the content knowledge of teachers and the way in which they teach, he did not take into account the scenario in which this was carried out which weakens his ideas. It is claimed that these criticism of Shulmans ideas are due to the fact that his ideas are largely 'assessment-driven' and are placing too much emphasis on outcome (Socket, 1987, p.208). Shulman (1987) himself admitted 'we must be careful that the knowledge-base approach does not produce an overly technical image of teaching'.

According to Donaldson et al (2012, p.38) 'The Knowledge Quartet' is a tool used 'for analysing teacher knowledge' created by Rowland et al (2005). According to Rowland and Ruthven (2011, p.18) this framework came about in response to a study of the 'mathematical content knowledge' of PGCE primary school teachers in both England and Wales and by observing video tapes of their mathematics lessons. It aimed to investigate 'the relationship between pre-service teachers' subject matter knowledge (SMK) and pedagogical content knowledge (PCK) of mathematics'. Carden (2018, p.10) stated that this study investigated 'the knowledge needed to teach mathematics' and organised this into four separate categories; foundation, transformation, contingency and connection. This is what then became known as 'The Knowledge Quartet'. This is a framework used to understand how 'subject knowledge' is used within the classroom and is used as a 'tool' to understand this. As stated by Rowland and Ruthven (2011, p.18) the 'Foundation' category represents the teacher's beliefs about the subject and their 'knowledge and understanding of mathematics pedagogy'. The second category, 'Transformation', represents the way in which a teacher uses 'representations and examples' throughout their lessons and within their planning. 'Contingency' accounts for a teacher's ability to respond to things that happen in the classroom that cannot be planned for or predetermined. An example used by Rowland and Ruthven (2011, p.18) was 'to respond appropriately to student's wrong answers'. Finally, the forth domain of the knowledge quartet is 'Connection'. This refers to the teacher's ability to link their knowledge to other lessons and other aspects of the lesson being taught. This is an interesting model as it takes into account different aspects of knowledge that need to be in place in order to secure student outcome, rather than using 'knowledge' as an umbrella term.

To conclude this section, as quoted by Guerriero (2017, p.7) 'it is clear that content knowledge alone is insufficient'. This have been supported by the key ideas of both Shulman's (1987) categorisation and 'The Knowledge Quartet' created by Rowland et al (2005). Further evidence such as the findings of a study conducted by Baumert et al (2010)

whereby they directly studied the link between PCK and the achievement of students found that ‘when teacher’s content knowledge is controlled, higher levels of knowledge do not predict better student scores’. This in turn suggests that student scores must be affected by other factors. (Guerriero, 2017, p.7). As explained in Guerriero (2017, p.10) Hill, Rowan and Ball (2005) conducted a study into the relationship between teachers Mathematics subject knowledge and student achievement. The researchers took into account how many ‘mathematic methods courses’ were taken and ‘whether teachers were certified’. It was found that there was no relationship between this and ‘student achievement gains’. This supports the idea that there are other factors that lead to successful student outcomes than the teacher just being knowledgeable and well trained.

Others disagree with the idea that other factors can effect student achievement, and believe that subject knowledge is indeed key to successful teaching. Research reported by the National Research Council (2000) that was conducted by Haselkorn and Harris (1998) found that approximately nine out of ten Americans consider the most successful way to improve student outcome is to have a qualified teacher in all classes. Influential educational psychologists such as John Dewey have also considered the relationship between subject knowledge and effective learning. Aubrey (1997, p.4) briefly described Dewey’s ideas by stating he believes that ‘some people were good teachers without studying pedagogy’. This diminishes Shulman’s (1987) emphasis on pedagogical content knowledge and indicates that knowledge alone can lead to great teaching.

When I was on my own professional teaching practice for the first part of my PGCE course I was able to experience the impact that a lack of teacher subject knowledge can have on the learning process of the children in my year six class. This is also one of the things that we are assessed on when we are observed by our university tutors and class mentors. This highlights that it must be important to have adequate subject knowledge in order to be a professional qualified teacher. However, when I first started training to be a teacher, one of the first things that I realised was that there is more to teaching than just knowledge alone. I am aware of the importance of the current and changing national curriculum and the three cross-curricular responsibilities outlined by the Welsh Government (2018, p.1). Unfortunately, on PTE1, I did not have much experience directly with digital competency aside from working with the interactive whiteboard. I felt comfortable using this and therefore cannot make any significant comments on the impact this may or may not have had on the students learning.

Initially, when I was placed at the top of the school for my first teaching practice, I felt nervous due to the fact the children in this class are between the ages of ten and eleven, about to head into comprehensive school and are therefore likely to have more subject knowledge than I if I was placed in, for example, reception or year one. During my six weeks in this class, I was able to cover a wide variety of subjects. For example, I taught numeracy, literacy, Welsh, physical education and science. Naturally, some subjects required me to have a broader range of subject knowledge, and even had to remind myself of some facts and concepts myself. I knew that this was essential if I was to be successful in carrying out a lesson whereby the children learn effectively.

One key experience that came to mind was when I was teaching ‘dissolving’ for a science lesson. The lesson entailed a small practical whereby the children would have to see whether certain materials would dissolve in water. The materials included salt, sugar, flour, wax, flour, a jelly cube, gravy granules, coffee granules and sand. I chose these materials to ensure that there was a mixture of materials that would both dissolve and not dissolve. See Figure 1 for a completed copy of a worksheet by one of the pupils. This was an enjoyable lesson to teach, and I ensured that I had sufficient subject knowledge before carrying out the task. However, I was thrown by one of the children claiming that ‘a material has only dissolved if the liquid is clear. Isn’t that right Miss?’ My initial reaction was that things can still dissolve even if they do not run clear. For example, gravy granules dissolve but do not create a clear solution. In previous lessons, the children had listened to a song whereby it stated that dissolving has occurred once the water is clear. Although I was confident with my original thinking, I began to question myself due to the nature of the child’s statement. This particular scenario links in with Rowland et al’s (2005) knowledge quartet framework. This incident particularly reminds me of the ‘contingency’ aspect of the knowledge quartet. As previously stated this refers to the teacher’s ability to deal with unplanned situations within the classroom (Rowland and Ruthven, 2011, p.18). In this situation, I wasn’t fully prepared to answer this child’s question, and had I been more confident in this subject area, I would have been able to respond to this child’s statements and queries with ease. See Figure 2 for a lesson plan used to carry out this lesson. In this instance, it was not that I didn’t have the subject knowledge, but I did not meet the criteria of the four domains introduced in the Knowledge Quartet and therefore this impacted my teaching. This experience also led me to consider Donaldson’s (2015) proposals for the new curriculum. I think it is important for

children to ask as many questions as they want as they should be encouraged to be ‘ambitious capable learners’ (Welsh Government, 2017, p.1).

Mathematics has always been a subject that I lack confidence in and the idea of teaching this subject to year six pupils was quite nerve-wracking. A large amount of the Mathematics that I taught was on the subject of co-ordinates. I did not find the prospect of teaching co-ordinates particularly daunting as this is fairly simple and I assumed that this would go smoothly. However, this had the opposite of the desired effect when it came to teaching it. I was able to learn a lot from this experience. The first lesson that I introduced the subject of co-ordinates I rushed the teaching of this subject and I moved to quickly for the children. Upon reflection, it appears that due to my increased subject knowledge, I rushed the topic and made it inaccessible to the children as I thought they would be able to grasp it quickly. In the following lessons teaching co-ordinates to the class, I taught it at a much slower pace so that the children were able to fully understand what I was teaching them. I found it hard to help the children who were struggling and teach it in a way for them to grasp it fully. This experience in Mathematics was particularly interesting, because despite thinking that this would be a fairly ‘simple’ topic to teach in which I had optimal subject knowledge, the reality was quite different. This suggests that my subject knowledge did not particularly increase pupil outcome and in some ways hindered my ability to teach it. Had I had skills in other areas, I would have realised that more focus should have been placed on how it was taught to the children. This links back to the work of Shulman (1987). It appears here that my CK was in place but my PCK was lacking and therefore the overall student outcome was not what was expected it to be. Linking back to the Knowledge Quartet further, it appears that although I had the ‘foundation’ and ‘connection’ domains in place when teaching co-ordinates, I lacked the ‘contingency’ and ‘transformation’ which means that student achievement was not at its best. In these cases, I can see why both Shulman’s (1987) CK and PCK and the knowledge quartet are useful constructs when discussing the relationship between teacher subject knowledge and student achievement.

Following an observation of a literacy lesson, my mentor complemented me on my ability to deliver a lesson on persuasive writing and advised that she was pleased that my subject knowledge was in place. This was positive to hear, but it leads me to question ‘was my lesson perfect just because my subject knowledge was in place?’. As a trainee teacher, I know this lesson wasn’t perfect and therefore this led me to realise that although my content knowledge was at a ‘good’ level when assessed, this by no means made my lesson

‘excellent’. Therefore, this in turn suggests that there are many other things to take into account. For example, was the lesson delivered effectively? Did the children understand? Did the children enjoy the work? Was the class managed appropriately? These are all things that teachers need to take into consideration in order to ensure that their students are learning effectively. As previously stated Shulman (1987) was able to identify seven different features of a knowledge base which highlights that knowledge takes several different forms and this experience confirms this (Ohle, 2010).

However, one of my experiences when I was on placement made query the need for such a large amount of emphasis on the pedagogy of teaching. According to the Welsh Government (2016) a proposal has been put in place with the aim of there being one million Welsh Speakers by 2050. An important place to start in order to achieve this aim is within primary schools in Wales. I have been aiming to use Welsh more and more within the classroom since I have been on placement. I was pleased to see children using Welsh more as a result of me using it within the classroom. For example, I found that simple words such as ‘diolch’ were being used more. This wasn’t particularly a result of me ‘teaching’ Welsh, but more of a natural result of me using it around the class. In circumstances like this, it indicates that as long as the content knowledge is in place so that Welsh can be used naturally by the teacher, children will naturally pick up on it and as a result use it themselves despite it not necessarily being explicitly ‘taught’ to the class as a whole. This experience goes against the findings of Shulman (1987) who places emphasis on the need for things to be taught in a certain way in order for children to learn effectively.

I was able to learn a lot on my first teaching practice. I was able to witness, especially due to being in year six, the importance of having a wide variety of background knowledge when teaching a subject. Referring back to the previously mentioned statement from Harlen (1999) ‘where teacher subject knowledge is weak, confidence levels to teach that subject are low, leading to restricted classroom practices’ (Rodrigues, 2005, p.57). I find this statement relatable and I believe that a lesson will not be successful if you do not have the confidence to teach it. However, I also note the importance of being able to deliver the material in such a way that the children can fully understand. I can see why Shulman (1987) is particularly influential in this area which his emphasis on combining both CK and PCK in order to be able to teach effectively.

To conclude, I believe that there is more to ‘great’ teaching and effective learning than simply having the knowledge required to teach. Although this is an important factor and will have at least some impact on overall student outcomes, I think that it is highly important to consider the other possible factors that make for improved student outcomes. I believe that Shulman (1987) presented some interesting ideas, particularly when going into detail regarding the CK and PCK. This clearly highlights that the delivery of a lesson is key. From my own experiences, I have noted that of course it is important to have background content knowledge for a lesson to be effective. However, I believe it is equally important to ensure that the delivery of the lesson is carried out in a fun and interesting way in order to engage the children. With regards to the knowledge quartet, I believe that the ‘contingency’ domain is of particular importance. Children have such enquiring minds, that being as prepared as possible for unexpected questions is key to keeping the class interested. My next steps as a teacher would be to ensure that my subject knowledge with things that I am not comfortable with is relevant. For example, become more confident in teaching digital competency so that I can ensure this is covered in my lessons in line with the current national curriculum (Welsh Government, 2017, p.1).

Appendix:**Figure 1: Completed science 'dissolving' worksheet by pupil in year six class**

Drawing Period

Does it Dissolve?

Material	Does it dissolve?
Flour	X
Sand	X
Coffee Granules	✓
Sugar	✓
Salt	✓
Gravy Granules	✓
Jelly cube	✓
Wax	X
Bath Salts	~~~~~

Change colour

not water will
make it fast

Cloudy
then back to water

With
hot
water

only
under
a flame

Figure 2: Science KS2 lesson plan used in year six on PTE 1

Canolfan Addysg Athrawon De-Orllewin Cymru  The South West Wales Centre of Teacher Education		1B
Session Plan – Key Stage 2		
Name of trainee: (Removed for purpose of assignment)		Session ref: Science
Personal target(s) in relation to QTS: • Ensure I am able to use my own subject knowledge appropriately in order to motivate learners • To use incidental Welsh		
Year group: Year 6	No. of learners: 30 Learners	ALN: Dyslexia, ADHD, Tourette's, Autism
Additional Adults: N/A		
Learning objective(s): • To be able to understand how materials dissolve from a material to a solution through a practical activity		Success criteria: • Understanding why certain things dissolve and why others don't • Use scientific language to explain the process of dissolving
Links to previous learning: Reverting back to what they have previously learnt about dissolving		
Curriculum coverage (range, skills): • Group work • Communicate ideas information and data • Analysing • Foster creativity and curiosity • Explore and share ideas • Making sense of the issue • Peer discussion • Use a table to display information • Enquiry • Develop scientific knowledge and understanding • Understand scientific processes		
<i>Literacy(LNF)</i> • Using scientific words correctly • Speak clearly, using formal language, varying expression, tone and volume, to keep listeners interested • Listen carefully to presentations and show understanding of the speakers' conclusions or opinions • Contribute purposefully to group discussion to achieve agreed outcomes		<i>Numeracy (LNF)</i> • Estimating and measuring • Using tables

<i>DCF</i> Not applicable	<i>Thinking</i> - Scientific thinking - Links to previous learning	<i>ESDGC</i> Not applicable	YCC Not applicable
<i>Key vocabulary(English/Welsh):</i> Incidental Welsh – da iawn, barod, counting amser taclus, dim siarad, gwrandewch, pwy sy' nesa? Scientific language – molecule, solution, dissolve, particle, solute, liquid, solid, soluble, insoluble			
Time	Session activities, organisation and management	Key questions & Assessment for Learning opportunities	
10 mins	Introduction: - I will conduct this lesson on 2 occasion, I will split the class into 5 groups. On the first occasion I will take 2 groups one after another and on the second occasion I will take 3 groups one after another. - First session: 20/11/18. Second session: 22/11/18. Each session will be approximately 20-30 minutes. Total: approx. 1 hr. 30 mins – 2 hrs. - I will begin the session with a quick 5 -minute intro where they recap what they have already learnt about dissolving - I will encourage the children to use scientific words, for example, solute, solution, molecule, particle etc. - Explain that we will be completing a practical activity	<i>Questions:</i> What do you already know about dissolving? Can you remember what ____means?	
	Main activities: - The main activity will be carried out in the science lab of the school - This activity is a practical activity so the children can witness materials dissolving into solutions	<i>Questions</i> What colour has the water gone? Has it dissolved?	

30 mins	• The children will put materials in some water one by one and discuss what is happening • Materials: coffee granules, sand, salt, sugar, gravy granules, cornflour etc. • They will have a work sheet to fill out to tick if things do, or do not dissolve • I will encourage discussion as they carry out the activity and encourage the children to use scientific language where appropriate	Has the material disappear completely? What do you already know about this material?
5 mins	Plenary: • Conduct a quick 5-minute plenary to see how the children found the lesson • Ask them to draw a smiley face on the bottom of their work sheet to indicate how positive they feel about the topic of dissolving so far	<i>AFL:</i> At the bottom of their work sheet get them to draw a smiley face indicating how well they understand dissolving and the language related to it

References:

Aubrey, C. (1997) *Mathematics Teaching in the Early Years: An Investigation of Teachers' subject knowledge*. Great Britain: Biddles Ltd.

BERA. (2018) *Ethical Guidelines for Educational Research*. London: BERA.

Bruer, J. (1994) *Schools for Thought: A Science of Learning in the Classroom*. USA: MIT Press.

Carden, C. (2018) *Primary Teaching: Learning and Teaching in Primary Schools Today*. Sage Publication: United Kingdom.

Coe, R., Aloisi, C., Higgins, S., Major, L. (2014) *What makes great teaching? Review of the underpinning research*. Sutton trust: Durham.

Donaldson, G. (2015) *Successful Futures*. United Kingdom: Crown Copyright.

Donaldson, G., Field J., Harries, D., Tope, C., & Taylor, H. (2012) *Becoming a Primary Mathematics Specialist Teacher*. Routledge: London.

Lewis, B. (2017) *New Wales school curriculum overhaul delayed a year*. [Online] Available from: <https://www.bbc.co.uk/news/uk-wales-41387459> [Accessed: 3rd of January 2019]

Loi, S. (2008) Teaching Knowledge, Work Based Learning and Life Experiences. *British Educational Research Association*. 3 (6) 1-6.

Ohle, A. (2010) *Primary school teachers content knowledge in Physics and its impact of teaching and students' achievement*. Logos Verlag: Germany.

Olszewski, J. (2010) *The Impact of Physics Teachers' Pedagogical Content Knowledge on Teacher Actions and Student Outcomes*. Germany: Logos Verlag.

Rodrigues, S. (2005) *International Perspectives on Teacher Professional Development: Changes Influence by Politics, Pedagogy and Innovation*. Nova Science Publishers: New York.

Rowland, T., Ruthven, K. (2011) *Mathematical Knowledge in Teaching*. Springer: United Kingdom.

Saha, L., Dworkin, G. (2009) *International Handbook of Research on Teachers and Training*. Springer: New York.

Shing, C., Saat, R., Loke, S. (2015) The Knowledge of Teaching – Pedagogical Content Knowledge (PCK). *The Malaysian Online Journal of Educational Science* 2015. 3 (3) 40-55.

Shulman, L. (1987) Knowledge and Teaching: Foundations of the New Reform. *Harvard Educational Review*. 57 (1) 1-23.

Socket, H. (1987) Further Comment: Has Shulman Got the Strategy Right? *Harvard Educational Review*. 57 (2) 208-220.

Turner, R. (2001) *Expect Teaching*. London: Routledge.

Welsh Government. (2016) *Vision for one Million Welsh Speakers Launched*. [Online] Available from: <https://gov.wales/newsroom/welshlanguage/2016/160801cymraeg/?lang=en> [Accessed: 4th January 2019]

Welsh Government. (2017) *New School Curriculum: Overview*. [Online] Available from: <https://beta.gov.wales/new-school-curriculum-overview> [Accessed: 31st December 2018]

Welsh Government. (2018) *Digital Competence Framework*. [Online] Available from: <http://learning.gov.wales/resources/browse-all/digital-competence-framework/?lang=en> [Accessed: 3rd of January 2019]

