Literature Review: Deep learning with technology in 14- to 19-year-old learners  
Ian Abbott, Andy Townsend, Sue Johnston-Wilder, Lynn Reynolds  
  
Institute of Education, University of Warwick

Table of contents

[14-19 developments 3](#_Toc243985273)

[Deep learning 4](#_Toc243985274)

[Deep learning versus surface learning 5](#_Toc243985275)

[Components of deep learning environments 6](#_Toc243985276)

[Developing a powerful learning environment 6](#_Toc243985277)

[The learning career 7](#_Toc243985278)

[Learning outcomes and assessment 7](#_Toc243985279)

[Supporting the ‘learning to learn’ approach 9](#_Toc243985280)

[Including learners in the process 11](#_Toc243985281)

[Quantifying deep learning in the formal learning environment 14](#_Toc243985282)

[The potential enhancement of deep learning using ICT 16](#_Toc243985283)

[Precursors to deep learning with ICT 17](#_Toc243985284)

[Components of deep learning in an ICT- rich environment 20](#_Toc243985285)

[Other influences on deep learning 23](#_Toc243985286)

[Learning platforms 23](#_Toc243985287)

[Animation 25](#_Toc243985288)

[Games 26](#_Toc243985289)

[ICT and subject sub-cultures 27](#_Toc243985290)

[Other Considerations 29](#_Toc243985291)

[Conclusion 31](#_Toc243985292)

[References 33](#_Toc243985293)

14-19 developments

Over a number of years there has been ongoing reform of 14-19 education and training in England, in an attempt to address some long-standing and interrelated problems (Jephcote and Abbott 2005). The White Paper, ‘14-19 Education and Skills’, sets out what it describes as a ‘once in a generation opportunity’ to transform secondary and post-compulsory education (DfES 2005, p10). The reform process in England is part of a European-wide reform of education and training aimed at better preparing young people for the future (Leney 2003). The need to raise educational standards has been at the core of government policy and allied to this is the drive to improve skills to make the UK a global leader by 2020 (Leitch 2006).

The most recent reforms have been wide-ranging and aim to “transform the delivery of learning from Key Stage 4 onwards. They reflect key priorities from the National Strategies, the Five-year Strategy for Children and Learners, Every Child Matters, the Framework for Achievement and the UK Skills Agenda. All types of education providers working with 14- to 19-year-olds will be expected to engage with the reforms. Some of the explicit aims of the reforms are to:

* provide broad, balanced and flexible curricula
* encourage attainment and retention at age 16
* offer a wide range of assessment levels to promote inclusion
* improve core skills for employability
* close the gap between vocational and academic provision

promote partnership working across providers (Becta 2008a).

A range of new initiatives has been developed with the introduction of specialised Diplomas in 2008 followed by the extension of these programmes until 2013. The Diplomas will enable learners to benefit from:

* rich and varied learning environments that engage learners in authentic tasks
* different ways of learning, including ‘learning by doing’, use of new technologies and collaborative, problem-based approaches, that meet affective as well as cognitive needs
* playing a central role in planning and reviewing their own learning to meet their interests and needs
* interactions with a variety of others, particularly those with experience of working in relevant sectors or contexts

assessment for learning and development of metacognitive capabilities, such as reflection, that promote deeper learning and the making of connections between contexts and subjects. (Cited from QCDA 2008, p3)

Deep learning

The term ‘deep learning’ has become widely accepted as a key concept in the transformation and personalisation of the learning process. How we prepare young people for life, leisure and work today is a question that employers, governments, parents, educators and young people themselves are asking in response to the changing landscape of the 21st century. The curriculum is evolving rapidly to address the needs of young people with changes to teaching, learning and assessment. Central to this is the changing role of the learner who is no longer the passive recipient of knowledge, but an active part of every facet of the change process, from design to implementation.

A deep learner is thought to be one who approaches knowledge and learning by relating new knowledge to previous knowledge. This is described as ‘knowledge transformation’ by Entwistle (2000). A deep learner also relates theoretical ideas to everyday experience; distinguishes between evidence and argument; organises and structures content into a coherent whole; interrelates knowledge from different sources; and is self-motivated (Atherton 2005). These attributes are highly desirable as they describe the flexible and independent learner who will succeed in a changing society.

A clear understanding of deep learning is needed to explore the possible benefits to the learner and to the wider community. Although there is no single specific definition, Simms (2006) gives the following criterion: “Deep learning is secured when, through personalisation, the conditions for student learning are transformed.”

This is useful as it highlights the importance of the conditions for deep learning and its close association with personalisation. The emergence of the term personalisation reflects the shift towards a much more learner-centred and inclusive education system. The focus on the individual found in deep learning makes this a potential source of personalisation.

Simms (2006) also gives a description of a learner engaged in deep learning: “An articulate, autonomous but collaborative learner, with high metacognitive control and the generic skills of learning, gained through engaging educational experiences with enriched opportunities and challenges, and supported by various people, materials and ICT linked to general well-being but crucially focused on learning, in schools whose culture and structures sustain the continuous co-construction of education through shared leadership.”

A similar description has been provided by the QCDA (2008). This describes a learner engaged in the new Diplomas: “A connective approach urges the importance for the learner of ‘putting together learning from different contexts to increase their versatility.’ The Diploma offers a range of sites for learning, including the workplace and virtual learning environments. This makes possible an exploration of the different cultures and practices embodied in any one line of learning, as well as customisation at a local level. Each site has potential for ‘three dimensions of learning: content (knowledge, understanding and skills), incentive (motivation, emotion and volition) and interaction (action, communication and cooperation), set within a wider societal context (Illeris 2007).’”

Deep learning versus surface learning

Understanding of deep and surface approaches to learning was derived from original empirical research by Marton and Säljö (1976) and since elaborated by, among others, Entwistle (1981), Ramsden (1992) and Biggs (1987,1993). Research on student learning has shown contrasting intentions and processes associated with both types of learning. Deep learning is characterised by the focus on the learner having the intention to gain a thorough understanding. To reach their own understanding, students tend to make connections with previous knowledge and examine evidence (Entwistle 2000).

An association may be made here with constructivist theories of learning, Vygotsky in particular, who believed that learning was a process that involved interaction with others. Interaction with others supports scaffolding through the zone of proximal development, which is the gap between what learners can do alone and what they can do with the support of someone more knowledgeable than themselves (Mujis 2007). With the correct support/scaffolding, learners will begin to recognise that learning is more rewarding when they seek personal meaning by transforming information and ideas in terms of their own previous knowledge and experience.

In contrast, the intention for surface learning is to cope with course requirements. There is an emphasis on rote learning and a lack of reflection or understanding as to the purpose of the study (Simms 2006). Typically, learners who use surface learning are unable to transfer knowledge to other situations and find it difficult to make sense of novel ideas. These are broad categories, and it is important to remember that they do not address the complexity of individual ways of studying (McCune 1998). Learners will use a combination of these strategies depending on the nature of the task. In relation to everyday studying, a third dimension has been identified – the strategic approach. This describes the intention to get the highest possible grades through effort and well-organised study (Au and Entwistle 1999).

The understanding that learners have of assessment will determine which mode of study they adopt. Interesting research has looked at ‘the paradox of the Chinese learner’. Chinese students are known to be prone to the use of rote memorisation and are more passive and less interactive than most students. However, they achieve well academically. They also have higher deep and strategic scores than their western counterparts (Biggs 1987). Research illustrates that Chinese students associate memorisation with understanding, as it makes memorisation a more efficient process for examination purposes (Au and Entwistle 1999). The significance of this is two-fold. Firstly, it highlights how assessment will affect the mode of learning. Secondly, it highlights the cultural differences that must be considered if deep learning is to be encouraged through personalisation in a society that is culturally diverse.

Components of deep learning environments

Implicit in the concept of deep learning is that it must be an active process where learners are searching for patterns and principles while using evidence and logic (Entwistle 2000). This is similar to the vision of the effective learner described in the DfES Pedagogy and Practice publication, Developing Effective Learners, (DfES 2004a). Effective learners will also work collaboratively, make connections with other work and be able to evaluate their own progress. According to Bloom’s taxonomy (1956), these are cognitively demanding expectations, and clearly learners need appropriate support. Thus, the nature of the learning environment is significant in encouraging the process of deep learning as well as in personalising the learner’s educational experience.

Developing a powerful learning environment

Teaching and learning models are key to developing a powerful learning environment. The nature of the learning objective and assessment of the needs of the learners will determine the choice of teaching and learning model. The use of a range of models from direct interactive teaching to group problem solving, for example, is essential for personalisation. This will create a coherent learning environment, where young people experience a range of approaches that enable them to increase their competence as self-motivated learners (DfES 2007). Coffield (2008) argues that “we must take account of the whole teaching-learning environment”. The term ‘powerful learning environment’ has been used to describe an environment that seeks to develop complex and higher order cognitive skills, deeper conceptual understanding and metacognitive skills such as the ability to self-regulate one’s own learning (Van Merrienboer and Paas 2003).

Other key questions that must be asked to determine if a learning environment is powerful include:

* Are thinking, learning, collaboration and regulation skills being taught?
* Is there a shift to more experiential, active, cumulative, constructive, goal-directed and reflective learning?

Is there a shift towards independent learning? (Simons and Bolhuis 2004)

Higher order cognitive skills are of particular interest in the 14-19 age group, where there is a growing emphasis on lifelong learning to give young people the necessary skills to strive in a changing society. The key element would appear to be the quality of the tasks that young people are asked to undertake, thus the emphasis on personalisation and the interest in how digital technology might enhance this experience.

The learning career

The individual nature of a young person’s journey through the education system has been described as a ‘learning career’ (Bloomer 1997). This includes the changes in a student’s attitudes towards knowledge and learning across time as well as their perception of the opportunities that have been made available to them. The research project, Transforming Learning Cultures in further education (TLC), has carried out a large study of teaching and learning in the further education sector (see James and Biesta 2007). TLC has developed two connected ideas: a theory of learning cultures and a cultural theory of learning (see, for example, Hodkinson et al 2007). Learning cultures, according to the TLC project, are “social practices through which tutors and students learn and not the contexts or environments in which they learn” (Coffield 2008 p16). The main issue is “how different learning cultures enable or disable different learning possibilities, for the people that come into contact with them” (James and Biesta 2007 p28). The cultural theory of learning attempts to explain the relationship between individual learners and their learning culture. In particular, learning culture is seen as something practical and significant in developing attitudes to study.

Learning outcomes and assessment

Traditionally, learning outcomes describe acquisition of certain types of skills or knowledge. Because of the wide-ranging requirements that need to be met by the 14-19 age group, researchers have suggested that learning outcomes need to be made more general to describe the learning that occurs over the whole of this transitional phase (Davies et al 2006). Simons and Bolhuis (2004) identify a range of learning outcomes described by politicians, parents, teachers and businesses, which seem relevant to this phase and which help us unpack the idea of what deep understanding might look like. These learning outcomes should be durable, flexible, functional, meaningful, generalised and application-orientated.

Assessment procedures are likely to have a large impact on the learning career of an individual, as these clearly affect students’ perceptions of both themselves and what they are required to learn, as well as of the opportunities they might have. To fully utilise deep learning, assessment procedures must emphasise and reward personal understanding. This is dependent on a clear understanding of the outcomes of lessons − by teacher and learner. To support the use of learning outcomes to encourage deep learning, Entwistle suggests the following categories with increasing relevance to deep learning as we move down the list:

* **Mentioning** - incoherent bits of information without any obvious structure
* **Describing** - brief descriptions of topics derived mainly from material provided
* **Relating** - outline, personal explanations lacking detail or supporting argument
* **Explaining** - relevant evidence used to develop structured independent arguments

**Conceiving** - individual conceptions of topics developed through reflection.

Education for the14-19 age group has become increasingly flexible in an attempt to construct a number of different types of learning careers to suit many different learner needs and aspirations. However, it is claimed that these appear to be failing the learners with lower levels of academic achievement as well as those at the higher end (Davies 2006). Education policy affecting the 11-18 year age group addresses this issue by incorporating a more context-based approach. It places increased emphasis on the breadth of learning, for instance, in the case of the new Diplomas. Also, changes to the GCSE science curriculum (which took place in 2006) have incorporated the element, ‘How science works’. In this case, learners are expected to apply the information, rather than simply repeat facts. In essence, they are being asked to show a deeper understanding of the information (see Figure 1).

**Figure 1:** Requirements from the AQA science specification. The old specification is prior to 2006 when changes were implemented.

The old and the ………..……………………..new

Drugs change the chemical processes in people’s bodies so that they become dependent or addicted to them and suffer withdrawal symptoms without them.

Candidates should use their skills, knowledge and understanding of how science works: to evaluate the different types of drugs and why some people use illegal drugs for recreation; to evaluate claims made about the effect ofcannabis on health and the link between cannabis and addiction to hard drugs.

This shift is part of a larger movement away from target-driven teaching to a teaching and learning methodology that responds to the increasing importance placed on examination results as a way of judging the effectiveness of teachers and schools. Mistrano (2008) makes the useful point that it is reasonable to question how study skills and habits of students have developed alongside these changes. Research indicates a worrying trend identified by university admissions tutors, who report that students are leaving school with a lack of independent thought, fear of numbers and expectations to be told the answers. Other researchers have noted that the drive for better results has made “learners progressively more dependent on the teacher and less creative and less motivated” (Deakin Crick 2006).

Supporting the ‘learning to learn’ approach

This trend of expecting to be told the answers has been acknowledged and the move within education towards Assessment for Learning (AfL) is seen as a way of addressing this. AfL is based on the principle that learners will improve most if they understand the aim of their learning, where they are in relation to this aim and how they can achieve this aim (DCSF 2008). Largely the work of Black and William (1998), AfL has been identified as one of the key components of deep learning (Simms 2006). AfL involves handing over key elements of the learning environment to the learners, placing a large emphasis on the relationship between the practitioner and learner, and considering how to nurture the relationship through choice of language and written comments on assignments (DfES 2004b). To have meaningful discussions about the learning process and give constructive feedback, the teacher needs to understand and make decisions about the learning process that is taking place. Techniques such as modelling open-ended questions, formative assessment, models and peer- and self-assessment have shifted emphasis from teaching to learning.

Reflection on one’s own progress is an important part of AfL and lays the foundations for ‘learning to learn’. This component of deep learning encourages a focus on the learning process, rather than the content of a subject. Several programmes that concentrate on this area have become popular, such as Building Learning Power, which focuses on perseverance, curiosity, self-knowledge and collaboration. Designed by Guy Claxton, BLP focuses on raising achievement and improving behaviour through learning to learn. James et al (2007) provide a full account of the recent developments in enabling teachers and students to learn how to learn.

Changes to the secondary curriculum brought about by the Secondary Curriculum Review are supporting this strand of deep learning. To be a ‘successful learner’ is a specific curriculum aim (QCDA 2008). The changes to support this transformation include reorganisation of the curriculum with a much greater emphasis on cross-curricular activities. Themes will run through all subject areas that provide relevant learning contexts. Personal, learning and thinking skills (PLTs) will also be supported by these changes. The approaches to learning will be more varied, encompassing more learners, with specific mention of the need to ‘involve learners proactively in their own learning’ and through a personalised curriculum. The RSA Opening Minds curriculum is stimulating significant debate in schools and offers a flexible model that allows schools, teachers and students to engage with and shape the framework that they need (Futurelab 2007).

The research in this area has attempted to ascertain whether ‘learning’ and ‘learning to learn’ are separate processes that can be nurtured. The recent interest in learning to learn stems from an understanding that learning is a lifelong process, which is demonstrated when people change careers and face challenges. Although the scientific evidence to support these processes is unclear (Hargreaves 2004), the evidence on learning environments suggests that learning to learn is a process that enhances learning, motivation and self-confidence. The processes that schools and colleges use to encourage learning to learn often include activities that claim to be ‘brain-based’. However, there is little to justify these claims – often the “account is abstract, unspecific [and] jargon-ridden” (Hargreaves 2004).

One aspect of learning to learn on which both scientists and practitioners do agree is metacognition. This is the capacity to monitor, evaluate, control and change how one thinks and learns. It involves:

* understanding the demands the demands of learning
* knowing about intellectual processes and how they work
* generating and considering strategies to cope with the task
* getting better at choosing the strategies that are most appropriate for the task

monitoring and evaluating the subsequent learning behaviour through feedback on the extent to which the chosen strategies have led to success in the task.

As with deep learning, there has been some difficulty within the research community in coming to agreement on an exact definition of metacognition. This debate largely revolves around the nature of the relationship between metacognition and self-regulation (Dinsmore 2008). This is unfortunate, as this concept has the potential to add significantly to educational practice. Clarity is needed (Kaplan 2008). Metacognition is closely associated with self-regulation and self-regulated learning; all three share an underlying notion of a “marriage of self-awareness and intent to act” (Dinsmore 2008). The concept of self-regulation evolved from metacognition when Baker and Brown (1984) separated metacognition into knowledge about cognition and self-regulatory mechanisms for checking the outcome, planning, monitoring effectiveness, testing, revising and evaluating. Not only have these processes been shown to have significance in learning environments, but they also have been directly linked to the learning theories of Piaget and Vygotsky (Fox and Riconscente 2008). For Vygotsky, metacognition and self-regulation are completely intertwined; the intentionality implied by self-regulation requires consciousness and the control required for consciousness requires self-regulation. This may seem far removed from standard learning environments; however, as the focus shifts to learning and as more sophisticated cognitive tools are developed, these concepts become more significant.

Computers and technology-rich environments afford the learner richer opportunities for the type of interactions that would support metacognition, self-regulation and self-regulated learning (Lajoie 2005). The digital environment may stimulate the mind by scaffolding learning. Technology-rich environments can be designed with cognitive tools that model human behaviour or provide complex simulations that learners can attend to and learn from (Lajoie and Azevedo 2006).

Including learners in the process

Collaborative and team working are thought to support the learning experience. Self-regulation becomes co-regulation (though ultimately that will lead to further self-regulation), and communication moves beyond practitioner-learner to learner-learner (Lajoie 2008). The nature of the practitioner-learner relationship is also changing, and recent work has examined the usefulness of engaging with students as co-researchers to investigate AfL in the classroom (Leitch et al 2007). This work aimed to determine the potential for transformation and improvement of education through the active involvement of the learners and found that learners are capable of being ‘creative, participative and active agents’, all features of deep learning. Participation has also been highlighted as an important component of personalisation. Hargreaves (2004) states, “the student’s active participation…is enhanced because he/she is actively involved in the design of learning, teaching, assessment and the life of the school through processes of co-construction”.

Research from Futurelab (2007) suggests ways in which to include learners in curriculum design and assessment. It discusses the difficulty in separating pedagogy and assessment practices and stresses the importance of learner participation in these processes. This allows the “creation of assessment and accreditation practices which are seen as relevant and meaningful to young people and may increase motivation and engagement with learning”. Clearly, institutional and statutory measures would be required to give sufficient recognition to these suggestions (Futurelab 2007).

The active involvement of learners, often described as ‘learner voice’, is considered to be another component of deep learning (Simms 2006). This has often been seen as a tokenistic gesture, associated with activities such as having a student council. To be a part of deep learning, learner voice must involve a significant number of learners in significant areas, such as learners acting as co-researchers, as described above. Embedding learner voice changes the relationship between learners and practitioners, developing the learning community in subtle ways (Simms 2006). How can this be fostered in the learning environment? The increased emphasis on learner voice has led to an interest in understanding the conditions that allow for productive talk. Thompson (2007, p50) reported on a formative evaluation of classroom talk in primary schools, stating that “promoting classroom talk is worth the taking of risks because it empowers pupils and gives them responsibility for their own learning…Spoken interaction is fun and can make children feel valued, helping to rehearse and focus thinking and allowing opportunities to make mistakes in a safe environment, leading to an increase in confidence and self-esteem…Talk is a life skill.”

To encourage deep learning, a specific type of learner-learner dialogue is needed and must be actively encouraged. These may be referred to as learning conversations. The suggested features of learning conversations may be:

* **reciprocal** – where teachers and learners listen to each other, share ideas and consider alternative viewpoints
* **supportive** – allowing conversations to open up. This builds confidence and enables the facilitation of metacognitive control. The role of scaffolding in this process (Vygotsky, Bruner) has received little attention. It is important that practitioners and learners are speaking the same language.

**cumulative** – encouraging ongoing discussion between the learners and practitioners, with each new conversation being built on the last. Again, there is a link to scaffolding (Simms 2006).

Clearly, for learner voice to be fully realised, practitioners must be willing to listen and learn. Personalisation of the curriculum will be aided by a situation where “roles are blurred and overlapping: practitioners learn as well as teach” and education becomes ‘user-led’ (Hargreaves, 2004). McIntyre et al (2005) examined how teachers responded to advice from learners about classroom practice. When consulted, learners’ suggestions included the following ideas:

* interactive teaching for understanding (including the active involvement of learners)
* contextualising learning in appropriate ways
* fostering a stronger sense of agency and ownership

arranging social contexts amenable to collaborative learning.

The overlap with the key elements of deep learning in the children’s comments is striking. Teachers gave a mixture of responses to children’s ideas. These ranged from enthusiastic and impressed to defensive and suspicious. In one case, the teacher found her use of ICT to be unsuccessful as she consistently underestimated the pupils’ knowledge. Following their advice, she incorporated games that were more competitive and activities that involved pupils in talking with each other. Provision was also made for visual, spatial and active learning styles. Both changes brought increased success. The teachers who engaged enthusiastically in the consultation process with pupils generally found this to be a very useful process. They reported a sustained change in how they interacted with the children. However, the range of responses from teachers raises questions about the amount of support that teachers receive to implement and understand the changes they are asked to make in their learning environments. The availability of continuing professional development is crucial if the changes are to be sustainable and involve all practitioners.

Coffield (2008, p28) claims that learners should be consulted in the fullest sense because:

**Learner consultation**

**tends to**

**Improve tutors’ teaching**

through

tutors’ greater awareness of pupils’ capacity

+

gaining new perspectives on their teaching

+

renewed excitement about teaching

+

transformed pedagogic practices

**enhance learner commitment and capacity for learning**

through

strengthening self-esteem

+

enhancing attitudes to college and learning

+

developing stronger sense of membership

+

developing new skills for learning

and to

**Transform tutor-learner relationships from passive and oppositional to more active and collaborative**

**and so is very likely to:**

**Improve learning**

Source: adapted from Ruddock and McIntyre (2007:152)

Other work supports the notion that learners are driven by personal communication and peer group interests. Brady (2007) found that young children learning ICT skills were motivated to acquire non-technological objectives such as the above; thus, training should be based on its relevance to the children at the time. Facer et al (2001) support this by suggesting that it is important to challenge dominant constructions of ‘valuable’ ICT skills and work with young people to develop their vision of an information society.

Quantifying deep learning in the formal learning environment

How much deep learning is happening now in the lecture room/classroom? Certainly, the changes to assessment and curriculum, such as personalisation, seem likely to support increased levels of deep learning. However, it is important to note that, at a time of transition when the curriculum is being reshaped quite dramatically and assessment procedures changed, there is likely to be an impact on the perception that learners have of assessment. Thus, metacognition might be high, but motivation low as learners (and parents) may feel insecure about the changes. Also, the perception of new systems and testing may affect achievement (Hong and Peng 2008).

Changes to teaching and learning will evolve from existing practices, thus an understanding of what these elicit is important. Practitioners can adopt a deep or surface approach to teaching, which has consequential effects on what and how students learn (Boulton-Lewis et al 2001). The role of the practitioner is of obvious importance. However, it must not be assumed that practitioners generally have similar ideas of what constitutes learning. Research has shown that practitioners understand learning to be everything from the transmission of facts to the transformation of the learner as a person. Boulton-Lewis et al (2001) also found that there were discrepancies between the type of learning that the practitioner thought was taking place and what was actually happening. Interestingly, the practitioners with the more sophisticated conceptions of teaching and learning were often the ones whose approach did not match the type of learning taking place. This underlines the need for continuing professional development to ensure that the approach to teaching and learning is effective.

Little research evidence exists that specifically examines how deep learning strategies affect the success of the learner. Zohar and Peled (2008) focus on what they term ‘metastrategic knowledge’ (Kuhn 2004), which has considerable overlap with deep learning. In their work, they explicitly shared the cognitive processes that were being used with learners. They emphasised the importance of simply talking to the learners about the cognitive strategies that were being used. This work, based on the ability to transfer knowledge in science laboratories, showed that there was a positive impact on the learning of both low- and high-achieving learners; however, the impact was greatest for the low-achieving group. This supports findings from mathematics education, where learners have been shown to benefit from metacognitive instruction (Mevarech and Fridkin 2006).

Other researchers have examined the social cognitive perspective of self-regulated learning, thought to be a component of deep learning (Wang and Wu 2008). This approach examines the interplay between personal (motivation), behavioural (learning strategies) and environmental (room, practitioner, feedback) factors and the effect on learning outcomes. Perhaps unsurprisingly, receiving elaborate feedback improved learner self-efficacy, which in turn improved the learner’s ability to choose appropriate learning strategies. The performance of these learners increased significantly. Numerous studies have linked development of these attributes to effective use of web-based tools (Sankaran and Bui 2001, Shih and Camon 2001). A study of internet searching strategies suggests that learners with high internet self-efficacy apply better information searching strategies than those with low internet self-efficacy in a web-based learning task (Tsai and Tsai 2003).

Smith and Colby (2007) looked specifically at deep and surface teaching and learning in the learning environment. They found that most practitioners were using surface learning strategies (64 per cent) indicating a lack of understanding of what they were trying to achieve. Also, 78 per cent of learners’ work indicated surface learning characterised by reproduction or categorising of information. The practitioners’ instructional approaches and the students’ learning outcomes were determined using the SOLO (structure of the observed learning outcome) taxonomy (Biggs and Collis 1982). This taxonomy can be reliably used to analyse and interpret lessons/lectures and assignments – and the student work produced in response to those assignments – giving information as to the quality of learning. The SOLO taxonomy is structured into five major hierarchical levels that reflect the quality of the learning of a particular task:

* **Prestructural** - represents a response that is irrelevant or misses the point
* **Unistructural** - surface learning, examining one aspect
* **Multistructural** - surface learning, examining two aspects
* **Relational** - deep learning, several aspects integrated into a whole

**Extended abstract** - deep learning, coherent whole generated to a higher level of abstraction.

This raises the question as to what prevents practitioners from fostering deep learning outcomes among their learners. Success is dependent on teachers having the training, tools and time to engage in practices that contribute to these outcomes. The characteristics of deep and surface learning must be understood, and learning objectives and outcomes for a particular session should consider this. This will affect the choice of assessment and materials that are used. Commercially prepared materials often elicit a surface response; however, the practitioner can choose how these are used in the learning environment. Again, it is crucial that practitioners have the intention to elicit deep learning, as well as an understanding of how to do so.

The potential enhancement of deep learning using ICT

Digital technology is thought to have the potential to manage and support young people’s current learning, and their processes of making key choices about future learning (see, for example, Sutherland et al 2009). According to Becta (2008a), “ICT-supported learning is a key motivator for the majority of 14- to 19-year-olds. The opportunity to collaborate with their peers, to create their own material and to personalise and reflect upon their learning, leads them to engage more effectively.”

Oblinger (2008) considers the implications of ‘growing up with Google’ and what this means for education. The internet has enormous implications for communication: Web 2.0 technologies enable collaboration and co-creation activities, exemplified by Wikipedia; text is easily supplemented with images such as icons, video and photos; real worlds and virtual worlds are blended giving learners access to new environments. The advantages that ICT brings to the 14-19 age group, in particular, include:

* supporting specialist learning
* supporting collaboration between institutions in the provision of choice
* planning personalised pathways through education provision
* monitoring progress: e-assessment and e-portfolios
* bringing the learning to the learner
* enabling ‘anytime anywhere’ learning
* reaching learners outside the sphere of formal education
* enhancing established pedagogies
* enabling independent and collaborative learning

developing new modes of learning. (Davies et al 2006)

The scope for enhancing the learning experience of young people, it seems, is endless. All of the above have the potential to add to the process of deep learning, as the underlying theme is one of creating an independent and flexible learner who is supported by a personalised programme. However, ICT is frequently used for whole group activities, often involving the interactive whiteboard, which does not support the notion of personalisation. Progress is being made with initiatives such as investment in learning platforms. These tools can give learners access to resource banks, which can encourage deep learning. However, the use of learning platforms is still at the stage where particular resources are pushed out to learners. Little progress has been made in enabling learners to choose their own pathways (Becta 2007). Learners often have a passive role, representing a very different experience from their use of ICT when they are outside formal learning situations. Creanor et al (2006) identify control and choice as key components of learner strategies when using ICT, as well as essential elements for metacognitive processes where the learner displays an understanding of how learning occurs.

Other research shows that 56 per cent of secondary school students and 56 per cent of further education students identified the use of technology in lessons as an aid to task completion, rather than as a cognitive tool for knowledge construction (Sheard and Ahmed 2008). Thus, there would appear to be a gap between the potential benefits of ICT for deep learning and the actual way that ICT is being used.

The emergence of ICT has been rapid, and there is no doubt that young people are experiencing a range in the quality and type of ICT in their education. Becta’s Harnessing Technology Review (2007) offers “a mixed picture of the adoption, use and impact of technology in education and skills”. Progress is being made with, for example, the improved use of learning platforms, with a rise from 46 per cent of secondary schools in 2007 to 63 per cent in 2008. Interestingly, only 3 per cent used learning platforms as part of a consortium, so sharing between providers is still very limited. Also, the improvement in use of learning platforms does not mean that all practitioners are using these tools. In fact, there are differences between the reported usage from ICT coordinators compared to practitioners and learners. Practitioners are certainly using more ICT in the classroom, but the ways in which it is being used are still limited, with only a third of secondary teachers using ICT to support collaborative learning.

The experience in further education has been recognised as being limited with only a small number reporting the use of technology to support information analysis (18 per cent), solve problems (9 per cent) or work with others (8 per cent). Thus, the use of ICT to enhance skills that are crucial for deep learning is limited at the further education level. The scope for development of personalised learning careers and assessment is slowly improving with 21 per cent of secondary teachers using technology to offer feedback to learners (Smith et al, 2008). The use of online assessment and e-portfolios is higher in further education, reflecting the wider range of courses, mainly in the vocational area, and the need for different forms of assessment. Ofsted (2009) identified areas of good practice in the use of ICT in further education, but still reported:

“Far more often, however, the virtual learning environment was still at the stage of being a repository for teaching material, albeit sometimes with an email facility to upload or download assignments and assessments. Fewer than a quarter of the colleges were using them to support independent learning, for example by planning courses or modules around chosen topics to re-enforce areas that students needed to develop, or to track progress through exercises and assessments linked to individual learning plans.” (Ofsted 2009, p12)

Precursors to deep learning with ICT

Significantly, practitioners who are using ICT are reporting that students are learning more effectively and have improved retention, improved outcomes and improved satisfaction. Elements of deep learning are being flagged up by practitioners. This begs the question: Which elements of practitioners’ ICT usage are stimulating this success and how can we work to develop this? Before examining learners and their experience, it is important that we consider teachers and their perception of ICT, as this is a highly significant precursor to any deep learning that will take place. Three main factors are thought to have an impact on successful use of ICT in formal learning: access, competence and motivation, with 40 per cent of practitioners not reporting all three in 2007 (Becta 2007).

Yoon et al (2005a) used a tripartite model (Oliver 1999) to examine the interplay between technology, practitioner support and learning task in an attempt to determine which practitioner actions were particularly useful in facilitating engaged learning. This work emphasised the importance of the practitioner highlighting the cognitive processes that the learners needed to use, as learners can get sidetracked by physical processes, such as focusing on background colour rather than the words in a mind map. Clearly, the choices that the practitioner makes prior to the session regarding the delivery of the task are crucial for learning to take place. There is similarity here with the work of Smith and Colby (2007) who highlight the need for clarity and intention when setting a task to encourage deep learning. Other work has indicated that explicit teaching of cognitive strategies not only improves the outcomes for learners carrying out a computerised task, but also results in a more marked improvement for low-achieving students (Zohar and Peled 2008).

The successful use of ICT in formal learning is dependent on practitioners having an understanding of the dynamics of ICT-based lessons in order to design engaging learning experiences for the learners (Yoon et al 2005b). The practitioners in this work needed support to reflect on their practice, recognise engagement using ICT and redesign lessons to facilitate engagement and deeper learning; this was not something they did automatically. A similar pattern is emerging in higher education where there has been a call for practitioners to examine the learning process in more detail to capture fully the potential of technology (Laurillard 2008). The potential for the investigation of models using spreadsheets, for instance, cannot be fully realised without a secure understanding of constructivist learning. Laurrilard (2008) points out that theorists such as Dewey, Piaget and Bruner, to name a few, share a common viewpoint that ‘what it takes to learn’ involves an active process. Technology is unlikely to change ‘what it takes to learn’; however, it is likely to facilitate that process and affect the role of the teacher.

Haymore et al (1994) identified the following indicators of learner engagement in technology-rich classrooms: taking the initiative, self-motivation, collaborating spontaneously and undertaking independent experimentation. These in turn are dependent on the practitioner understanding the benefits which ICT tools bring to the learning experience. Socio-cultural theory has been used to explain how human action is mediated by tools. Tools in a learning environment may be artefacts such as paper, pencil and computers or semiotic systems such as language, graphs and diagrams (Armstrong et al 2005). The idea of the person acting with mediation tools both expands the view of what a person can do and suggests that a person might be constrained by the situated and mediated action (Wertz 1991). Both the practitioner and the learner bring a history of experience to the classroom influenced by their previous culture of learning and tool use. The tension, between the mediation tools and the individuals using them, results in a continuous process of transformation and creativity (Wertz and Rupert 1993). Thus when faced with a new technology, a practitioner is likely to make sense of this in terms of previous experiences with older technologies. That many practitioners use the digital whiteboard as an extension of a non-digital white board has been recorded on numerous occasions (Smith et al 2005).

The focus on digital tools such as word processors, dynamic geometry software, music composition software and email has led researchers to be optimistic about the advantages that these offer learners. However, John and Sutherland (2005) make the useful point that care must be taken as learning is a complex interaction between the learner, the technology and the context. There is nothing inherent in technology that automatically guarantees learning. Thus, the interactive whiteboard potentially affords interaction if the practitioner perceives that it can be used in that way and the software is available. However, the interactive whiteboard may not afford interaction if the practitioner perceives it as a presentational tool only (Armstrong et al 2005). These researchers give another example of the use of a museum-based interactive exhibit to teach about emergent animal behaviour. The learning objectives were to design a fish, place it in the virtual fish tank and compare how different characteristics contributed to survival. The lesson did not go as planned as the learners viewed this as ‘gaming software’ − a notion which video analysis revealed was reinforced by the language that the practitioner had used to introduce the task.

Learner perception and experiences of how technology is used in the learning environment are also significant in determining whether successful learning will take place. Often, it seems that learners may be disappointed with the use of technology, with students considering their practitioner’s use of ICT to be uninspiring (Oblinger 2003). In fact, it has been suggested that formal education runs the risk of becoming less relevant if more effective strategies for learning with technology are not supported (Oblinger 2008, De Freitas 2008). There has been considerable effort made to acknowledge the differing experiences, strengths and expectations of young people regarding the use of technology. Oblinger (2003) and Raines (2002) report that learners who have grown up in the digital era prefer to work in teams and engage in experiential activities. Their strengths include multi-tasking, working towards goals and collaborating.

The net generation, as Oblinger (2008) calls them, expects immediate responses and feedback. They also bring a consumer orientation to education. Learners expect technology to bring convenience. They want to access material anywhere and at any time, as well as receive feedback on their work. Efficient, convenient, technology-mediated transactions are expected, though this may develop into an entitlement culture where learners expect success with little academic effort (Taylor 2006). Undoubtedly, technology will have influenced the learning style of young people as different opportunities become available. There is a higher expectation for sensory-rich and experiential activities – whether physical or virtual (Oblinger 2008).

Components of deep learning in an ICT- rich environment

The challenge now is to identify which components of technology used in the formal learning environment are supporting deeper learning. The scope is vast and progress will only be made if practitioners feel confident when delivering technology-rich lessons that have been personalised to meet the needs of their classes. This is particularly significant for the 14-19 age group, which is characterised by huge personal, social and psychological change. This is a period of transition for young people as they move from compulsory to post-compulsory education and training, into the labour market and onto higher education. Young people continue to develop their cognitive skills and their ability to self-regulate their learning (Davies et al 2006). Such development is best fostered by providing challenging learning tasks and a range of approaches. The learner should have meaningful choice over the tasks and how to complete them. That young people may be motivated by some tasks and not by others is accepted. The potential for digital technologies to deliver challenging and motivating tasks is clear, thus increasing the self-worth of the learner; however, it is a very complex area. Davies et al (2006) also suggest that the design of powerful learning environments for this age group must be based on constructivist learning theories. They have derived six key questions from this:

* Are the intended outcomes of the learning durable, flexible, functional, meaningful, generalisable and application-orientated?
* Are thinking, learning, collaboration and regulation skills being taught?
* Is there a shift of focus towards more experiential learning: more active, cumulative, constructive, goal-directed, diagnostic and reflective learning?
* Is there a shift towards more independent learning: more discovery-orientated, contextual, problem-orientated, case-based, socially and intrinsically motivated learning?
* Is there conscious attention for the gradual increase of independence according to the sequence of independent work, strategic learning and self-directed learning?

Is there modelling, external monitoring, scaffolding, metacognitive guidance, attention for self-evaluation, practice of skills, feedback and reflection?

There is even the suggestion that practitioners must take an experimental stance to their teaching in order to understand more fully what is going on in the formal learning environment. Some are already doing this in an attempt to unpick some of the issues. Independent learning at a number of schools in Bedfordshire has been examined in an attempt to identify deep and surface learning in context (Mistrano 2008). The extent to which learners were monitored during time out of lessons was of fundamental importance, as the students needed support with self-regulated learning, particularly when accessing ICT. There are important implications for whole school/college decisions regarding the endorsement of learning strategies, thus funding, by senior management. The reforms set out in the White Paper on further education, Raising Skills, Improving Life Chances (DfES 2006), supported the extension of personalisation through individualised learning programmes. Huddleston and Unwin (2008, p160) argue that “the [further education] teacher becomes a facilitator of learning rather than a provider”. They go on to claim that “the implications for workforce development should not be underestimated”.

There is recurring mention of self-regulated, individualised learning programmes and independent learning in the literature surrounding deep learning. To further understanding of web-based learning, self-regulated learning has been broken down into the interaction between personal, behavioural and environmental influences (Wang and Wu 2008). Personal influence (motivation and self-efficacy) is thought to be highly significant in determining success when carrying out web-based activities (Joo et al 2000); it is also linked to learner persistence and quality of effort, both components of deep learning. Behavioural influence refers to the learning strategies and the feedback behaviours that learners adopt. Web-based learning has the potential to give learners greater access to a range of learning strategies as well as collaborative projects where activities such as peer-assessment can take place. Lastly, environmental influence refers to the quality of feedback that a learner receives. Clearly, these influences affect one another; for example, self-efficacy helps determine which learning strategies are chosen, and good quality feedback has an impact on self-efficacy.

So how can technology help create “clear learning pathways through the education system and the motivation to become independent, e-literate, fulfilled, lifelong learners”? (Hopkins 2006) The impact of ICT on learning is extending beyond the classroom, with learners accessing information at home. There are also an increasing number of initiatives that allow different providers to communicate with each other to offer individual learning plans which may reach learners normally outside the sphere of formal education.

Exam boards are considering issues such as multi-location assessment, electronic portfolios and the use of digital video (Ridgeway et al 2004). Traditional assessment processes will change, resulting in an increased number of personalised pathways and increased levels of inclusion. Tools such as eduViz are being designed to support assessment of individual learners. This visualisation tool helps practitioners explore and assign grades, giving a clear overview of the strengths and weaknesses of learners so that scaffolding can take place to allow progression (Sorelle et al 2008).

There is also mention throughout the deep learning literature of the need for new learning outcomes and the need for new forms of instruction/sharing information with learners. Researchers refer to the change as ‘process-orientated instruction’, which is focused “on the further development of thinking, learning and self-regulation and thinking integrated in the regular domain instruction” (Simmons 2001, p179). Consideration of the type of technology that a learner will experience and the affordances that it can bring is now needed to understand how deep learning can be fostered in the formal learning environment.

Within this environment, perhaps the most familiar technology now is the interactive whiteboard. This is popular as it is flexible and versatile as a teaching tool to support multiple needs within a lesson (Glover and Millar 2002). It also allows the practitioner to face the class and maintain eye contact while teaching. Learners saw interactive whiteboards as effective tools in facilitating the learning process; however, the pupils point out the practitioner’s lack of ICT skills, associated cost and technical unreliability (Wall et al 2005). The interactive whiteboard lends itself to the effective integration of multimedia as it enables seamless and easy access to resources such as CD ROMs, digital videos and audio files. However, Schmid (2008) asks the pertinent question: “What actually is meant by effective integration of multimedia?” ‘Multimedia learning’ must be understood in order for this to be an effective process. Mayer (2001) put forward a cognitive theory of multimedia learning, which focuses on the cognitive processing of verbal and visual material. There are three main assumptions:

* The dual channels assumption suggests the visual and verbal information is processed in separate channels.
* The capacity assumption suggests that each channel is limited in the amount of material that can be processed at one time.

The active processing assumption suggests that, for meaningful learning to take place, conscious effort needs to be spent in selecting, organising and integrating the new information into existing knowledge.

Other influences on deep learning

Learning platforms

Learning platforms are being developed to support teaching and learning using multimedia. They typically provide tools for assessment, communication, uploading content, returning learners’ work, administration, and use of tools such as blogs over the internet. Several learning management systems, such as Moodle and Blackboard offer a wide range of ways to support e-learning. Often, all of these features are not fully exploited and these systems are simply used to supplement web-enhanced modality (McCreanor 2000). Multimedia is often not used and the contents remain static, represented by HTML pages, presentation and word processed documents (DeLucia et al 2009).

Simple user interaction may affect both the cognitive processing during learning and the cognitive outcome of learning. Incorporating interactivity into a multimedia presentation is known to improve deep learning (Mayer and Chandler 2001). However, this is a complex process: interaction has been shown to increase the ability to transfer information, although it has no effect on the retention of information. If too many learning elements need to be processed and related simultaneously, as is the case with narrated animations, cognitive load becomes high and understanding of complex concepts can be hindered (Tindall-Ford et al 1997). Working with and without interactive computer packages has been examined in an attempt to determine whether deep learning was taking place (Evans and Gibbons 2007). Interactivity adds an additional cognitive dimension, in that it allows the learner to influence the flow of information. It thus exerts control over the learning process and discourages passive learning. Interactivity has been shown to increase problem-solving ability as well improve memory, though the latter was a much weaker effect. This is consistent with the notion that the effect is greater on information transfer, rather than simple retention (Mayer 2001).

Other researchers have focused on synchronous versus asynchronous systems, in an attempt to determine the effect of immediate feedback on deep and surface learning (Offir et al 2008). Growing interest in this has been stimulated by the rising demand for distance learning. Distance learning appears to support the notion of independent learning. However, for deep learning to be achieved, the need for transaction between the learner and practitioner or between learners is important. Offir et al (2008) identified the quality of questioning as being crucial to effective deep learning, thus learner-practitioner interaction is very important. Perhaps unsurprisingly, learners with higher cognitive ability were better equipped to overcome the low-level of interaction that accompanies asynchronous learning. Synchronous transaction between the learner and the practitioner had been used with equipment that is not normally accessible in schools and colleges, such as the electron microscope. Video streaming was used to transmit images of fireflies to the learners who could ‘ask a scientist’ about a particular structure, challenging the usual practitioner/learner role. The learners enjoyed working as co-researchers and displayed an increased understanding of the relevance and purpose of the task (Hunt 2006).

Considering synchronous and asynchronous learning using computer-based technologies has generated considerable interest in the quality of questioning. This is because there are obvious limitations to the scope of questioning that can take place when using an asynchronous or multimedia package. Questions are often classified with various taxonomies existing, perhaps the best known being Bloom’s taxonomy (Bloom et al 1956). Taxonomies can range from low-level recall (surface) to high-level evaluation and synthesis (deep) questions. It is well documented that the type of questions used by the practitioner impacts on student achievement (Redfield and Waldman-Rousseau 1981, Yopp 1988). Craig et al (2006) have examined the impact of deep level questions on learning when using the computer package, Autotutor[[1]](#footnote-1). Learners listened to dialogue between animated agents containing different level questions, corresponding closely to Bloom’s taxonomy. Learners were then given another example and invited to generate their own questions. The learners who had overheard the deeper level questions went on to display greater transfer skills, generating higher-level questions. Overall, they performed better.

Systems such as Moodle offer the potential and flexibility to design online courses that are tailored to the needs of a specific learning group (Martin-Blas et al 2009). Particular interest has been shown in the potential for web-based peer assessment. This would enhance learners’ cognitive processing, helping them to construct knowledge, while promoting positive attitudes to discussion and cooperation. The need for social interaction has been raised elsewhere as an explanation for the failure of courses (Redfern and Naughton 2002).

There is increasing interest in collaborative virtual environments to integrate social interaction and learning such as Web3D environments, a typical classification used to refer to any three dimensional (3D) graphic technology open to the world wide web (Chitaro and Ranon 2007). DeLucia et al (2009) examine the use of an existing virtual world and the associated analogous technologies, Second Life[[2]](#footnote-2), to create a virtual campus and stimulate peer-to-peer interaction, group work and communication. Using the virtual world helped to change the relationship between the teacher and the learner − “the distance between the student and teacher is reduced: it is more natural, spontaneous and easy to communicate in Second Life”. Being able to think, act and talk in new ways has enormous potential, as does the fact that virtual worlds do not rely on words and symbols. Learners can have a variety of experiences in the virtual world, such as participating in a mission to Mars or being involved in a native culture. They can take on the role of an expert or be involved in a community of novices to pose or solve problems (Oblinger 2008).

Learning@Europe[[3]](#footnote-3) provides a three-dimensional shared environment for learning. One thousand secondary students from six European countries took part in this project. They interacted with one another synchronously and asynchronously in cultural competitions. Teams were always composed of students from two different countries. Teachers reported a positive impact on knowledge (about history and related subjects), skills (use of ICT in learning/teaching processes, group work), attitudes (more curiosity towards history, increased motivation and increased interest in other cultures) and engagement. The social impact was crucial for the success of this with improved relationships with remote peers, teachers and classmates. The project created a sustained interest from teachers and students (Di Blas and Poggi 2007). The researchers argued that the extensive workload and challenge proved that the learners saw this activity as more than just a game.

Animation

The Ofsted Annual Report on the national curriculum called for ‘moving text images’ to be more fully used throughout English teaching (Ofsted 2005). There is evidence that the use of such texts can benefit English and literacy. Various researchers (Burn and Leach 2004, Madden et al 2009) have considered the impact of moving text images on learners’ communicative and narrative abilities. In addition to reading moving text, educators attach considerable importance to learners creating their own resources. Using computer packages to support this process has had a considerable impact on learners’ writing skills. Practitioners felt that the learners were immersed in the story compared to a control group who often made up endings showing that they had not fully engaged.

Other researchers have contrasted the impact of using animated pedagogical agents (social agency environment) with just using text in computer-based sessions (Moreno et al 2001). Learners designed plants and decided on adaptations for different environments with and without the animated support. The social agency environment had an element of discovery, offering the greatest potential for learning and more challenge, possibly facilitating constructivist learning. Learners were assessed for retention, problem solving transfer and interest, all of which were higher with the animated agent.

How might the animated agent have a positive impact on learning? Constructivist theories have their roots in motivational theories, which propose that learners work harder to make sense of presented material. They therefore learn more deeply when they are personally interested in the task (Harp and Mayer 1998). Thus, animated pedagogical agents may personalise the learning task and help learners feel an emotional connection with the agent. This feeling of a positive personal relationship promotes interest in the learning task, which in turn fosters constructivist theories (Lester et al 1997).

Games

“People acquire new knowledge and complex skills from game play, suggesting gaming could help address one of the nations’ most pressing needs - strengthening our (American) system of education and preparing workers for 21st century jobs.” (Federation of American Scientists 2006, p3)

Computer games have become an integral part of our social and cultural environment (Oblinger 2004). Most young people regularly play computer games (McFarlane et al 2002). This popularity has helped create a generation of young people whose cognitive abilities and expectations have been shaped by the challenge of games, and thus traditional educational methods can seem lacking (Facer 2003). The motivation of games could be combined with curricular content to develop what Prenksy (2003) calls ‘Digital Game-Based Learning’, rendering academic subjects more learner centred, more enjoyable, more interesting and, thus, more effective. Games can specifically support powerful learning environments as they can:

* support multi-sensory, active, experiential, problem-based learning
* favour activation of prior knowledge given that players must use previously learned information in order to advance
* provide immediate feedback enabling players to test hypotheses and learn from their actions
* encompass opportunities for self-assessment through the mechanisms of scoring and reaching different levels
* increasingly become social environments involving communities (Oblinger 2004).

There has been significant effort in recent years to determine whether there is evidence to support the assumption that games are motivational and educationally effective. Papastergiou (2009) compared gaming and non-gaming approaches in secondary school ICT lessons and found that the gaming approach produced a considerable improvement in both the knowledge of the subject matter and student enjoyment, engagement and interest in the learning process. Findings from another recent study, which focused on maths lessons, supported this (Ke and Grabowski 2007). Increased interest in the learning process is of particular significance to deep learning as there is potential to develop the ‘learning to learn’ component.

The design of computer-based teaching can be driven by the designer’s conception of the nature of teaching, which can range from ‘teaching-as-transmitting’ to a ‘teaching-as-communicating’ view (Moreno et al 2001). Clearly, the design of the game is important and there is considerable literature that emphasises the importance of applying established educational strategies and theories in the design of games and the facilitation of game-based learning. However, there has been little examination of how established learning theories and instructional design are being applied in the development of educational games.

Kebritchi and Hirumi (2008) categorised the pedagogical foundation of a large number of games developed between 2000 and 2007. The categories were: direct instruction, experiential learning theory, learning by doing, discovery learning theory, situated cognition, constructivism and unclassified approaches. Out of 55 games that were examined, 31 had no information regarding pedagogical foundations. The need for an understanding of the pedagogical foundations is important on two fronts: it allows practitioners to incorporate these into the curriculum while fully understanding which learning outcomes are expected and what type of learning (deep or surface) they are trying to achieve. There are also implications for the relationship between the games designer and the curriculum. To be effective, this relationship needs to be a partnership with practitioners.

The recent evolution of educational games has also generated a need for a framework to evaluate the effectiveness of these games. The use of games is more complex than just being part of the learning process. Their design needs to recognise the context in which they are being used, for instance whether they are used in schools and colleges and the value systems that shape them, such as assessment (De Freitas and Oliver 2006). The issues are similar for work-based learning. When designing work-based learning experiences, developers ask: What is the educational benefit that learners can create in one context given their experience in another? This is essentially referring to the transfer skills that are an essential component of deep learning.

There has been an understandable interest in using commercial games in the classroom for educational purposes. These are readily available and familiar to the learners, thus they may increase motivation, while offering the potential to move away from a content-based to competency-based situation. Sandford et al (2006) carried out a detailed study into this and found a complicated interplay of factors. Learners were certainly more engaged, but the reasons why were unclear - whether it was the result of having autonomy or the result of being familiar with the game. The researchers and teachers also struggled with the ways in which the learners learnt how to use the computer games. A linear progression was expected and this was not the case, making it difficult to manage the activity. More understanding is clearly needed to clarify how young people interact with computer games, whether they are educational games or those that are ‘off the shelf’.

ICT and subject sub-cultures

The socialisation aspect of ICT use is further complicated by the subject sub-culture, which exists across curriculum areas (John 2005). Subjects seem to influence the pedagogy that is framed within them bringing various traditions and contexts (Shulman 1987). Some researchers have examined the impact of subject sub-culture on the integration of ICT (Olson 2000, Goodson and Mangan 1995, John and LaVelle 2004). The notion of cultural transparency (Wenger 1990) has been used to suggest ways to move forward in different subject areas. Wenger argues that for ICT to be used successfully in a subject area, its significance as a learning tool must be highly visible. However, at the same time, its role as a mediating technology, supporting the visibility of subject matter must render it invisible. The balance between the two is crucial if ICT is to play a significant role in transforming subject pedagogy and learning. Selwyn (1999) found that in ICT-resistant communities the role of transparency is reversed. Computers become highly visible as mediating technologies (often getting in the way of learning) and highly invisible as learning tools.

Clearly, widespread and effective use of ICT will be affected by the congruence of the subject and the technology (Ruthven et al 2004). The affordances that the technology offers, both real and perceived, will have an impact. Computer resources can be classified as type A or type B (Counsell 2003). Type A means that the learning focus is intrinsic to the ICT usage, thus the learning could not take place in the same way without ICT. Type B has less convergence with learning activities and this learning can take place without the technology. Classification such as this is useful as it encourages the clear intent that is known to be a precursor of deep learning.

Other considerations

“Scientific progress sometimes comes not from new methods or technologies but from new ways of framing old problems.” (Clark 2006)

Technology and ICT certainly offer new ways of affecting the complex interaction of learning, motivation and problem solving that take place in education. However, how much do we really know about learning – deep or surface? Educational science emphasises the learning of conscious, declarative knowledge (Sun et al 2005). It has been suggested that as much as 90 per cent of our learning may be automated and unconscious (Bargh 1999). While this may further explain the interest in fully understanding the notion of deep learning, this also raises questions about what percentage of our self-regulatory and learning processes have been exploited to date. Automated procedural knowledge is the result of repetition and unconscious routines. Neuroscience has indicated that this type of behaviour is pleasurable, possibly having the same neural reward processes as drug addiction (Helmuth 2001). Thus, routines in the classroom, such as the sharing of learning objectives, gradually transform conscious declarative knowledge into automated procedural routines over time. Considering these findings with respect to some of the key elements of deep learning, such as self-regulation, adds further complexity as this is generally accepted to be a conscious process. There is even suggestion that educational programmes to help learners develop self-regulatory processes have failed for this very reason − they have focused on conscious, declarative systems (Molden and Dweck 2006).

Other researchers suggest that the constructivist ideas of Vygotsky further support the importance of automated learning. Learners who have adequate automated learning strategies in place may thrive in unguided learning settings. However, those who are lacking these skills need clear instruction in problem-solving and learning strategies (Kirschner et al 2006). There is significance for the design of multimedia packages (Mayer 2001). Cognitive load theory is thought to describe the conditions under which automated processes protect working memory, thus to some extent automated processes are already affecting software design. This is problematic as automated processes are difficult, perhaps impossible, to measure. If this is the case, how can the design of software progress to develop this area of learning?

Regardless of the potential of automated learning, computer-based learning environments (CBLE) have been found to positively impact on self-regulated learning (Winters et al 2008). Examining a number of studies allowed these researchers to draw some conclusions on the ways forward with web-based learning. High-ability learners or those with prior knowledge were better equipped to manage tasks and achieve the maximum from the learning environment. Prior experience of asynchronous computer based learning enhanced the learner’s capacity to plan active strategic processes such as managing information. Consideration of learner profile perhaps offers another way in which to make more effective use of web-based learning.

The use of ICT in education has not always been welcomed. Some researchers have described the inappropriate use of multimedia in class, which can lead to “interactions which are largely gratuitous” (Aldrich et al 1998). Cairncross and Mannion (2001) suggest that we can overcome this by looking at the learning process itself in order to re-evaluate the usefulness of ICT with respect to deep learning, considering individual learning needs. Disadvantages with technological advances are also suggested by Olson and Clough (2001). They suggest that the web is becoming a substitute television. As such, there is concern that learners’ notion of learning is shifting to the extent that they think it should be ‘fun’ all the time. Practitioners are increasingly incorporating technologies into their pedagogy to catch learners’ attention, but are doing so at the expense of serious study. The use of probes in science can undermine the learners’ understanding of what they are actually measuring and this is given as an example of inappropriate use of technology. There is a danger that learners’ thinking will be hidden or masked by the use of technology.

The measurement or evaluation of the value that ICT adds to learning is a desirable process as this may give an indication of how to move forward to realise fully the potential benefits of ICT with respect to deep learning. Tools to measure the benefits provided by ICT are emerging, although this is a complicated process as technology is changing rapidly. Hrastinski (2008) reviewed the recent developments in online participation. Participation is thought to be an intrinsic part of learning (see earlier section for discussion of Vygotsky) and previous research has shown that it benefits learners. There are numerous ways in which a learner may participate online, such as through writing or dialogue. Most research focuses on low-level conceptions of participation such as frequency counts of messages. However, there is a growing movement towards examining more complex dimensions such as whether participants feel they are taking part and whether they are engaged in dialogue; such examination uses a combination of perceived and actual measures of participation.

Another way to demonstrate that specific instructional approaches and educational technologies are effective in improving complex problem-solving skills has been developed with a project entitled, “The DEEP methodology for assessing learning in complex domains” (Spector 2006). This involved the consideration of different problem scenarios. Subjects were asked to generate an approach to a solution rather than find the solution itself, thus demonstrating transferable skills. Differences between experts and non-experts produced responses at three different levels: surface, structure and semantic. As expected, experts made links much more easily. This particular approach may be used with individuals or groups to follow progression over time.

Conclusion

Laurillard (2008) considers the impact of the shift from oral representation to written communication and the opportunities this brought to the individual learner thousands of years ago. The shift from the written word to the interactive medium of the computer is having an equally radical effect on learning. The potential for new ways to represent knowledge is difficult for the individual to begin to understand. However, progress is undeniably occurring and a balance is being found between what learners need and what technology can offer. The fact that the potential of e-learning is not obvious to every teacher and that this now needs discussion, is becoming clear. For the potential of technology to be fully realised, it must be carefully tailored to aspects of learning such as assessment and cognition. Referring back to our original criterion for deep learning:

‘Deep learning is secured when, through personalisation, the conditions for student learning are transformed’ (Simms 2006).

A number of examples that illustrate the potential for the transformation of the learning environment with the use of technology have been provided in this review. There are also a number of examples in the report on our action research project (Becta 2009). However, do these approaches help generate the deep learner or ‘an articulate, autonomous but collaborative learner, with high metacognitive control and the generic skills of learning’? Evidence would suggest that technology has the potential to enhance an environment that is conducive to deep learning with:

* novel approaches to assessment and feedback (p19)
* interactivity encouraging active learning and increasing cognition (p19)
* online courses using Moodle (p22)

personalisation of learning tasks using animated agents (p24).

These are no longer fantastic ideas to which to aspire, but are commonplace features of many learning environments. It is becoming apparent that successful learning is dependent on the commitment and understanding of the practitioner. Without a full appreciation of the affordances that technology might bring to their learning environment, the potential is likely to remain untapped. It is equally important that we challenge the assumption that all young people are naturally adept at using technology and have an equal understanding, perhaps better, understanding of the lesson than the practitioner. Technology can facilitate the role of the practitioner. However, whether it can alter ‘what it takes to learn’ (Laurillard 2008) remains unclear.

To fully examine this possibility, it may be that the learning process itself needs to be reconsidered. Theorists have explored the social aspect of learning for some time, from the discussion of an idea with a peer to experiential learning, both of which have been highlighted as components of deep learning. Recent work has suggested that learning theories need to be re-examined in the light of new technologies to help us fully understand which aspects of learning the technology is actually enhancing, with the collaboration element (learner-learner and teacher-learner) thought to be particularly significant (Laurillard 2009). There is, of course, the complex interaction between the cognitive process and the motivation to engage, both of which are influenced by collaboration. This would appear to be an appropriate place to lay secure foundations of our knowledge of learning with technology. This would allow the exploration of more sophisticated ideas such as self-regulation and co-regulation.

Perhaps the most significant link between deep learning, ICT and the 14-19 age group is the evidence that the use of interactive packages has a positive impact on the transfer of information, but not necessarily retention. This is an exciting prospect as the recent reform of the 14-19 sector is designed to create learners who can bring a range of skills to the workplace, rather than just the recall of facts. This has implications for the way in which ICT is utilised in existing qualifications and the range of new qualifications, especially the Diplomas.

There are emerging issues relating to the proper use of resources to support ICT developments. In the past, inappropriate utilisation of funds to implement ICT strategies has been an ongoing problem, with respect to both software and training for practitioners. We are only just beginning to realise the potential for using applications such as games properly in the learning environment. More collaboration is required between the games designers and educators, if these are to truly facilitate learning. A thorough re-examination of the learning process in the light of technological advances can only enhance the capacity of learners to learn.

References

Aldrich, F, Rogers, Y and Scaife, M (1998), ‘Getting to Grips with Interactivity: Helping Teachers Assess the Educational Value of CD-ROMs’, *British Journal of Educational Technology* 29 (4) 321-332.

Armstrong, V, Barnes, S, Sutherland, R, Curran, S, Mills, S and Thompson (2005), ‘Collaborative Research Methodology for Investigating Teaching and Learning: The Use of Interactive Whiteboard Technology’, *Educational Review* 57 (4) 457-489.

Atherton, J S (2005), *Learning and Teaching: SOLO taxonomy*  
www.learningandteaching.info/learning/solo.htm

Au, C and Entwistle, N (1999), ‘Memorisation with Understanding in Approaches to Studying: Cultural Variant or Response to Assessment Demands’, European Association for Research on Learning and Instruction Conference, August 1999. www.leeds.ec.uk/edcucol/documants/00001728.htm

Baker, L and Brown, A L (1984), ‘Metacognitive Skills and Reading’, in Pearson, P D (ed), *Handbook of Reading Research*, New York, Longman.

Bargh, J A (1999), ‘The Unbearable Automaticity of Being’, *American Psychologist* 51, 355-365.

Becta (2007), *Harnessing Technology Review 2007: Progress and Impact on Technology in education,* Coventry, Becta.  
http://publications.becta.org.uk/display.cfm?resID=33980  
  
Becta (2008a) *How Technology Supports 14-19 Reform: An Essential Guide*, Coventry, Becta.  
http://publications.becta.org.uk/display.cfm?resID=31532&page=1835

Becta (2008b) *Harnessing Technology Review 2008: The Role of Technology and its Impact on Education,* Coventry, Becta.  
<http://publications.becta.org.uk/display.cfm?resID=38751>

Becta (2009 forthcoming), *14-19 Deep Learning*, Coventry, Becta.

Biggs, J (1999), *Teaching for Quality Learning at University Buckingham*, Society for Research into Higher Education and Open University Press.

Biggs, J (1987), *Student Approaches to Learning and Studying*, Australian Council for Educational Research, Hawthorn, Australia.

Biggs, J (1993), ‘What do Inventories of Students' Learning Process Really Measure? A Theoretical Review and Clarification’, *British Journal of Educational Psychology* 83, 3-19.

Biggs, J and Collis, K (1982), *Evaluating the Quality of Learning: The SOLO Taxonomy,* New York, Academic.

Black, P and William, D (1998), *Inside the Black Box: Raising Standards Through Classroom Assessment,* King’s College, London.

Bloom, B S (1956), *Taxonomy of Educational Objectives: The Classification of Educational Goals, Handbook 1, Cognitive Domain,* New York, Longmans.

Bloomer, M (1997), *Curriculum Making in Post-16 Education: The Social Conditions of Studentship,* London, Routledge.

Boulton-Lewis, G M , Smith, D J H, McCrindle, A R, Burnett P C and Campbell, K J (2001), ‘Secondary Teachers’ Conceptions of Teaching and Learning, *Learning and Instruction* 11, 35-51.

Brady, B (2007), ‘Developing Children’s Participation: Lessons from a Participatory IT Project’, *Children and Society*, 21, 31-41.

Burn, A and Leach, J (2004), ‘ICT and Moving Image Literacy in English’, in Andrews, R (ed) *The Impact of ICT on Literacy Education*, London, Routledge Falmer.

Cairncross, S and Mannion, M (2001), ‘Interactive Multimedia and Learning: Realising the Benefits’, *Innovations in Education and Teaching International* 38, 2, 156-164

Chitaro, L and Ranon, R (2007*), ‘*Web 3-D Technology in Learning, Education and Training’, *Computers and Education* 49, 1-2.

Clark, R (2006), ‘Not Knowing What We Don’t Know: Reframing the Importance of Automated Knowledge for Educational Research’, in Clarebout, G and Elen, J (eds) *Advances in Studying and Designing (Computer-Based) Powerful Learning Environments*, Rotterdam, Sense Publishers.

Coffield, F (2008), *Just Suppose Teaching and Learning Became the First Priority*, London, Learning and Skills Network.  
www.lsneducation.org.uk/news/?ID=5862

Counsell, C (2003), ‘The Forgotten Games Kit: Putting Historical Thinking First in Long, Medium and Short Term Planning’, in Haydn, T and Counsell, C (eds) *History, ICT and Learning in the Secondary School*, London, Routledge.

Craig, S D, Sullins, J, WEitherspoon, A and Gholson, B (2006), ‘The Deep Level Reasoning Question Effect: The Role of Dialogue and Deep-Level Reasoning Questions During Vicarious Learning. *Cognition and Instruction* 24(4) 565-591.

Creanor, L, Trinder, K, Gowan, D and Howells, C (2006), ‘LEX The Learner Experience of E-learning’, Final Project Report, August 2006, Glasgow Caledonian University and the Open Learning Partnership.

Davies C, Hayward G, and Lukman, L (2006), *14-19 and Digital Technologies: a Review of Research and Projects*, Futurelab Series, Report 13.

DCSF (2008), *The Assessment for Learning Strategy*, London, DCSF  
<http://publications.teachernet.gov.uk/eOrderingDownload/DCSF-00341-2008.pdf>

De Freitas, S and Oliver, M (2006) ‘How can Exploratory Learning with games and Simulations Within the Curriculum be Most Effectively Evaluated?’ *Computers and Education* 46, 249-264

De Freitas, S (2008), ‘Emerging Trends in Serious Games and Virtual Worlds’, in *Emerging Technologies for Learning* *Volume 3*, Coventry, Becta  
http://partners.becta.org.uk/index.php?section=rh&rid=13768

Deakin Crick, R (2006), *Learning Power in Practice: A Guide for Teachers*, London, Paul Chapman.

DeLucia, A, Francene, R, Passero, I and Totora, G (2009), ‘Development and Evaluation of a Virtual Campus on Second Life: The case for Second DMi’, *Computers and Education* 52, 220-233.

DfES (2004a), *Pedagogy and Practice: Teaching and Learning in Secondary Schools Unit 17: Developing Effective Learners*, London, DfES.   
http://nationalstrategies.standards.dcsf.gov.uk/node/174759

DfES (2004b), *Pedagogy and Practice: Teaching and Learning in Secondary Schools Unit 12: Assessment for Learning,* London, DfES.  
http://nationalstrategies.standards.dcsf.gov.uk/node/96853?uc=force\_uj

DfES (2005), *14-19 Education and Skills*, London, HMSO.  
http://publications.dcsf.gov.uk/eOrderingDownload/CM%206476.pdf

DfES (2006), *Further Education: Raising Skills, Improving Life Chances*, London, The Stationery Office.

DfES (2007), *Pedagogy and Personalisation*, London, DfES.  
http://nationalstrategies.standards.dcsf.gov.uk/node/85123

Di Blas, N and Poggi, C (2007), ‘European Virtual Classrooms: Building Effective Virtual Educational Experiences’, *Virtual Reality* 11,129-143.

Dinsmore, D L, Alexander, P A and Loughlin, S M (2008), ‘Focusing the Conceptual Lens on Metacognition, Self-regulation and Self-regulated Learning’, *Educational Psychology Review* 20, 391-409.

Entwistle, N (1981), *Styles of Learning and Teaching: An Integrated Outline of Educational Psychology for Students, Teachers and Lecturers,* Chichester, Wiley.

Entwistle, N (2000), ‘Promoting Deep Learning Through Teaching and Assessment: Conceptual Frameworks and Educational Contexts’, TLRP Conference, Leicester.

Evans, C and Gibbons, N (2006), ‘The Interactivity Effect in Multimedia Learning’, *Computers and Education* 49(4), 1147-1160 (adults).

Facer, K (2003), *Computer games and Learning*, London, Futurelab.  
www.futurelab.org.uk/resources/publications-reports-articles/discussion-papers/Discussion-Paper261

Facer, K, Sutherland, R, Furlong, R and Furlong, J (2001), ‘What’s the Point in Using Computers? The Development of Young People’s Computer Use in the Home’, *New Media and Society* 3, 199-219.

Federation of American Scientists (2006*) Harnessing the Power of Video Games for Learning*. http://www.fas.org/gamesummit/Resources/Summit%20on%20Educational%20Games.pdf

Fox, E and Riconscente, M M (2008), ‘Metacognition and Self-Regulation in James, Piaget and Vygotsky’, *Educational Psychology Review* 20, 373-389.

Futurelab (2007), *Developing and Accrediting Personal Skills and Competencies*, Futurelab. www.futurelab.org.uk/resources/documents/project\_reports/Developing\_and\_Accrediting\_Personal\_Skills\_and\_Competencies.pdf

Glover, D and Millar, D (2002), ‘Running with Technology: The Pedagogic Impact of the Large-Scale Introduction of Interactive Whiteboards in One Secondary School’, *Journal of Information Technology for Teacher Education* 10, 257-277.

Goodson, I F and Mangan, J F (1995), ‘Subject Cultures and the Introduction of Classroom Computers’, *British Educational Research Journal* 21 (5) 613-629.

Hargreaves, D (2004), *Personalising Learning 2: Student Voice and Assessment for Learning*, Specialist Schools Trust.  
www.ssat-inet.net/pdf/Student%20voice%20and%20assessment%20for%20learning%20-%20Cahpters%201%20and%202.pdf

Harp, S F and Mayer, R E (1998), ‘How Seductive Details Do Their Damage: A Theory of Cognitive Interest in Science Education’, *Journal of Educational Psychology* 90, 414-434.

Haymore, J, Ringstaff, C and Dwyer, D C (1994), ‘Student Engagement Revisited: Views from Technology-Rich Classrooms’. http://www.apple.com/euro/pdfs/acotlibrary/rpt21.pdf

Helmuth, L (2001), ‘Beyond the Pleasure Principle’, *Science*, 294, 9843-984.

Hodkinson P, Biesta G and James, D (2007), ‘Learning Cultures and a Cultural Theory of Learning, *Educational Review*, 59(4) 415-427.

Hong and Peng (2008), ‘Do Chinese Students’ Perceptions of Test Value Affect Test Performance? Mediating Role of Motivational and Metacognitive Regulation in Test Preparation’, *Learning and Instruction* 18(6), 499-512.

Hopkins, D (2006), ‘Realising the Potential of System Reform’ [online] UK  
[www.davidhopkins.co.uk/articles/systemreform.pdf](http://www.davidhopkins.co.uk/articles/systemreform.pdf)

Hrastinski, S (2008), ‘What is Online Learner Participation?’, *Computers and Education* 51, 1755-1765.

Huddleston, P and Unwin, L (2008), *Teaching and Learning in Further Education*, London, Routledge.

Hunt, J (2006), ‘ICT Mediated Science Enquiry: The Remote Access Microscopy Project’, *International Journal of Learning*, 12(8), 203- 212.

Illeris, K (2007), *How We Learn: Learning and Non-Learning in School and Beyond*, London, Routledge.

James, D and Biesta, G (2007), *Improving Learning Cultures in Further Education,* Abingdon, Routledge.

James, M et al (2007), *Improving Learning How to Learn*, Abingdon, Routledge.

Jephcote, M and Abbott, I (2005), ‘Tinkering and Tailoring: The Reform of 14-19 Education in England’, *Journal of Vocational Education and Training* 57 (2), 181-202.

John, P and LaVelle, L (2004), Devices and Desires: Subject Sub-Cultures, Pedagogic Identity and the Challenge of Information Communication Technology, *Technology, Pedagogy and Education*, 13(3) 307-326.

John, P (2005), ‘The Sacred and the Profane: Subject Sub-Culture, Pedagogical Practice and Teachers’ Perceptions of the Classroom Uses of ICT’, *Educational Review* 57 (4) 471-490.

John, P and Sutherland, R (2005), ‘Affordance, Opportunity and the Pedagogical Implications of ICT’, *Educational Review*, 57 (4) 405-413.

Joo, M, Bong, J and Choi, H (2000), ‘Self-Efficacy for Self-Regulated Learning, Academic Self-Efficacy and Internet Self-Efficacy in Web-Based Instruction. *Educational Technology Research and Development* 48 (2) 5-17.

Kaplan, A (2008), ‘Clarifying Metacognition, Self-regulation and Self-regulated Learning: What’s the Purpose? *Educational Psychology Review* 20, 477-484.

Ke, F and Grabowski, B (2007), ‘Game Playing for Maths Learning: Cooperative or Not?’, *British Journal of Educational Technology* 38(2) 249-259.

Kebritchi, M and Hirumi, A (2008) ‘Examining the Pedagogical Foundations of Modern Educational Computer Games’, *Computers and Education* 51, 1729-1743.

Kirschner, P, Sweller, J and Clark, R (2006) ‘Why Minimally Guided Learning Does Not Work: An Analysis of the Failure of Discovery Learning, Problem-Based Learning, Experimental Learning and Inquiry-Based Learning, *Educational Psychologist* 41(2), 75-86.

Kuhn, J B, Katz, J B and Pearsall, S (2004), ‘Developing Reason’, *Thinking and Reasoning* 10, 197-217.

Lajoie, S P (2005), ‘Cognitive Tool for the Mind: the Promises of Technology: Cognitive Amplifiers or Bionic Prosthetics?’, in R.J. Sternberg, R J and Preiss, D (eds) *Intelligence and Technology: Impact of Tools on the Nature and Development of Human Skills*, Mahwah, Erlbaum.

Lajoie, S P (2008), ‘Metacognition, Self-regulation and Self-regulated Learning: a Rose by any Other Name’*,* *Educational Psychology Review* 20, 469-475.

Lajoie, S P and Azevedo, R (2006), ‘Teaching and Learning in Technology-Rich Environments’, in Alexander, PA and Winne, PH (eds) *Handbook of Educational Psychology*, Mahwah, Erlbaum.

Laurrilard, D (2008), ‘Technology Enhanced Learning as a Tool for Pedagogical Innovation’, *Journal of Philosophy of Education* 42(3-4) 521-533.

Laurrilard, D (2009), ‘The Pedagogical Challenges to Collaborative Technologies’, *International Journal of Computer-Supported Collaborative Learning*.4 (1), 5-20

Leitch, R, Gardner, J, Mitchell, S, Lundy, L, Odena, O, Galanouli, D and Clough, P (2007), ‘Consulting Pupils in Assessment for Learning classrooms: the Twists and Turns of Working with Students as Co-researchers’, *Educational Action Research* 15 (3), 459-478.

Leitch, S (2006), *Prosperity for all in the Global Economy: World Class Skills*, Final Report, London, The Stationery Office.  
www.dcsf.gov.uk/furthereducation/uploads/documents/2006-12%20LeitchReview1.pdf

Leney, T (2003), ‘Developing the 14-19 Curriculum and Qualifications in England – Aims and Purposes: International and Comparative Aspect’, Discussion Paper for Nuffield Review of 14-19 Education and Training.

Lester, J C, Stone, B A and Stelling, G D (1999), ‘Lifelike Pedagogical Agents for Mixed Initiative Problem Solving in Constructivist Learning Environments’, *User Modelling and User-Adapted Interaction* 9, 1-44.

Madden, M, Chung, P W H and Dawson, C W (2009), ‘Cartoons Beyond Clipart: A Computer Tool for Storyboarding and Storywriting’, *Computers and Education* 52, 188-200.

Martin-Blas, T and Serrano-Fernandez, A (2009), ‘The Role of New Technologies in the Learning Process: Moodle as a Teaching Tool in Physics’, *Computers and Education* 52, 35-44.

Marton, F and Säljö, R (1976), ‘On Qualitative Differences in Learning — 1: Outcome and Process’, *British Journal of Educational Psychology,* 46, 4-11.

Marton F and Säljö, R (1976), ‘On Qualitative Differences in Learning — 2: Outcome as a Function of the Learner's Conception of the Task’, *British Journal of Educational Psychology* 46, 115-27.

Mayer, R E (2001), *Multimedia Learning*, Cambridge University Press.

Mayer, R and Chandler, P (2001), ‘When Learning is Just a Click Away: Does Simple User Interaction Foster Deeper Understanding of Multimedia Messages? *Journal of Educational Psychology* 93, 390-397.

Mevarech, Z R and Fridkin, S (2006), ‘Who Benefits From IMPROVE? The Differential Effects of IMPROVE on Mathematical Knowledge and Reasoning’, Metacognition Conference, Cambridge, UK.

McCreanor, P T (2000) ‘Developing a Web-Enhanced Course: A Case Study’, in the proceedings of 2000 IEEE 30th ASEE/IEEE Frontiers in Education Conference.

McCune, V (1998), ‘Academic Development During the First Year at University’, in Rust, C (ed), *Improving Students as Learners*, Oxford, Oxford Brookes University, Centre for Staff and Learning Development.

McFarlane, A, Sparrowhawk, A and Heald, Y (2002), *Report on the Educational Uses of Games,* TEEM.  
www.teem.org.uk/publications/teem\_gamesined\_full.pdf

McIntyre, D, Pedder, D and Ruddick, J (2005), ‘Pupil Voice: Comfortable and Uncomfortable Learnings for Teachers’, *Research Papers in Education* 20(2), 149-168

Mistrano, A (2008), ‘Practitioner Research Regarding Independent Learning in Sixth-Form Education Within Eight Bedfordshire Schools’, *Teacher Development* 12(3), 165-177.

Molden, D C and Dweck, C D (2006), ‘Finding “Meaning” in Psychology: A Lay Theories Approach to Self-Regulation, Social Perception and Social Development’, *American Psychologist* 61(3), 192-203.

Moreno, R, Mayer, R E, Spires, H A and Lester, J C (2001), ‘The Case for Social Agency in Computer-Based Teaching: Do Students Learn More Deeply When They Interact with Animated Pedagogical Agents?’ *Cognition and Instruction* 19(2) 177-213.

Mujis, D (2007), ‘Understanding how pupils learn: Theories of Learning and Intelligence’, in Brooks, V, Abbott I and Bills, L (eds), *Preparing to Teach in Secondary Schools*, Maidenhead, Open University Press.

Oblinger, D (2003), ‘Boomers, Gen-Xers and Millenials: Understanding the New Students’, EDUCAUSE Review, July/August 2003.

Oblinger, D (2004), ‘The Next Generation of Educational Engagement’, *Journal of Interactive Media in Education* 8, 1-18.

Oblinger, D (2008), ‘Growing up with Google, What it Means for Education’, *Emerging Technologies for Learning* 3, 11-29.

Offir, B, Lev, Y and Bezalel, R (2008), ‘Surface and Deep Learning Processes in Distance Education: Synchronous Versus Asynchronous Systems, *Computers and Education* 51, 1172-1183.

Ofsted (2005) *Annual Report of Her Majesty’s Chief Inspector of Schools 2004/2005*, London, The Stationary Office.

Ofsted (2009), *Identifying Good Practice: A Survey of College Provision in Information and Communication Technology*, London, Ofsted.

Oliver, R (1999) ‘Exploring Strategies for Online Teaching and Learning’, *Distance Education* 20(2), 240-254.

Olson, J K (2000), ‘Trojan Horse or Teacher’s Pet? Computers and the Culture of Schools, *Journal of Curriculum Studies* 32(1), 1-9.

Olson, J K and Clough, M P (2001), ‘Technology’s Tendency to Undermine Serious Study: A Cautionary Note’, *The Clearing House*, 74(1), 8-13.

Papastergiou, M (2009), ‘Digital Game-Based Learning in High School Computer Science Education: Impact on Educational Effectiveness and Student Motivation’, *Computers and Education* 52, 1-12.

Prensky, M (2003), ‘Digital Game-Based Learning’, *ACM Computers in Entertainment* 1, 1-4.

QCDA (2008), *The Diploma and its Pedagogy,* London, QCDA.  
www.qcda.gov.uk/libraryAssets/media/The\_Diploma\_and\_its\_pedagogy.pdf

Raines, C (2002) ‘Managing Millenials’ excerpt from ‘Connecting Generations: The Sourcebook’   
www.generationsatwork.com/articles/millenials.htm

Ramsden, P (1992), *Learning to Teach in Higher Education,* London, Routledge.

Redfern, S and Naughton, N (2002), ‘Collaborative Virtual Environments to Support Communication and Community in Internet-Based Distance Education’, *Journal of Information Technology Education* 1(3), 201-211.

Redfield, D L and Waldman-Rousseau, E W (1981), ‘A Meta-Analysis of Experimental Research on Teacher Questioning Behavior’, *Review of Educational Research* 51, 237-245.

Ridgeway, J, McCusker, S. and Pead, D. (2004), *Literature Review of E-assessment*: Report 10, London, Futurelab. http://www.futurelab.org.uk/resources/publications-reports-articles/literature-reviews/Literature-Review204  
  
Rudduck, J (2003), *Pupil Voice and Citizenship Education: A Report for the QCA Citizenship and PSHE team*, QCDA.

Rudduck, J and McIntyre, D (2007), *Improving Learning Through Consulting Pupils,* Oxford, Routledge.

Ruthven, K, Hennessy, S and Brindley, S (2004), ‘Teachers Representations of the Successful Use of Computer-Based Tools and Resources in Secondary English, Mathematics and Science’, *Teaching and Teacher Education* 20(3) 259-275.

Sandford, R, Ulicsak, M, Facer, K and Tudd, T (2006), *Teaching with Games: Using Commercial Off-the-shelf Computer Games in Formal Education*, London, Futurelab.  
www.futurelab.org.uk/resources/documents/project\_reports/teaching\_with\_games/TWG\_report.pdf.

Sankaran, S R and Bui, T (2001), ‘Impact of Learning Strategies and Motivation on Performance: a Study of Web-Based Instruction’, *Journal of Instructional Psychology* 28, 191-201.

Schmid, E C (2008), ‘Potential Pedagogical Benefits and Drawbacks of Multimedia Use in the English Language Classroom Equipped with Interactive Whiteboard Technology’, *Computers and Education* 51, 1553-1568.

Selwyn, N (1999), ‘Differences in Educational Computer Use: The influence of Subject Cultures’, *The Curriculum Journal* 12(1), 11-29.

Sheard, M and Ahmed, J (2008), *Learner Strategies Using Learning Technologies in Taught Curriculum Time*, Coventry, Becta.  
http://partners.becta.org.uk/index.php?section=rh&catcode=\_re\_rp\_02&rid=15480

Shih, C C and Camon, J (2001), ‘Web-Based Learning: Relationships Among Student Motivation, Attitudes, Learning Styles and Achievements’, *Journal of Agricultural Education* 42, 12-20.

Shulman, L S (1987), ‘Knowledge and the Foundations of New Reform’, *Harvard Educational Review* 57(1) 1-22.

Simms, E (2006), *Deep Learning-1. A New Shape for Schooling*, Specialist Schools and Academies Trust.

Simons, P R J (2001), ‘Six Key Questions for Complex Learning Environments’, in Kremer, H-H and PFE Sloane (eds) *Konstruction, Implementation and Evaluation Komplexer Lehr-Lern-Arrangements* (pp173-186). Paderborn: Eusi-Verlagsgesellschaft.

Simons, P R J and Bolhuis, S (2004), ‘Constructivist Learning Theories and Complex Learning Environments in Mulder, R H and Sloane P F E (eds), *New Approaches to Vocational Education in Europe*, Didcot, Symposium Books.

Smith, H J, Higgins, S, Wall, K and Miller, J (2005), ‘Interactive Whiteboards: Boon or Bandwagon? A Critical Review of the Literature’, *Journal of Computer Assisted Learning* 21, 91-101.

Smith, T and Colby, S A (2007), ‘Teaching for Deep Learning’, *The Clearing House*, 80(5), 205-210.

Smith, P, Rudd, P and Coghlan, M (NFER)(2008), Harnessing *Technology: Schools Survey 2008 Report 1: Analysis*, Coventry, Becta.

Sorelle, A, Friedler, Yee Lin Tan, Nir J. Peer and Shneiderman, B (2008,*) ‘*Enabling Teachers to Explore Grade Patterns to Identify Individual Needs and Promote Fairer Student Assessment’*,* *Computers and Education* 51, 1467-1485.

Spector, J M (2006), ‘From Learning to Instruction’inClarebout, G and Elen, J (eds) *Avoiding Simplicity, Confronting Complexity: Advances in Studying and Designing (Computer-based) Powerful Learning Environments*, Rotterdam, Sense.

Sun, R, Slurarz, P and Terry, C (2005), ‘The Interaction of the Explicit and the Implicit in Skill Learning: a Dual-Process Approach’, *Psychological Review* 112, 159-192.

Sutherland, R, Robertson, S and John, P (2009), *Improving Classroom Learning with ICT*, Abingdon, Routledge.

Taylor, M (2006), ‘Generation NeXt Comes to College: Today’s Post-Mortem Student’, *A Collection of Papers on Self-Study and Institutional Improvement* 2, 48-55.   
www.taylorprograms.org/images/Gen\_NeXt\_article\_HLC\_06.pdf

Tindall-Ford, S, Chandler, P and Sweller, J (1997), ‘When Two Sensory Modes are Better Than One’, *Journal of Experimental Psychology: Applied* 3, 257-287.

Thompson, P (2007), ‘Developing Classroom Talk Through Practitioner Research, *Educational Action Research* 15(1), 41-60.

Tsai, M J and Tsai, C C (2003), ‘Information Searching Strategies in Web-Based Science Learning: The Role of Internet Self-Efficacy’, *Innovations in Education and Teaching International* 40, 43-50.

Van Merrienboer, J J and Paas, F (2003), ‘Powerful Learning and the Many Faces of Instructional Design: Towards a Framework for the Design of Powerful Learning Environments in DeCorte, E, Verschaffel, L, Entwistle, N and Van Merrienboer, J (eds) *Powerful Learning Environments: Unravelling Basic Components and Dimensions,* Pergamon, Oxford.

Wall, K, Higgins, S and Smith, H (2005), ‘The Visual Helps Me Understand Complicated Things: Pupils Views of Teaching and Learning with Interactive Whiteboards’, *British Journal of Educational Technology* 36, 851-867.

Wang, S and Wu, P (2008), ‘The Role of Feedback and Self-Efficacy on Web-Based Learning: The Social Cognitive Perspective’, *Computers and education* 51(4),1589-1598.

Webb, G. (1997) ‘Deconstructing Deep and Surface: Towards a critique of phenomenography’. Higher Education 33, 195-212.

Wenger, E (1990), *Towards a Theory of Cultural Transparency: Elements of a Discourse of the Visible and Invisible*, University of California.

Wertz, J V (1991), *Voices of the Mind*, Cambridge, MA, Harvard University Press.

Wertz, J V and Rupert, L, J (1993), ‘The Authority of Cultural Tools in a Sociocultural Approach to Mediated Agency’, *Cognition and Instruction* 11(3) 227-239.

Winters, F I, Greene, J A and Costich, C M (2008), ‘Self-Regulation of Learning Within Computer-Based Learning Environments: A Critical Analysis’, *Educational Psychology Review* 20, 429-444.

Yoon, F S, Ho, J and Hedberg, J G (2005a), ‘Teachers as Designers of Learning Environments’, *Computers in the Schools* 22(4), 145-157.

Yoon, F S, Ho, J and Hedberg, J G (2005b), ‘Teacher Understandings of Technology Affordances and their Impact on the Design of Engaging Learning Experiences’, *Educational Media International* 42(4), 297-316.

Yopp, R H (1988), ‘Questioning and Active Comprehension’, *Questioning Exchange* 2(3) 231-238.

Zohar, A and Peled, B (2008), ‘The Effects of Explicit Teaching of Metastrategic Knowledge on Low- and High-Achieving Students’, *Learning and Instruction* 18 (4), 337-353.

1. AutoTutor is an intelligent tutoring system that helps students learn by holding a conversation with them. The tutor appears as an animation that acts as a dialogue partner with the learner. [↑](#footnote-ref-1)
2. Second Life is an online virtual world where people can interact by creating their own avatars. The idea is that the world is created based on the imaginations of its residents. Some schools and universities use Second Life to explore its learning potential. www.secondlife.com [↑](#footnote-ref-2)
3. Learning@Europe is a virtual environment in which learners can interact. This is used for educational purposes. The idea is to foster collaboration between learners in different European countries. The site uses Webtalk3 as the core technology in providing a three dimensional environment. www.learningateurope.net/ [↑](#footnote-ref-3)