State of the Art – Teacher Effectiveness and Professional Learning

Introduction

One of the key findings from decades of Educational Effectiveness Research is the importance of the classroom level as a predictor of pupil outcomes. Research has consistently shown not only that the classroom level can explain more of the variance in pupil outcomes than the school level, but that a large proportion of this classroom level variance can be explained by what teachers do in the classroom (Muijs & Reynolds, 2010). As a result of these findings classroom practise has become firmly integrated into theoretical and empirical models of educational effectiveness (e.g. Creemers & Kyriakides, 2008). As part of this endeavour, school effectiveness has made strong links to the older field of teacher effectiveness, and has used many of the methods associated with that field, such as classroom observation using standardised observation instruments, adding to that different methods such as surveys and qualitative exploration, and newer understandings of learning and teaching. One element that has traditionally been less developed in educational effectiveness research is that of teacher professional development. This omission is somewhat peculiar in the light of the importance of professional development in models of effective school improvement, and the clear implication that if teacher behaviours are key to educational effectiveness, we need to pay attention to ways in which we can change practise as well as looking at what effective practise is.

This paper therefore aims to summarise some key recent key findings and developments in the area of teacher effectiveness, including recent developments in meta-cognition and brain science. In light of what we have said above, the paper will also discuss recent work on professional development.

Of course, it would not be possible to present a full and comprehensive overview of all these areas in a paper of limited length such as this one. Rather, we have presented what we feel are some key developments in the field, as a basis for discussion at this State of the Art session. We hope it will serve this purpose.

In the first section, we will look at current research on teacher effectiveness. Section 2 will discuss key findings on meta-cognition and ‘new learning’. In section 3 we will look at possible consequences of recent research on learning to teacher effectiveness, and in the final section we will look at professional development.
1.1. Research into teacher effectiveness: Major findings

During the last 35 years, researchers have turned to teacher behaviours as predictors of student achievement in order to build up a knowledge base on effective teaching. This research has led to the identification of a range of behaviours which are positively related to student achievement (e.g., Brophy & Good, 1986; Creemers, 1994; Doyle, 1986; Galton, 1987; Muijs & Reynolds, 2000). The most consistently replicated findings of teacher effectiveness studies conducted in different countries link student achievement to the quantity and pacing of instruction. Amount learnt is related to opportunity to learn and achievement is maximised when teachers prioritise academic instruction and allocate available time to curriculum-related activities. Consistent success is another significant factor associated with student achievement. To learn efficiently, students must be engaged in activities that are appropriate in difficulty level and suited to their current achievement levels and needs (Stallings, 1985).

Effective teachers are also expected to organise and manage the classroom environment as an efficient learning environment and thereby to maximise engagement rates (Creemers & Reezigt, 1996; Kyriakides, 2008). Doyle (1986) claims that key indicators of effective classroom management include: good preparation of the classroom and installation of rules and procedures at the beginning of the year, smoothness and momentum in lesson pacing, consistent accountability procedures, and clarity about when and how students can get help and about what options are available when they finish. As far as the actual teaching process is concerned, research into classroom discourse reveals that, although there is a great deal of teacher talk in the classes of effective teachers, most of it is academic rather than managerial or procedural, and much of it involves asking questions and giving feedback rather than extended lecturing (Cazden, 1986; Kyriakides & Creemers, 2008).

The findings summarised above deal with factors associated with the quantity of academic activity. The variables presented below concern the form and quality of teacher’s organised lessons and can be divided into those that involve giving information (structuring), asking questions (soliciting) and providing feedback (reacting). In regard to the structuring factor, Rosenshine and Stevens (1986) point out that achievement is maximised when teachers not only actively present material but also structure it by: a) beginning with overviews and/or review of objectives; b) outlining the content to be covered and signalling transitions between lesson parts; c) calling attention to main ideas; and d) reviewing main ideas at the end. Summary reviews are also important since they integrate and reinforce the learning of major points. These structuring elements not only facilitate memorising of the information but allow for its apprehension as an integrated whole with recognition of the relationships between parts (Creemers & Kyriakides, 2008). Moreover, achievement is higher when information is presented with a degree of redundancy, particularly in
the form of repeating and reviewing general views and key concepts. Clarity of presentation is also a consistent correlate of student achievement (Scheerens & Bosker, 1997; Seidel & Shavelson, 2007). Effective teachers are able to communicate clearly and directly with their students without digression, speaking above students' levels of comprehension or using speech patterns that impair the clarity of what is being taught (Smith & Land, 1981; Walberg, 1986). Muijs and Reynolds (2000) indicate that the focus on teachers actively presenting materials should not be seen as an indication that traditional lecturing and drill approach is an effective teaching approach. Effective teachers ask a lot of questions and attempt to involve students in class discussion. There should also be a mix of product questions (i.e., expecting a single response from students) and process questions (i.e., expecting students to provide explanations), but effective teachers ask more process questions (Askew & William, 1995; Kyriakides & Creemers, 2008, 2009). Effective teachers also use seatwork or small group tasks since they provide needed practice and application opportunities. The effectiveness of seatwork assignments is enhanced when the teacher explains the work that students are expected to do and once the students are released to work independently the teacher circulates to monitor progress and provide help and feedback.

Classroom climate is a significant teacher factor. The climate is usually seen as associated with the behaviour of the stakeholders, whereas culture is seen as measuring the values and norms of the organization (Heck & Marcoulides, 1996; Hoy, Tater, & Bliss, 1990). Classroom climate research is described as the stepchild of psychological and classroom research (Creemers & Reezigt, 1996). The classroom effects research tradition initially focused on climate factors defined as managerial techniques (e.g., Doyle, 1986). Management is necessary to create conditions for learning and instruction, but management itself is not sufficient for student results (Creemers, 1994). On the other hand, the psychological tradition of classroom environment research paid a lot of attention to instruments for the measurement of students' perceptions of climate. Many studies report on their psychometric characteristics (Fraser, 1991). We advocate the need to integrate elements of different research traditions and search for the contribution of the teacher in creating the classroom as a learning environment. Effectiveness studies conducted during the last two decades (e.g., Kosir, 2005; Rohrbeck, Ginsburg-Block, Fantuzzo, & Miller, 2003; Slavin, 1983; Slavin & Cooper, 1999) reveal the importance of investigating the teacher's contribution in creating a learning environment in his/her classroom by taking into account the following elements of the classroom environment: teacher-student interaction, student-student interaction, students' treatment by the teacher, competition between students, and classroom disorder (Creemers & Kyriakides, 2008; Kyriakides & Christoforou, 2011). The first two elements are important components of measuring classroom climate, as classroom environment research has shown (Cažden, 1986; den Brok, Brekelmans, & Wubbels, 2004; Fraser, 1991). However, teacher effectiveness research is concerned with the type of interactions that exist in a classroom rather than how students perceive teacher interpersonal behaviour (Kyriakides, 2008). The other three elements refer to the attempt of teachers to create a businesslike and supportive environment for learning especially since research on teacher effectiveness reveals that the classroom environment should not be only businesslike but also needs to be supportive for the students (Walberg, 1986). Thus, effective teachers expect all
students to be able to succeed and their positive expectations are transmitted to their students.

There are of course some key limitations to this research. The vast majority of the research discussed above has focussed on basic skills in English and maths, largely ignoring other subjects and outcomes (more on this later). There is also the issue of the lack of a link to practise in a lot of extant research.

1.2. Teacher Effectiveness and the Dynamic Model of Educational Effectiveness

In this context, the dynamic model of educational effectiveness has been developed in order to establish stronger links between educational effectiveness research and improvement of practice (Creemers & Kyriakides, 2006).

The dynamic model takes into account the fact that effectiveness studies conducted in several countries reveal that the influences on student achievement are multilevel (Teddlie & Reynolds, 2000). Therefore, the dynamic model is multilevel in nature and refers to four different levels: student, classroom, school, and system. The teaching and learning situation is emphasized and the roles of the two main actors (i.e., teacher and student) are analyzed. Based on the main findings of teacher effectiveness research, the dynamic model refers to factors which describe teachers’ instructional role and are associated with student outcomes. These factors refer to observable instructional behaviour of teachers in the classroom rather than on factors that may explain such behaviour (e.g., teacher beliefs and knowledge and interpersonal competencies). The eight factors included in the model are as follows: orientation, structuring, questioning, teaching-modelling, applications, management of time, teacher role in making classroom a learning environment, and classroom assessment. These eight factors do not refer only to one approach of teaching such as structured or direct teaching (Joyce, Well, & Calhoun, 2000) or to approaches associated with constructivism (Schoenfeld, 1998). Specifically, the dynamic model does not refer only to skills associated with direct teaching and mastery learning such as structuring and questioning but also refers to orientation and teaching modelling which are in line with theories of teaching associated with constructivism (Brekelmans, Sleegers, & Fraser, 2000). Moreover, the collaboration technique is included under the overarching factor of the contribution of the teacher to the establishment of the classroom learning environment.

The dynamic model is also based on the assumption that although there are different effectiveness factors, each factor can be defined and measured by using five dimensions: frequency, focus, stage, quality, and differentiation. These dimensions help us describe in a better way the functioning of each factor. Specifically, frequency is a quantitative way to measure the functioning of each factor whereas the other four dimensions examine qualitative characteristics of the functioning of each factor operating at the system/school/classroom level. The dimensions are not only important for a measurement perspective but also and even more so for a theoretical point of view. Actions of teachers associated with
each factor can be understood from different perspectives and not only by giving emphasis to the number of cases that the actions occur in teaching. In addition, the use of these dimensions may help us develop strategies for improving teaching since the feedback given to teachers could refer not only to quantitative but also to qualitative characteristics of their teaching practice. Some supportive material for the validity of the dynamic model has been provided (see Antoniou, 2009; Kyriakides & Creemers, 2008, 2009). Specifically, three longitudinal studies revealed that the proposed measurement framework can be used to describe the functioning of each teacher factor (Antoniou, 2009; Kyriakides & Creemers, 2008, 2009). Using multilevel modelling techniques, the added value of using each dimension of teacher factors to explain variation on student achievement has also been identified. Moreover, a quantitative synthesis of 88 teacher effectiveness studies revealed that all teacher factors of the dynamic model are associated with student achievement (Kyriakides & Christoforou, 2011). Factors excluded from the dynamic model were found to be weakly associated with learning outcomes but some support to two factors associated with constructivism (i.e., self-regulation and concept mapping) has also been provided. Further research is therefore needed to identify whether the dynamic model should be expanded.

The dynamic model, as explained above, attempts to describe the complex nature of effective teaching by pointing out not only the importance of specific factors and dimensions but also explaining how the functioning of each factor can be defined. The model is also based on the assumption that these factors and their dimensions may be inter-related and the importance of grouping of specific factors for explaining achievement is stressed. In this way not only the complex nature of effective teaching is illustrated but also specific strategies for teacher improvement may emerge. In order to investigate the significance of the teacher level of the dynamic model and especially its potential to improve teaching practices and student attainment, the concept of grouping of factors (i.e., factors which operate at the same level and are related to each other) was further explored by analyzing the data of the longitudinal studies mentioned above. By using the Rasch model, it was found that the teaching skills included in the dynamic model can be grouped into five stages which are discerned in a distinctive way and move gradually from skills associated with direct teaching to skills concerned with new teaching approaches (see Kyriakides, Creemers & Antoniou, 2009). The first three levels are mainly related with the direct and active teaching approach by moving from the basic requirements concerning quantitative characteristics of teaching routines to the more advanced requirements concerning the appropriate use of these skills as these are measured by the qualitative characteristics of these factors. These skills gradually also move from the use of teacher-centre approaches to the active involvement of students in teaching and learning. The last two levels are more demanding since teachers are expected to differentiate their instruction (level 4) and demonstrate their ability to use the new teaching approach (level 5). Furthermore, taking student outcomes as criteria, teachers who demonstrate competencies in relation to higher levels were found to be more effective than those situated at the lower levels. This association is found for achievement in different subjects and for both cognitive and affective outcomes. Therefore, evidence supporting the possibility of defining grouping of teacher factors emerged from this study. This also implies that more comprehensive strategies with synergetic
effects can be developed in order to address the improvement needs of each teacher.
Section 2: Teacher effectiveness and new learning outcomes (Greetje van der Werf)

2.1. Introduction

Creemers and Kyriakides paper implies that EER should take into account the new goals of education and related to this, their implications for teaching and learning. In their dynamic model of educational effectiveness they have included ‘new learning’ as one of the outcome variables, next to cognitive, affective and psychomotor outcomes (See e.g. Kyriakides and Creemers, 2009, p. 64). One of the most important new aims of education is self-regulated learning (SRL), because today’s society requires students to be able to learn in a self-regulated way during and after schooling and throughout their entire working life (EU Council, 2002). However, although self-regulated learning already for several decades has been a major topic of educational research (Winne, 2005), it is still an issue that is understudied in the field of educational effectiveness. In this paper I will present – without pretending to be extensive and complete - a state of the art about the research findings related to SRL, that might have implications for educational effectiveness theory and research, and maybe practice as well.

2.2. What is self-regulated learning and why is it important?

The concept of self-regulated learning came up with the beginning of constructive learning theories, in which the idea was that students should take responsibility for their own learning and should play an active role in the learning process (Zimmerman, 2001). Since that period many theories about SRL have been developed, varying from cognitive strategy-oriented in the 1970, meta-cognitive oriented in the 1990’s to motivational and volitional oriented in the more recent period (Paris & Paris, 2001; Boekaerts & Corno, 2005). Recently, self-regulation is conceptualized generally as comprising three areas of psychological functioning: cognition, meta-cognition, and motivation/affect. Cognition pertains to the cognitive information-processing strategies that are applied to task performance, for example attention, rehearsal, elaboration. Meta-cognition regards to strategies to control and regulate cognition. Motivation and affect includes all motivational beliefs about oneself related to a task, for example self-efficacy beliefs, interest, or emotional reactions to oneself and the task (Boekaerts, 1999). Each of these components of SRL are necessary, but not sufficient for learning (Butler & Winne, 1995). According to Schraw, Crippen, and Hartley (2006), the role of metacognition is the most important, “because it enables individuals to monitor their current knowledge and skills levels, plan and allocate limited learning resources with optimal efficiency, and evaluate their current learning state” (p. 116). For this reason, I will in this paper mainly focus on metacognition. Metacognition is also referred to as ‘thinking about thinking’, or higher order thinking, involving active control over the cognitive processes that are engaged in learning (Newell, 1990). Generally, it is conceptualized as existing of different components. The most common distinction in components is the one between metacognitive knowledge and metacognitive skills (See also Veenman, van Hout-Wolters, & Afflerbach, 2006). Schraw, et al. (2006) calls the two main components respectively knowledge of cognition and regulation of cognition. Knowledge of cognition refers to the individual’s knowledge about ones own cognition. It includes three subcomponents: 1) declarative knowledge, referring
to knowledge about oneself as learner and about the factors that influences one’s performance; 2) procedural knowledge, referring to knowledge about strategies and procedures; 3) conditional knowledge, including knowledge of why and when to use a particular strategy. Regulation of cognition includes at least three main components, planning, monitoring and evaluation. Planning regards to goal setting, activating relevant prior knowledge, selecting appropriate strategies, and the allocation of resources. Monitoring includes the self-testing skills that are necessary to control learning. Evaluation refers to appraising the outcomes and (regulatory) processes of one’s learning.

In numerous studies has been established that SRL, and in particular metacognition has a significant impact on students’ academic performance, on top of IQ and/or prior achievement [See for example the review of Pressley & Harris (2006), Ponitz, Mc. Clelland et al. (2008), and the Handbook of metacognition in education (Hacker, Dunlosky, & Graesser, 2009)]. Veenman, Wilhelm and Beishuizen (2004) and Veenman and Spaans (cited in Veenman et al., 2006, p.6) found that metacognitive skills and intelligence are moderately correlated. On the average, intelligence uniquely accounts for 10 percent of variance in learning, metacognitive skills uniquely accounts for 17 percent of the variance, whereas both predictors together share another 20 percent of variance in learning for students of different ages and background, for different types of tasks, and for different domains. The implication is, according to Veenman et al. (2006) that an adequate level of metacognition may compensate for students’ cognitive limitations. So, additionally to the fact that SRL is an important new learning outcome, there is at least one other reason to include metacognition in educational effectiveness research. Metacognition is an important predictor at student level, independently from intelligence and prior achievement. The question, than, is whether metacognition is a cognitive aptitude that students develop – like intelligence – rather independently from education, or whether it could be trained or promoted by education, and if so to what extent and how?

2.3. Development of metacognition: the role of education

Veenman et al. (2006, p.8) state that up until recently there existed a general consensus that metacognition is a relatively late-developing capability, emerging at the age of 8-10 years, and quite rapidly expanding during the years thereafter, until around the age of 15. Moreover, certain metacognitive skills, like monitoring and evaluation, appear to mature later than others like for example planning. Whitebread, Coltman, et al. (2009) consider this as an increasingly untenable position. They argue that already very young children (younger than 6 years) may reveal elementary executive functions that are closely related to metacognition. Moreover, younger children can predict and evaluate more accurately their own performance than older children when the tasks are ecologically valid and meaningful to them. Younger children also can engage in strategic behaviours in the context of meaningful and age-related tasks. Veenman et al. (2006) concludes that it is most likely that metacognitive knowledge and skills already develop during pre-school and early-school years at a very basic level, but become more sophisticated and academically oriented whenever formal education requires the explicit utilization of a metacognitive repertoire. They also argue, referring to Alexander et al. (2006) and Veenman et al. (2004) that metacognition develops along a monotonic incremental line throughout the school years, parallel to the development of intellectual abilities. Furthermore, metacognitive skills seem to
initially develop in separate domains, and later on become generalized across domains (Veenman & Spaans, 2005). Most students develop metacognition spontaneously, picking it up from their parents, peers, and teachers, but there is considerable variation between students in their level of metacognition. However, a quite large group of students does not acquire a sufficient level of metacognition, due to a lack of opportunities, role models, or putting effort in it. There is also evidence that the acquirement and use of metacognition is dependent on gender and socio-economic background, in the advantage of females and students from culturally-rich environments (Leutwyler, 2009).

It is against this background that training and instruction for enhancing metacognition have become an important field of study over the last decade. However, the educational effectiveness paradigm has not yet been permeated into this field. With the exception of the study by Leutwyler and Maag Merki (2009) in secondary education, there are no empirical field studies that show whether schools or teacher differ with respect to the degree to which they foster students’ metacognitive knowledge and skills, and which factors at the school and teacher level are responsible for this difference (if any). Most of the studies in the field of metacognition and instruction deal with specifically designed programs for enhancing students’ self-regulated learning, including metacognition. The results of recent meta-analyses of these intervention studies have provided clear evidence that training students in SRL and in particular metacognition increases their academic achievement, with effect sizes higher than .50 (Dignath, & Buettner, 2008; Dignath, Buettner, & Langfeldt, 2008; Hattie, Biggs, & Purdie, 1996; Hattie, 2009). From these studies, we may conclude that metacognitive training could improve students’ academic outcomes, both in primary and in secondary education as well. Additionally, Dignath and Buettner (2008) and Dignath, et al. (2008) found that metacognitive training improves students’ metacognitive strategy use with effect sizes of .72 and .88 for primary and secondary education respectively. However, from their meta-analyses it remains unclear whether the same interventions produced substantial effect sizes for both academic achievement as well as metacognitive strategy use. Hattie et al. (1996) found that study skills interventions did not affect students’ study skills (effect size .16), but only their academic performance and motivation (effect sizes respectively .57 and .48). So, based on the results of meta-analyses it is still inconclusive whether metacognitive instruction indeed improves students’ metacognition, which in turn affects their academic performance. This is due to the fact that in general intervention studies report whether only product measures (i.e. the effects on learning outcomes), or only address process measures (i.e. the effects on metacognition). Until now, unfortunately, it is still impossible to establish causal relations between metacognitive instruction, (changes in) metacognitive knowledge and skills, and learning outcomes (Veenman et al, 2006). Nevertheless, we could learn from the meta-analyses which kind of – generic – metacognitive interventions are the most promising for at least improving students’ academic achievement, and possibly or by implication also their metacognitive knowledge and skills. However, the results of the meta-analyses showed that the effects of the interventions were much smaller when they were implemented by teachers in actual classrooms than when they were implemented by researchers. So, we have to be careful with conclusions about whether teachers actually could implement these interventions in educational practice.

2.4. Effective metacognitive interventions
From the literature three fundamental principles for successful metacognition instruction are known (Veenman et al., 2006). The first is embedding metacognitive instruction in the content matter to ensure connectivity. The effectiveness of this principle was empirically supported by the meta-analysis of Hattie et al. (1996). They found that training of metacognitive knowledge, skills and strategies that were situated in context, using tasks within the same domain as the target content, and promoting a high degree of learner activity and metacognitive awareness, was the most effective, not only for academic performance but for strategy use and affect and motivation as well.

The second principle is informing learners about the usefulness of metacognitive activities to make them exert the initial effort. Veenman, Kerseboom and Imthorn (2000) make a distinction between students suffering from either an availability or a production deficiency of metacognition. Students with an availability deficiency do not possess sufficient metacognitive knowledge and skills, and metacognition instruction have to start from the basic onwards. Students with a production deficiency possess the knowledge and skills already, but fail to use them. Instruction, then, could be limited to cueing metacognitive activities during task performance. Hattie et al. (1995) found that the effects of study skills training were higher for primary school students than for adolescents. This finding makes sense, because older students already possess certain skills, which are difficult to change into more appropriate ones, or which they do not use. In the meta-analysis by Dignath at al. (2008), the most effective interventions were those in which instruction of metacognitive strategies was combined with metacognitive reflection. Instruction of metacognitive strategies does not improve strategy use and learning outcomes per se. Supplementary components, like feedback about strategy use, providing knowledge about strategies and the benefit of using them, are needed to make self-regulated learning effective. Moreover, this is needed to maintain self-regulated learning over time, or stated in terms of the third principle, prolonged training is conditional to guarantee the smooth and maintained application of metacognitive activities. Also Butler & Winne (1995), Hattie and Timperley (2007) and Hattie (2009) emphasizes the importance of feedback in self-regulated learning. Important is that the kind of feedback is given at the appropriate level, which is at the self-regulation level including self-monitoring, directing and regulation of action. According to Hattie et al. (1996) “strategy training should be seen as a balanced system in which individual’s abilities, insights and sense of responsibility are brought into use, so that strategies that are appropriate to the task at hand can be used. The students will need to know what those strategies are, of course, and also the conditional knowledge that empowers them: the how, when, and why of their use” (p. 131). The implication is that effective strategy training becomes embedded in the teaching context itself (Hattie, ibidem, p. 131). However, little is known thus far about the role of the teacher as a model or about their skills for providing students with feedback at the self-regulatory and metacognitive level. Several studies found that in fact many teachers lack sufficient knowledge about metacognition (Veenman, 2006; Waytens, Lens, & Vandenberghe, 2002). All together, this paves the way for including metacognitive instruction factors in teacher effectiveness theory, research and professional development.

2.5. Some tentative implications for teacher effectiveness theory, research and practice
The description above about the state of the art considering the importance of students’ metacognitive knowledge, skills and strategy use for academic achievement, the role education could play in promoting metacognition, and the evidence-based knowledge about how metacognitive instruction could be effective implies the following:

a) Metacognition should be included as a separate outcome variable in teacher effectiveness models (e.g. the dynamic model of Creemers and Kyriakides) as the most important new learning outcome. It should be placed in the model as a mediating variable between student variables and quality of teaching variables on the one hand and other outcome variables (mainly the cognitive ones) on the other hand. The quality of teaching variables should be analyzed, in order to establish whether the elements of metacognitive strategy instruction are sufficiently included. In particular, the element of feedback at the appropriate levels needs further attention.

b) More empirical research is needed to investigate how teachers embed metacognitive instruction in their classes, and what the effects are on students’ metacognitive knowledge, skills and strategy use. Moreover, research should focus on differences in effective metacognitive instruction for students of different age, intelligence, background characteristics, etc. For doing so, development of instruments for measuring students’ metacognition is needed, as well as for measuring the factors at teacher level that cover the elements of metacognitive instruction.

c) Teachers should be trained in how to apply metacognition instruction. Teacher training should be accompanied with experimental research into the effects of training on 1) the improvement of teacher skills in metacognitive instruction, 2) students’ improvement of metacognitive strategy use, and 3) students’ improvement of academic performance on tasks for which the application of such skills are needed.
Section 3: Research on Learning (Daniel Muijs)

This section aims to start some discussion on the relationship between recent research in brain science and neuroscience and the field of teacher effectiveness. We will provide an overview of, in our opinion, the most salient findings from brain research to pedagogy and draw some conclusions regarding the field of teacher effectiveness that follow from these findings.

A range of theories of learning has developed over the past century. The most influential in terms of teaching practices have probably been behaviourism, which underlies a lot of the work on Direct Instruction, and constructivist theories such as those of Vygotsky (1978) and von Glasersfeld (1985) which have been influential in the development of more self-directed learning approaches. While influential, both theories have significant weaknesses and are increasingly being superceded by brain and neuro-scientific research (Muijs, 2008).

In recent decades, research methodologies in psychology have progressed significantly, leading to major breakthroughs in cognitive and brain science. Brain imaging methodologies have allowed experimental methods to be used to study the actual functioning of the brain in ways that was previously impossible. This is leading to important breakthroughs and insights into how children and adults learn, with potentially far-reaching consequences for teaching and education. This is not, of course, the same as saying that brain research and neuroscience lead directly to prescriptions for teaching. The laboratory setting and the usually limited scope of the studies, focussing on one particular process, mean that transferability to the classroom will always be difficult. Furthermore, interest in the field is primarily in uncovering fundamental tenets, rather than in classroom application. Also, this is still very much a developing field, so new findings are continuously emerging and may challenge what we think we know at present. Nevertheless, just as the older research on learning mentioned in part 1 of this paper had clear implications for practise, the same can be said to be true of the evolving fields of brain- and neuro science. What then can be said to be some key findings relevant to educational effectiveness? In our view, these relate primarily to

1. The role and functioning of memory
2. The modular and pattern making role of the brain
3. The role of emotional components of learning.

We will discuss these below.

First, though, it is important to establish exactly what is meant by learning according to the brain science. In contrast to many more philosophically oriented positions, the definition of learning in brain science is straightforward: Learning occurs when the synaptic potential of a neuron is permanently changed, or, in other words, when a neuron becomes more likely to transmit an electric current or potential (Shell et al, 2010). The brain is then essentially an information processor, designed to take in and process stimuli to allow action on the external world in the form of motor functions. An important element here is that activity in itself is important here. The more a neuron fires, the more it is enabled to fire again. Activity can therefore occur because other neurons have fired at it or because the internal capacities of the neuron have changed. If not used, neurons eventually die. Patterns are formed
through connections between neurons. Learning leads to structural changes in the brain. Imaging methodologies appear to show that the acquisition of a great amount of highly abstract information may be related to a particular pattern of structural gray matter changes in particular brain areas (Draganski, 2006).

3.1. The role and functioning of memory

Especially important in brain theory is the role of memory in learning processes. The memory consists of three parts: the sensory buffer, the working memory and the long-term memory.

The memory works as follows: one’s experiences (tactile, visual or auditory) are registered in the sensory buffer, and then converted into the form in which they are employed in the working and long-term memories. The sensory buffer can register a lot of information, but can only hold it briefly. Some parts of the information in it will be lost, other parts will be transmitted to the working memory. The working memory is where ‘thinking gets done’. It receives its content from the sensory buffer and the long-term memory but has a limited capacity for storing information, a fact that limits human mental processes. The working memory contains the information that is actively being used at any one time (Muijs, 2010).

![Figure 1 The structure of memory](image)

Figure 1 The structure of memory

The long-term memory has a nodal structure, and consists of neural network representations, whose nodes represent chunks in memory and whose links represent connections between those chunks. As such, nodes can be equated with concepts, and links with meaningful associations between concepts. Together these form schemata, or clusters of information. Activating one item of the cluster is likely to activate all of them (Best 1999). This means that memorization and making connections are two crucial components of learning, according to cognitive information processing theory. Making connections is particularly important. The
Brain has literally millions of neurons that can be linked in neural nets in an almost unlimited number of ways.

These structural characteristics of the brain have some important pedagogical consequences. In particular, if working memory is where information processing happens, the limitations of working memory are of great importance to learning. This, indeed, is the basic thesis of the so-called cognitive load theory, which suggests that the limited capacity of the working memory places a limit on the amount of information that can be processed at any one time. These limitations only apply to new information that has not been stored in long-term memory. This type of information can only be stored for a short period of time. This is not the case for information from the long-term memory, which can be retrieved for an indefinite time and in large quantities. Thus, it is important that learning tasks do not overload working memory, something that is often a problem with individual and discovery learning approaches (Kirschner et al, 2006). Rather, a structured approach, akin to mastery learning, or an approach whereby cognitive load is limited through collaborative group work (with different pupils taking on different parts of the load) are more appropriate, and may account for the lack of effectiveness of discovery oriented approaches among pupils with lower levels of competence or prior knowledge (the latter often coming from social capital in the home) as found in a lot of effective teaching research (Muijs & Reynolds, 2010). The capacity of the short-term memory is itself not independent from the long-term memory. The more information about a specific area or skill that is contained in the long-term memory, the easier it will be for the working memory to retrieve the necessary information for quick processing. The capacity of the working memory is influenced by the extent and speed with which prior knowledge (in the broad terms defined here) can be accessed. The capacity of the working memory is therefore part-determined by extent of prior knowledge, as well as the extent to which prior knowledge is organised in a way that makes it easily accessible. This capacity is open to change, and practise and learning can increase capacity, which in turn is linked to achievement in maths and reading (little research exists on other subject areas) (Molfese et al, 2010). Of course, this potential for change means that popular sayings on actual number of chunks of information that can be processed are not very helpful. This is linked to the importance of inhibitory control, the extent to which children are able to filter distracting and irrelevant information.

One lesson here is that in terms of psychological assessment more attention may need to be paid to testing working memory and inhibitory control at an early age so as not to misdiagnose learning problems and be better able to tailor instruction, as, while standardised instruments have been developed, they are not yet widely used in education. Training tasks using attention control and error correction have been found to have a positive effect on both inhibitory control and working memory (Dowsett & Livesey, 2000).

3.2. The modular and pattern making role of the brain

A second key finding from brain research refers to the importance of both specialisation and networking in the brain.
An interesting finding concerns the modular nature of the brain. This means that brain functions are made up of small subsystems (modules) that can perform specific functions independently. This is particularly useful as it allows some compartmentalisation, which reduces the interdependence of components, and leads to greater robustness. For example, the hippocampus, a structure located within the medial temporal lobe of the brain and long associated with memory function, appears to be critical for everyday episodic memory (our record of personal events), but is not necessary for semantic memory (our lifetime accumulation of universal factual knowledge) (Eichenbaum, 1997).

This modular organisation of the brain also allows flexibility, that allows the brain to adapt existing brain functions to new situations and learning (Bassett et al, 2010). This flexibility and modularity is implicated in the effectiveness of learning, as, according to Bassett et al (2010) flexibility of a participant in one session could be used as a predictor of the amount of learning in the following session. This flexibility and plasticity of the brain has important consequences for teaching, in that it clearly implies that there is not one single ‘pathway to learning’. Rather, the brain grows and reconfigures according to different stimuli presented. In other words, views of learning as determined by fixed learning ‘styles’ receive little support from brain architecture, and in all likelihood each individual will be able to learn in several different ways.

However, as well as being modular, the brain is importantly also a pattern-making network. Different parts of the brain work together to develop learning. Vargha-Kadem et al (1997) demonstrated this by using imaging research to study the ways different parts of the brain interact in information processing. These studies have shown that complementary memory functions in which representations are formed in the cerebral cortex are then bound together into semantic associations by the parahippocampal region, and then further processed by the hippocampus to add contextually rich episodic or spatial information. Cortical areas, including those in the parahippocampal region, encode specific memory cues and can sustain and regenerate these item-specific representations. By contrast, the activity of hippocampal neurons reflects myriad combinations of items or abstract relations between stimuli (Eichenbaum, 1997). Therefore, specialisation and modularity are combined with networking and interrelationships between different parts of the brain.
What Brain research is therefore telling us that the brain is a pattern maker. The brain takes information and orders it. The implications for learning and instruction are that supportive of connectionist views of learning and teaching (Askew et al, 1997). Connecting existing knowledge to prior learning will help pattern-making, and will also ensure that the high capacity of the long-term memory is used.

3.3. Emotional components of learning

The final critical finding from recent brain research relates to the importance of emotion in learning. Emotions can both help and hinder learning. On the positive side, emotions help us to recall information from the long-term memory, through allowing any information received through the sensory buffer to be perceived as positive or a threat. Research suggests that the brain learns best when confronted with a balance between high challenge and low threat. The brain needs some challenge to activate emotions and learning. This is because if there is no stress the brain becomes too relaxed and cannot actively engage in learning. Too much stress is also negative, however, as it will lead to anxiety and a ‘fight’ response which are inimical to learning. A physically safe environment is particularly important in reducing overly strong levels of stress (Sousa 1998). Stress, particularly chronic stress, undermines learning by impairing students’ ability to concentrate. Students functioning in a more relaxed environment, who feel less overwhelmed, have better brain function (Dias-Ferreira et al., 2009). One recent study (Liston et al., 2009) compared how highly stressed and relatively nonstressed medical students performed on tasks that required that they shift their attention from one visual stimulus to another. Their results showed that the extremely stressed students scored lower on tests and had reduced processing in certain brain regions, implying that chronic stress disrupts the brain’s ability to shift attention, a function certainly necessary for classroom learning (Carew & Magsamen, 2010). All of this has clear implications for classroom climate.

An interesting finding comes from a recent study relating activation of different parts of the brain by high and low competence individuals when given norm- or criterion references feedback on a task. Interestingly, criterion referenced feedback was associated with activation of those parts of the brain associated with negative affect among the high competence subjects, while norm-referenced feedback was associated with activation of these same brain regions among low competence subjects. Norm-referenced feedback was also associated with greater activation of brain regions associated with attention among high competence individuals. This suggests that they find information from this type of feedback to be more informative than that from criterion-references feedback (Kim et al, 2010). These results, while being as they are from one relatively small scale study are not definitive, do suggest that more research may be needed on the impact of feedback on different types of student, as the strong move towards promoting criterion referenced forms of feedback may lack attention to differential effectiveness.
3.4. Conclusion

There has historically always been a relationship between research on learning and classroom practices. Behaviourism was clearly influential in the formation of Direct Instruction models, while the work of Piaget and Vygotsky clearly influenced the constructivist movement in teaching. There has, however, never been a simple one-way relationship between learning theory and teaching practice. Pedagogy and educational research have always been needed to mediate the findings of psychological learning research. The effective teaching research of the 1970’s and beyond (e.g Brophy & Good, 1978) clearly adapted and strengthened behaviouristically oriented methods for the classroom. More recently, the development of brain science has shown a lot of promise and is significantly enlightening our knowledge of individual learning. However, as before, a simple translation of this research into classroom practice is not a given.

As Fischer et al (2007, p1) point out “There can be no direct transfer of insights from neuroscience and genetics to classroom practice, but only transfer mediated through a joining of practice with research.” This in part implies a new role for educational effectiveness research, in helping develop and empirically testing classroom practices that appear to be congruent with brain science, thus fulfilling the key translator role between the laboratory and systemic practice. The development of new studies of teacher effectiveness, in which insights from brain science are applied to the classroom and rigorously evaluated, would therefore form a useful new area of work for researchers in the field. The term rigorous is stressed here, as too often enthusiasts can take on new ideas without recognising the possibility that no effects may be shown and the need therefore to create robust evaluation methods. One example of how this might work is the use of small scale experiments within a single school context, that can then be expanded and tested in more diverse settings before any systematic roll-out is attempted. Control and experimental groups are formed and the outcomes compared in school. Small scale experimental work like this will allow innovations to be introduced and tested within a school context, before trying them out in other schools. In contrast to the model of national roll outs, this model allows each school to test innovations within its own context and with its own staff, putting educational innovations simultaneously on a sounder and more contextual footing. Designs whereby factors such as social background are controlled for can easily be built into these models, ensuring that equity is taken into account and impact on equity actually measured rather than going for the usual impressionistic statements that constitute so much of current evaluation. In that way we can genuinely assess at the outset the equity impact of educational innovations rather than waiting until national roll outs or relying on often politicised opinions to inform this process, and include effectiveness as a key element of innovation. Taking a more experimental approach towards innovation could also help alleviate the problem of waste which is endemic in education, as money is spent on large scale programmes that have no serious scientific basis and no evidence of impact on students.

Current research is already suggestive of the importance of certain practices, such as structured instruction that does not overburden the working memory, the plasticity and flexibility of the brain and the need for more sophisticated diagnostics. In future, brain research may change and overturn a number of the assumptions made here. In all cases, however, it is important to develop a dialogue with this evolving science, while endeavouring to test, rather than just accept, its validity in the classroom.
Section 4: Professional Learning (Helen Timperley and Lorna Earl)

This paper is based largely on the work of Helen Timperley and her colleagues in New Zealand. Over the past 10 years, they have been involved in a series of research projects trying to understanding how teachers learn and why some approaches to professional learning might be better than others. One element of that work was a synthesis of the empirical literature about the kinds of professional learning and development associated with positive outcomes for students’ engagement, learning and well-being.

4.1. Professional Development and Professional Learning Research

Every day teachers and school leaders face new challenges - introducing new curricula, assessment approaches and technologies into their classrooms and schools; serving students who do not respond to instructional practices in familiar ways; ensuring literacy and numeracy for all, and the list goes on. Raising the bar and closing the gap has become a mantra in many countries with teacher professional learning the multi-million dollar solution. Policy directives and billions of dollars, pounds, euros, etc, are being directed into professional development for teachers, with the expectation that this combination will make schools better and improve student learning.

Unfortunately, much of this investment has failed to meet its goals, particularly with respect to improving student learning and engagement. Eric Hanushek from the International Academy of Education and International Institute for Educational Planning in UNESCO, for example, highlighted the importance of teacher quality while, at the same time, rejected professional development as a key policy lever because despite some success in general they [professional development programmes] have been disappointing.

In recent years, there has been questions about the effectiveness and quality of many professional development processes and whether there is a school culture that supports and values teachers’ professional learning, as well as considerable research about the kind of professional learning that is most effective in deepening and enhancing teachers’ practices.

4.2. Professional Learning and Professional Development: Best Evidence Synthesis

A recent major report from New Zealand has gone deeper and been more focused on identifying the characteristics associated with professional learning for teachers that is empirically linked to student outcomes. This document: Teacher Professional Learning and Development: A Best Evidence Synthesis written by Helen Timperley and colleagues consolidates the international evidence about how to promote teacher learning in ways that impact on outcomes for the diversity of students in our classrooms. The authors of this synthesis developed a theoretical framework.
comprising 84 different characteristics of the professional learning environment likely to impact on student outcomes and analysed studies to identify the characteristics of professional learning that were associated with outcomes for students for teachers who have received at least some initial teacher education and who are in the process of deepening their knowledge and refining their skills (detailed in the following graphic).

In a paper for the International Academy of Education, Timperley provides a summary of this major study that identifies 10 key principles related to teacher professional learning and development that have demonstrated positive impact on valued student outcomes.

**Principles of Teacher Professional Learning and Development with Demonstrated Positive Impact on Valued Student Outcomes**

<table>
<thead>
<tr>
<th>Principles</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Focus on valued student outcomes (P1)</td>
<td>Professional learning experiences that focus on links between particular teaching activities and valued student outcomes are associated with positive impacts on those outcomes.</td>
</tr>
<tr>
<td>Worthwhile content (P2)</td>
<td>The knowledge and skills developed are those that have been established as effective in achieving valued student outcomes.</td>
</tr>
<tr>
<td>Integration of knowledge and skills (P3)</td>
<td>The integration of essential teacher knowledge and skills promotes deep teacher learning and effective changes in practice.</td>
</tr>
<tr>
<td>Assessment for professional inquiry (P4)</td>
<td>Information about what students need to know and do is used to identify what teachers need to know and do.</td>
</tr>
<tr>
<td>Multiple opportunities to learn and apply (P5)</td>
<td>To make significant changes to their practice, teachers need multiple opportunities to learn new information and understand its implications for practice. Furthermore, they need to encounter these opportunities in environments where there are both trust and challenge.</td>
</tr>
<tr>
<td>Approaches responsive to learning processes (P6)</td>
<td>The promotion of professional learning requires different approaches depending on whether new ideas are, or are not, consistent with the assumptions that currently underpin practice.</td>
</tr>
<tr>
<td>Opportunities to process new learning with others (P7)</td>
<td>Collegial interaction that is focused on student outcomes can help teachers integrate new learning into existing practice.</td>
</tr>
<tr>
<td>Knowledgeable expertise (P8)</td>
<td>Expertise external to the group of participating teachers is necessary to challenge existing assumptions and develop the kinds of new knowledge and skills associated with positive outcomes for students.</td>
</tr>
<tr>
<td>Active leadership (P9)</td>
<td>Designated educational leaders have a key role in developing expectations for improved students outcomes and organizing and promoting engagement in professional learning opportunities.</td>
</tr>
</tbody>
</table>
Maintaining momentum (P10)  |  Sustained improvement in student outcomes requires that teachers have sound theoretical knowledge, evidence-informed inquiry skills, and supportive organizational conditions.

4.3. *Professional Learning as a Cycle of Inquiry*

Finally, the synthesis offers a cycle of inquiry that can provide a model for using the findings in practice not only to facilitate deep professional learning that changes practice and student outcomes, but also provides a framework for evaluating professional learning approaches. As a culmination of the learning from the Best Evidence Synthesis, Timperley and colleagues describe an inquiry cycle (Figure 1) that moves from professional development as events to professional learning where teachers engage in an extended collaborative inquiry based on the particular needs of their students.
What knowledge and skills do our students need to meet important goals?

What knowledge and skills do we as professionals need to meet the needs of our students?

What has been the impact of our changed actions on outcomes we value for our students?

Deepen professional knowledge and refine professional skills

Engage students in new learning experiences

Figure 1
Teacher inquiry and knowledge-building cycle to promote important outcomes for students

This cycle starts with teachers investigating what students need to know and do to meet goals valued by the communities in which they live and are educated. Students’ engagement, learning and well-being are the touchstone. When teachers have a deep understanding of the profiles of their students, they then move to
inquire about what knowledge and skills they need if they are to be more effective in addressing the needs of individuals and groups of students, particularly those not achieving as well as others. From there, teachers engage in new professional learning to intentionally deepen their knowledge and refine their professional skills in the focus areas. This new professional learning frames the kinds of new learning experiences that they can bring to their students. But that’s not the end. Given that the effectiveness of all teaching practice is influenced by context and no particular practices can be guaranteed to result in particular outcomes, the final stage of the inquiry involves examining the impact of changed actions on the outcomes for the students who were the focus of the inquiry. The purpose is to understand what has been effective and what has not. The findings from this examination then lead to another, and usually deeper, cycle of inquiry and knowledge-building. In Figure 1, the inquiry questions are in the rounded boxes with the actions often associated with more traditional approaches to professional development identified in the rectangular boxes.

Through engaging in ongoing cycles of inquiry and building knowledge, teachers develop the adaptive expertise required to retrieve, organise and apply professional knowledge when old problems persist or new problems arise. Adaptive expertise can be best understood by contrasting it with routine expertise. Both kinds assume teachers learn throughout their lifetimes. Routine experts learn how to apply a core set of skills with greater fluency and efficiency. Adaptive experts, on the other hand, continually expand the breadth and depth of their expertise and are tuned into situations in which their skills are inadequate. Teachers with adaptive expertise, therefore, have the capability to identify when known routines don’t work and to seek new information about different approaches when needed.

4.4. Shifts in Thinking

In a book that will be published soon, Timperley identifies a number of shifts in thinking that are necessary for teachers’ professional learning to be effective.

From Professional Development to Professional Learning
The first shift is a move from thinking in terms of professional development to thinking in terms of professional learning. Both are intentional, ongoing, systematic processes. Over time, however, the term “professional development” has taken on connotations of delivery of some kind of information to teachers in order to influence their practice. Professional learning implies an internal process in which individuals create professional knowledge through interaction with this information in a way that challenges previous assumptions and creates new meanings. Professional learning requires teachers to be seriously engaged in their learning whereas professional development is merely participation.

Focus on Students
The second important shift in thinking about professional learning is the centrality of students to the process. Improvements in student learning and well-being are not a by-product of professional learning but should be its central purpose. Student engagement, learning and well-being should be the reason for teachers to engage in professional learning, the basis for understanding what needs to change, and the criteria for deciding whether those changes have been effective.
From Forms of Delivery to Knowledge and Skills
The third shift in thinking involves foregrounding the knowledge and skills that underpin the changes, rather than forms or delivery methods of professional learning. All too often professional development focuses on activities (e.g. PLCs, coaching, professional readings, reflection and inquiry), not content. It is also important to have the right content. The knowledge and skills that form the focus of professional learning can be too broad (often defined by experts and not necessarily specific to the immediate demands of classroom teaching and learning) or too specific (practical suggestions to solve the immediate concerns of this teacher without wider reference to theory or principle underlying these suggestions). Neither forms of knowledge are particularly helpful in bringing about sustained improvements in teaching and learning. The knowledge and skills developed through professional learning must meet the double-demand of being both practical and understood in principled ways that can be used to solve teaching and learning challenges encountered in the future.

Professional Learning as Collaborative Inquiry
The fourth shift in thinking is about the nature of professional learning that makes a difference. Effective professional learning happens when teachers frame their own learning by identifying goals for both themselves and their students; creating partnerships with those with expertise to ensure their learning is focused and likely to achieve the desired goals; working together to investigate, challenge and extend their current views; and then generating information about the progress they are making so that they can monitor and adjust their learning. Ongoing collaborative inquiry and learning becomes central to teachers’ images of being professional and through this process teachers become self-regulated learners. In fact, the process of inquiry in teacher learning is similar to the assessment as learning process for students.

Collaborative inquiry is much more than having time to reflect together about their practice. Most teachers reflect daily on their practice as they go about their work. Collaborative inquiry is a systematic process for learning in which a group works together in repeated episodes of reflection and action to examine and learn about an issue that is of importance to them. Engaging in collaborative inquiry allows educators to work together searching for and considering various sources of knowledge (both explicit and tacit) in order to investigate practices and ideas through a number of lenses, to put forward hypotheses, to challenge beliefs, and to pose more questions. It is the foundation of conceptual change as individuals come across new ideas or discover that ideas that they believe to be true don’t hold up when under scrutiny. When teachers engage in this kind of progressive inquiry, they move far beyond story swapping to constructing new knowledge through solving problems of understanding.

Professional Learning At All Levels
The final shift directs attention to those who support teacher learning within schools or outside of them. Teachers can’t solve entrenched problems within our education system alone so everyone who has a place in the chain of influence from policy to practice needs to engage in inquiry and knowledge building cycles to ensure their efforts are effective in developing the kind of professional and student learning that makes a difference. Just like teachers, facilitators of professional learning and school leaders need to engage in ongoing inquiry into the impact of their policies and
practices. This impact isn’t always positive. An important question for all to ask, for example, is whether their approaches to promoting professional learning are consistent with a defensible theory of professionalism. Is the rhetoric about developing motivated professionals who can make informed decisions about their practice based on deep knowledge, then contradicted by approaches to professional learning that involve brief workshops about how to teach something? Michael Fullan suggests that successful problem-solving requires the whole system to be involved in co-dependent partnerships. The research I have undertaken suggests that nowhere is this more important than in the area of professional learning. Successful problem-solving involves a process of learning both up and down the system layers.

4.5. Summary

We began this paper by pointing out that professional development often does not make a difference to student outcomes. Recent work shows that when professional development becomes professional learning, new learning on the part of teachers can make a substantial difference in student outcomes but it is not easy. Making significant changes in practice requires intensive and challenging professional learning experiences that not only extend teachers’ repertoire of strategies and approaches, but also engage them in activities and dialogue that allows them to examine their existing beliefs in order to identify the difference between the beliefs they hold and the beliefs underpinning the new ideas.
Concluding remarks

In this set of papers we have attempted to give a flavour of some of the latest developments in research on teaching, learning, metacognition and professional development, with a view towards sparking debate and thought about the future of research and practise in teacher effectiveness. As we have seen, significant development is taking place in the development of integrated models, such as the Dynamic Model of Educational Effectiveness, that aim to incorporate research and practise while focussing on a range of outcomes, including metacognition. This search for integration has clear advantages in the light of the complexities of the processes involved.

We see these papers as an invitation to dialogue, and as a further move towards the field developing by building cumulatively on existing knowledge and theory rather than constantly attempting to reinvent the wheel. Only by doing this will we be able to develop a realistic understanding of teaching, and take our place on the table as a mature field of social scientific enquiry.
References

Section 1


**Section 2**


**Section 3**


Carew, J. & Magsamen, T. (2010). *Neuroscience and Education: An Ideal Partnership*


Section 4

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