

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

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Introduction

Anecdotally many graduates may recall a proverbial research professor to whom lecturing was an inconvenience. It could not be argued that his subject knowledge was beyond reproach by the students; however his disciplinary knowledge and focus could be said to restrict his ability to teach. Ball (2008) concludes that the knowledge needed to teach, particularly primary students, must be categorized as different from disciplinary knowledge by referring instead to the knowledge of how to teach the content. The aim of this essay is to conduct a review of the literature surrounding the relationship of subject knowledge to effective learning and teaching, and secondly to analyse the author's personal experience of the question in relation to his own teaching practice.

A consideration of the literature

The modern debate about teacher subject knowledge is commonly attributed to the work of the American educational psychologist Lee Shulman. Shulman (1986) divides a teachers knowledge into 3 groups; Content Knowledge (CK), Pedagogical Content Knowledge (PCK) and Curricular Knowledge. These ideas would later inform much of the future research in the field (Rowland, 2005). CK is described as the teacher's knowledge of the subject (Kleickmann, 2013). PCK describes how a subject may be made accessible to a student and blends with the teacher's content knowledge (Grigg, 2015). Shulman argues that teachers must fully understand the subject across all three areas of knowledge in order to teach. He advocates for examination of a teacher's knowledge and argues that all teachers must become researchers contributing to

a communal body of knowledge and understanding. Shulman (1986) concludes that to teach a subject requires a greater depth of understanding.

Shulman

In his seminal work, Shulman (1987) notes that the majority of reviews of good classroom teaching focussed more on the management of the children in that environment than the development to the classroom ideas and learning. By way of showcasing good teaching Shulman describes the practice of an excellent teacher 'Nancy', who demonstrates both strong and appropriate subject knowledge (CK and PCK) and a flexible strategy for teaching which adapts to the needs of the class and the demands of the subject matter. Shulman's identification of the lack of research into teacher subject knowledge sparked an area of research which continues to this day Kleickmann (2013). Shulman (1987) describes a number of scenarios in which a veteran teacher shows greater pedagogical knowledge than a newly qualified teacher. The superiority of a veteran to an amateur is not based on their years of experience but rather their depth of subject matter knowledge. The process of becoming expert in a field has been debated by a number of studies which commonly find that those who engage in deep self-evaluation and use the feedback to implement changes in their practice are able to master skills more quickly than those who do not engage in this form of deliberate practise (Coughlan, 2014). Ericsson (2008) found that deliberate practise model demonstrated how a novice turns into an expert.

Hattie

Whilst the vast majority of educationalists agree with Shulman's findings it could be argued that Shulman neglects to provide more context to the teacher's ('Nancy') situation as there is no empirical evidence provided to support the efficacy of 'Nancy's' teaching. One of the most influential educational theorists John Hattie built upon Shulman's ideas in his many subsequent writings using empirical data to classify the effects of teacher subject knowledge. Hattie (2012) asserted that teachers remained the greatest influencers on learning, with the most numerous above 'hinge point' factors relating to teaching. Hattie defines this 'hinge point' as a strategy, intervention or technique which may be shown to have positive effect of or above $d=0.4$. Hattie defines $d=0.4$ as the average effect of a year's schooling. Hattie also states that the greater in

school variance compared to inter-school variance points to the teacher as a pivotal factor in effective learning. Hattie (2012) ascribes teacher subject knowledge an effect size of $d=0.12$, well below the $d=0.40$ hinge point that Hattie recommends teachers dedicate their attentions. One of Hattie's key assertions is that evidence showed a small effect size in relation to a teachers subject knowledge (CK and PCK) when compared to the depth of understanding of that subject, the teacher's own attitude and assessment for learning (AFL). When these statements are applied to Shulman's (1987) 'Nancy', it may be argued that she demonstrates not only good CK and PCK but the attitude and assessment tools to fit Hattie's (2012) description of an expert and effective teacher.

In his belief that the attitudes to learning fostered by the teacher are key, Hattie (2012) states that it is more important for a teacher to create an environment of safety where mistakes are truly accepted as an intrinsic and essential component of learning and as such do not draw ridicule from the student, his peers or the staff. Hattie's work further strengthens Shulman's (1987) claim that 'Nancy' is an expert educator by highlighting the necessity for a teacher to be flexible in their approach by planning for contingencies and unforeseen learning barriers whilst providing learners with multiple avenues for learning. Across Hattie's writing and lectures (including Hattie, 2012, 2014) he places the importance of a teacher understanding their impact over and above their CK, PCK and Curricular Knowledge. Therefore it can be argued that an educational professional of the most secure and deep CK is at risk of wasting their effort if they do not understand the impact of the knowledge and pedagogy that they are imparting. Both Hattie (2012) and Shulman (1987) agree that for effective teaching surface knowledge is insufficient and that a depth of understanding is required to enable a teacher to develop the pedagogy necessary for the most effective learning.

Metzlara (2012) found that in a study that examined both student and teacher's subject knowledge, the effectiveness of the teaching was linked to teacher subject knowledge but there was variation in effect size in respect to the subject itself. The research showed that in mathematics there was a significant relationship resulting in a 9% increase in achievement; however there was a much lower correlation of little to no significance in reading. This study supports John Hattie's conclusions that subject matter in isolation has a below hinge point ($d=0.40$) impact on effective learning. Whilst Hattie's continued meta-analysis is no doubt an

impressive undertaking it is not without criticism; Eacott (2017) warns against the blind acceptance of such numerous data from a single individual at the detriment of other researchers. It is also prudent to consider that Hattie's methods of distilling an element of learning in isolation can never be complete as evidenced by the constant addition of new learning elements added to Visible Learning for Teachers (Hattie, 2012) since the 2009 edition.

Knowledge Quartette

Rowland (2005) heavily referenced Shulman's work, and built upon many of its concepts by developing the Knowledge Quartet (KQ) from research focusing on mathematics teachings. The researchers studying the teaching of PGCE primary students, categorised 18 elements which they refined into a teaching tool comprised of four categories; Foundation, Transformation, Connection, and Contingency. Foundation is stated to be the building block from which the three other categories flow and describes a teacher's CK. We may therefore conclude that Rowland (2005) places a large weighting on CK and PCK for successful teaching and learning. In contrast to Shulman (1987), Rowland describes an inexperienced teacher's (Naomi) teaching. At one point during the lesson 'Naomi' struggles to convey the objective to the children and appears 'exacerbated', this would seem to evidence Hattie's (Hattie, 2012) assertion that a key component of a successful teacher ability to draw on deep subject knowledge and provide contingencies. The remaining categories tend to favour the teacher's PCK in translating, linking and developing the learning objectives. When the Knowledge Quartet is applied to Shulman's 'Nancy' (Shulman, 1987), it can be argued that she has satisfied the criteria set out in the Knowledge Quartet: secure knowledge (Foundation), appropriate scaffolding (Transformation), building on previous knowledge (Connections) and the lesson's malleability (Contingency).

Rowland (2005) is sympathetic to 'Nancy' and the necessity of a teacher to manage the behaviour of the class and establish themselves as a credible and inspiring leader before any elements of the quartet can be implemented; however there would appear to be myriad other factors to consider for effective teaching Hattie (2012). Rowland's research (Rowland, 2005) was conducted in the UK and therefore may prove more pertinent to a teacher in the UK than Hattie's global research; however the opposing view would counter that Hattie's work controlled for country specific differences by combining data from across the world. The work of Metzler (2012) may also suggest that the knowledge quartet could be less effective for other subjects.

McAuliffe (2013) concludes that KQ is a valid tool for identifying the content knowledge it may be best utilised with other tools such as Ball's MKfT (Ball, 2008) to provide a more holistic view of teacher subject knowledge. It is interesting to note that Metzlera (2012) found mathematics to yield higher significances between teacher subject matter knowledge and effective learning than data about reading subject matter knowledge. The findings of Ball (2008) agree with Shulman (1986) that content knowledge is highly important for effective teaching but warns of the over reliance on scholarly knowledge in the teaching profession. They argue that CK must be fundamentally linked to PCK for teaching.

Other arguments

Grigg (2015) acknowledges and agrees with the work of Shulman (1986, 1987) and suggests that the content knowledge and pedagogical content knowledge must be viewed in unison for effective teaching. In addition Grigg states that good content knowledge will engage with alternative views and consider all implications; a statement which echos Hattie's mantra to 'know your impact'. Grigg references fact that much of the writing and content available independently is pedagogically content free. Therefore students may require the teacher to provide them with the PCK to interpret the information irrespective of the teachers own content knowledge. With the advent of new technologies Grigg (2015) explores the changing role of the teacher with regard to content knowledge. Grigg asserts that increasingly teachers are viewed as facilitators of knowledge, particularly as tools such as the internet offer students access to far more detailed and complex knowledge that any teacher could be expected to retain. Therefore the teacher's responsibility shifts to providing students with the tools to assess, evaluate and digest knowledge. It may be inferred in this instance that the importance of the teacher's CK diminishes in respect to their PCK. Additionally Grigg predicts that the importance of the teacher's contingency skills (Rowland, 2005) and the teacher's flexibility and adaptability 'on the hoof' must be strengthened.

Cremlin (2014) discusses the difference in subject knowledge between the primary school and the secondary school teacher, noting that the primary teacher whilst generally teaching a lower intellectual level, must have a far broader subject knowledge than their secondary colleague. Cremlin believes that a primary teacher's knowledge may be partitioned into four areas; Factual

information, access to further information, teaching strategies, specific teaching techniques. These elements are rated as extremely important for successful teaching and learning and Cremlin advises that teachers have an obligation and a duty to understand their own knowledge and to seek to keep their CK, PCK and techniques informed of both contemporary and historic developments. The reflection of a teacher upon their knowledge is a thread that links the literature around teacher subject knowledge from Shulman's work in the 1980s through to the current philosophies. The teaching world like the natural world is constantly changing new influences, focuses and stresses dictate that an individual or group who cannot adapt or evolve will surely be left behind. In the nature an organism or species who failed to adapt or evolve would under all but the most unlikely circumstances, be out-competed and made extinct. If we carry this example over to teaching we may conclude that the whilst the failure to adapt would likely be to the detriment of the learning, the teacher is less likely to cease to teach. The obvious difference between the two environments is the factor of competition; in the natural world it is ever present but the teaching world relies on a variety of factors to take the place of such ruthless competition. Firstly the teacher must possess the professional desire and attitude to further their knowledge and understanding independently. Secondly the government and management must enable, incentivise and monitor a teachers subject knowledge. Finally society must support, encourage and foster a climate where the quality of the teacher and education (both academic, creative and practical) is appreciated and celebrated. Let us consider the most commonly discussed and debated factor, namely the role of government, management and teacher trainers. It is commonly accepted that trainee primary teachers must demonstrate a predetermined level of subject matter knowledge in several areas to begin training however across the UK no there is no requirement to demonstrate PCK; therefore we can infer the primary role of teacher training is to develop a trainee's PCK and relevant skills. Likely explanation for the lack of requirement of PCK in trainee teachers is that it has never been taught to them. This raises a question if we accept as Shulman (1987) and others that followed have, that we must assess the content knowledge, how are we best to do so? Furthermore if we accept Sulman's (1987) and Hattie's (2012) assertions that deep subject knowledge is required for effective teaching, it may be prudent to teach PCK and relevant techniques and skills to learners as part of their education; logic dictates that learning in such a way should deepen their understanding.

When considering the role of teacher subject knowledge in the foreseeable future in Wales and to a lesser extent the rest of the UK; one must consider the implications of the 'Successful Futures' (SF) report (Donaldson, 2015) and its subsequent adoption into policy by Welsh Government. The primary impact of SF will be on the curriculum and therefore on the curriculum knowledge of teachers. SF acknowledges that pressures and influences upon teaching will change over time; therefore the report urges government to enable teachers to future proof their teaching by increasing the amount of cross curricular integration. SF also advises that government take an arms length approach to teaching. This may prove important in allowing the education sector however like Shulman and Hattie, Cotton (2010) argues that teacher knowledge audits are an invaluable approach for one identifying and improving their own teacher subject knowledge and thus their confidence and teaching effectiveness.

Analysis and evaluation of your subject knowledge for primary teaching

This section aims to focus on my personal experience of teaching with reference to my own subject knowledge including CK, PCK and Curricular knowledge. As a primary trainee teacher in my first professional training experience; I was placed in one of three year 2 classes in a large South Wales primary school. The school had a below national average free school meals level and had been rated good to excellent by the most recent ESTYN report.

Numeracy subject knowledge

Of the three core subject areas of primary education in Wales (Literacy, Numeracy and Digital Competency), one may argue that numeracy and its relevant subject knowledge is the most measurable particularly with reference to CK. For the purpose of addressing the question in this essay I feel a particular maths lesson (Lesson A) is relevant. Lesson A was the second in a series of lessons introducing the learners to subtraction. The learning objective of Lesson A was to understand the process of counting-on in multiple chunks of 10 along a number line, as a method of subtraction. My GCSE grade A and Physics A-levels would satisfy most observers (as they have the teacher training requirements) that my content knowledge is sufficient to teach

Foundation Phase mathematics. This knowledge was supplemented by pedagogical content knowledge delivered by University of Wales Trinity St David, the school's mathematics coordinator and via professional discussion with my class teacher. My curriculum and pedagogical knowledge was informed by the National Curriculum support guide (Welsh Government, 2013). Armed with this knowledge and with a mentor approved lesson based on the Foundation Phase I had felt a degree of confidence as Lesson A began. Cotton (2010) believes that a teacher's confidence in the classroom demonstrates their subject knowledge, where by good subject knowledge leads to a teacher's classroom confidence. Conversely Wragg (2002) asserts that anxiety reduces a teacher's awareness of the class and their learning. The lesson proceeded in an acceptable manor, with all students actively engaged in the activities. During observations of the learner's work it became evident that learners were making a common counting error which, in most cases did not lead to an incorrect answer, did add a secondary and unnecessary step in the counting process. The errors were commonly as follows: for the calculation ' $81 - 20 = ?$ ', when 'chunk counting' (in groups of 10s) from 20 to 81 students would 'chunk jump' to an intermediate value of 60 and make a second 'jump' from 60 to 80. Whilst still correct, this elongated process exposed the students to greater risk of calculation error. During professional discussion with the mentor it was suggested that learners needed to make better note of the value that they were 'jumping' towards on their number line. I gathered the pupils and modeled the desired technique.

Lesson A demonstrates the contrast between CK and PCK. If we accept that CK is secure and good curriculum knowledge is demonstrated, it follows that the reason for the learners errors were the teacher's PCK. Good PCK as identified by Hattie (2012), demonstrates deeper understanding of the subject and understanding of common errors. Teachers who have deep PCK may be considered expert (dependant on other factors), however it can be argued strong PCK cannot be developed without the teacher's active learning and reflection in response to 'real world' situations (Grigg 2015). Utilising the Knowledge Quartette (Rowland, 2005) as a lens to analyse this lesson would be prudent as the theory's inception was based on Mathematics education research. Firstly the foundation of the academic knowledge and beliefs is demonstrated by the teacher's academic qualifications, and personal views and attitudes. The foundation has informed the pedagogy and lesson plan. Secondly the connection to previous work was based on the learners previous use of similar 'chunk jumping' (Welsh Government, 2013) when solving addition calculations and was both observed and recorded in the learner's

books. The pedagogy was informed by review of learners' previous knowledge and the curriculum. Thirdly transformation of foundation knowledge into pedagogically consumable knowledge (Shulman, 1987) is evidenced by the use of number line techniques, however the student errors indicate as previously stated, that some PCK was lacking. Lastly and underpinning the three other areas identified in the knowledge quartette (Foundation, Connection and Transformation), sits contingency, which Rowland (2005) describes as the ability to react to unforeseen events. The learner's common error could be described as a lack of Transformation that therefore required a contingency despite the fact that deep PCK would have identified this situation and likely prevented it. The contingency in Lesson A is evidenced by the assessment of the learners work, the subsequent professional discussion and the re-modelling of the technique.

As the lead teacher in Lesson A I must ask the question, would I have been able to identify address the learners technique error without the assistance of the mentor? This question highlights the importance of contingencies for just as no lesson is perfect there will always be a requirement for any teacher of any degree of experience and expertise, to possess the skills and understanding to implement successful contingency strategies. Thus the conclusion I must draw is that the fact contingencies are a necessity they should not be relied as safety net to catch PCK weaknesses. The four factors of the KQ must all be fit for purpose for effective learning.

Literacy subject knowledge

To contrast the numeracy focussed Lesson A, I propose to look at a subject matter knowledge in a literacy focussed lesson. The school in which I have been training, uses the 'Read, Write Inc.' strategy from Ruth Miskin (Miskin, 2018), and as such I was afforded limited opportunities to plan reading and writing lessons based on CK. Therefore literacy and language skills were incorporated into other lessons in accordance with the developing curriculum based on Donaldson (2015) in which language, literacy and communication are viewed as a key area of learning and experience incorporated across the curriculum. The literacy incident I propose to analyse occurred during a lesson (Lesson B) concerned with the objective of compiling a series of facts on nocturnal animals by using electronic devices (ipads) to access online material. It

should be noted that as the class and was combined with other form and year classes, and split into 7 'Read, Write, Inc.' (WRI) groups, each taught by a different teacher, I had varying amounts of contact time with the pupils for their main literacy lessons. Lesson B centered around the theme of nocturnal animals and proceeded as per the lesson plan and all students were able to satisfy the success criteria. When marking the work my attention was brought to the work of a particular child 'Child A'. Child A had completed the learning objective and demonstrated the desired learning; however the class teacher noted that as Child A was in the most advanced of the WRI groups the amount of writing that he had done was less than could be expected of his ability. Clearly Child A had not been adequately challenged. Using the first element of the KQ (Foundation) I believe my CK was adequate as evidenced by my academic achievements. The connection to previous work built upon the learners experience of using the technology and their previous writing experience. The transformation could be identified as the use of the nocturnal animal focus which was drawn from the pupils suggestions. Few notable contingencies were employed as the children grasped the task at hand. When evaluating the reasons that child A did not perform at the level that could be expected of him it is fair to lay the criticism at the pedagogy and PCK for not challenging him adequately and at the contingency for not having a plan in place to rectify this. However I believe that the key factor that must inform both the Transformation and Contingency elements of the KQ is an strong understanding of Child A and the subsequent development of a relationship whereby his work and attitudes could be factored in to the pedagogy.

When comparing Lesson A and Lesson B both examples highlight the importance of strong PCK. Using the lens of the KQ it could be argued as Metzlera (2012) found, that KQ is more relevant to Mathematics and that for less linear subjects such as literacy there may be more diffuse factors influencing effective learning.

Conclusions

The conclusion I must draw echoes that of the Delphic maxim 'know thyself'; in accordance with the views of Shulman (1976) and those that built upon his work, a teacher must have a strong understanding of their own knowledge. He must be less afraid to explore and critically reflect upon his own subject knowledge (CK and PCK) to identify areas that require reinforcement and

the depth that Hattie (2012) states is necessary of an expert teacher. Teacher subject knowledge can be shown to be integral to effective learning; however it is also shown to be just one component of effective teaching, thus it may be viewed as cog in within a machine; without it the machine would not function and yet it is one of many cogs that must be present. Shulman (1987) and Hattie (2012) are among those who advocate that deep understanding of subject matter is necessary for effective teaching and learning. Therefore we might conclude that we should teach our learners to teach and in doing so deepen their understanding.

In the article that can be said to have initiated the discussion of teacher subject knowledge; Shulman's 1986 'Those who understand' (Shulman,1986), Shulman addresses the most egregious and calumny statement ever leveled at the education profession, that of George Bernard Shaw's ' Those who can do, those who can't teach'. When we consider the empirical evidence, the published literature and my personal experiences; the quote though wittily cannot be said to apply to those who educate. Teachers do not just teach, teachers do.

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