Rethinking Pedagogy for a Digital Age

Designing and delivering e-learning

Edited by Helen Beetham and Rhona Sharpe

Routledge
Taylor & Francis Group
LONDON AND NEW YORK

Chapter 1

Learning and e-learning

The role of theory

Terry Mayes and Sara de Freitas

EDITORS' INTRODUCTION

Mayes and de Freitas argue that design decisions need to be based on clear theoretical principles. While there is consensus on many theoretical issues in pedagogy, the authors identify three broadly different perspectives on learning and three sets of pedagogic priorities that arise from them. They go on to suggest that each of these perspectives is incomplete, and that a principled approach to e-learning requires an understanding of all three as distinct viewpoints on the learning process.

Introduction

It is arguable that there are really no models of e-learning per se – only e-enhancements of existing models of learning. Technology can play an important role in the achievement of learning outcomes but it is not necessary to explain this enhancement with a special account of learning. Rather, the challenge is to describe how the technology allows underlying processes common to all learning to function effectively. A true model of e-learning would need to demonstrate on what new learning principles the added value of the 'e' was operating. Where, for example, the 'e' allows remote learners to interact with each other and with the representations of the subject matter in a form that could simply not be achieved for those learners without the technology, then we may have a genuine example of added value. However, in this example the role of the technology may be primarily to get remote learners into a position to learn as favourably as if they were campus-based, rather than offering a new learning method. In such a case the enhancement is an educational one, though the underlying learning theory explains both campus-based and distance learning with the same theoretical constructs.

Even something that looks like a new paradigm for achieving learning outcomes, a peer-to-peer learner-matching tool, for example, will also not need a new account of learning, though its educational value may be enormous if it could be exploited through an infrastructure that integrated its use with quality assurance methods. We will argue in this chapter that in the powerful new learning opportunities that are being facilitated in an entirely new way through the Internet, we are beginning to witness a new model of education, rather than a new model of learning.

The need for theory

Biggs (1999) describes the task of good pedagogical design as one of ensuring that there are absolutely no inconsistencies between the curriculum we teach, the teaching methods we use, the learning environment we choose, and the assessment procedures we adopt. To achieve complete consistency, we need to examine very carefully what assumptions we are making at each stage and to align those. Thus, we need to start with carefully defined intended learning outcomes, we then need to choose learning and teaching activities that stand a good chance of allowing the students to achieve that learning, then we need to design assessment tasks that will genuinely test whether the outcomes have been reached. This process is easy to state, but very hard to achieve in an informed way. Biggs' book is largely about how the task of making the design decisions can be made more straightforward by adopting the assumptions of a constructivist pedagogical approach, where the focus is always on what the learner is actually doing: placing the learning activities at the heart of the process. Thus, Biggs uses the term 'constructive alignment' to indicate that in his view the guiding assumptions about learning should be based on constructivist theory. The relevant point is that the alignment process cannot proceed without first examining the underlying assumptions about learning, and then adopting teaching methods that align with those assumptions.

The main purpose of this chapter is to outline the theoretical underpinning of e-learning, and to argue that, to be comprehensive, e-learning design must consider three fundamental perspectives, each of which leads to a particular view of what matters in pedagogy. The intention is to show how e-learning can be approached in a principled way, which means uncovering the implicit assumptions about e-pedagogy, and then asking the right questions. We thus try to place e-learning models within the design framework described above. But the crucial step is the one Biggs made when he adopted a constructivist approach to ground the design decisions: there must be guidance on how to judge whether the learning and teaching processes adopted will really achieve the intended learning outcomes. For good pedagogical design, there is simply no escaping the need to adopt a theory of learning, and to understand how the pedagogy that is suggested by the theory follows naturally from its assumptions about what is important. Even when defining a learning outcome there are implicit assumptions about what is important. Is the learning to demonstrate smooth performance – applying a clinical procedure, say? Or is it to demonstrate the deep understanding of a principle – so that it can be explained clearly to someone else? Or is it being able to make appropriate judgements in a difficult social situation? Each of these intended outcomes would require a different kind of theoretical perspective and a different pedagogical approach.

Learning theory and pedagogical design

There are distinct traditions in educational theory that derive from different perspectives about the nature of learning itself. Although learning theory is often presented as though there is a large set of competing accounts for the same

phenomena, it is more accurate to think of theory as a set of quite compatible explanations for a large range of different phenomena. In fact it is probably true to say that never before has there been such agreement about the psychological fundamentals (Jonassen and Land 2000). Here, we follow the approach of Greeno *et al.* (1996) in identifying three clusters or broad perspectives that make fundamentally different assumptions about what is being explained.

The associationist perspective

The associationist approach models learning as the gradual building of patterns of associations and skill components. Learning occurs through the process of connecting the elementary mental or behavioural units, through sequences of activity followed by feedback. This view encompasses the research traditions of associationism, behaviourism and connectionism (neural networks). Associationist theory requires subject matter to be analysed as specific associations, expressed as behavioural objectives. This kind of analysis was developed by Gagné (1985) into an elaborate system of instructional task analysis of discriminations, classifications and response sequences. Learning tasks are arranged in sequences based on their relative complexity according to a task analysis, with simpler components as prerequisites for more complex tasks.

Neural network theory (Hinton 1992) can also be regarded as following the associationist tradition in the way that it models knowledge states as patterns of activation in a network of elementary units. This approach has not yet been applied widely to educational issues, but is potentially significant. It suggests an analysis of knowledge in terms of attunement to patterns of activities, rather than in terms of task components as traditional task analysis requires.

Robert Gagné (1985) set out the psychological principles on which the dominant approach to training has subsequently been based. The instructional approach known as Instructional Systems Design (ISD) is essentially a recursive decomposition of knowledge and skill. Much of what is termed e-learning is still based in the training departments of organizations within a training philosophy that is traditional ISD. The intellectual base for this consists of principles that are widely accepted within the organizational training culture and which derive essentially from associationism.

The basic principle of ISD is that competence in advanced and complex tasks is built step by step from simpler units of knowledge or skill, finally adding coordination to the whole structure. Gagné argued that successful instruction depends on placing constraints on the amount of new structure that must be added at any one stage. So ISD consists of several steps:

- Analyse the domain into a hierarchy of small units.
- Sequence the units so that a combination of units is not taught until its component units are grasped individually.
- Design an instructional approach for each unit in the sequence.

Analysis of complex tasks into Gagné's learning hierarchies – the decomposition hypothesis – involves the assumption that knowledge and skill need to be taught from the bottom up. This assumption has been the subject of long controversy (e.g. Resnick and Resnick 1991), but is still prevalent in e-learning. Combining this approach with immediate feedback, and with the individualizing of instruction – through allowing multiple paths to successful performance where each student is provided with the next problem contingent on their response to the previous one – led to the development of programmed instruction. This approach, ideally suited to automation through simple technology, came to be widely discredited along with the excesses of 'behavioural modification' in a crude application of behaviourist theory to education. However, it is worth underlining the point made by, for example, Wilson and Myers (2000), that although behaviourism is currently widely dismissed when offered as a serious theoretical basis for education, and mistakenly often associated with a teacher-centred model of learning, this view is seriously wide of the mark. Behaviourism was centrally concerned to emphasize active learning-by-doing with immediate feedback on success, the careful analysis of learning outcomes, and above all with the alignment of learning objectives, instructional strategies and methods used to assess learning outcomes. Many of the methods with the label 'constructivist' – constituting the currently accepted consensus on pedagogy among educational developers – are indistinguishable from those derived from the associationist tradition.

The cognitive perspective

As part of a general shift in theoretical positioning in psychology starting in the 1960s, learning, as well as perception, thinking, language and reasoning became seen as the output of an individual's attention, memory and concept formation processes. This approach provided a basis for analysing concepts and procedures of subject matter curricula in terms of information structures, and gave rise to new approaches to pedagogy.

Within this broad perspective, certain sub-areas of cognitive research can be highlighted as particularly influential, e.g. schema theory, information processing theories of problem-solving and reasoning, levels of processing in memory, general competencies for thinking, mental models, and metacognitive processes. The underlying theme for learning is to model the processes of interpreting and constructing meaning, and a particular emphasis was placed on the instantiation of models of knowledge acquisition in the form of computer programmes (e.g. Anderson and Lebiere 1998). Knowledge acquisition was viewed as the outcome of an interaction between new experiences and the structures for understanding that have already been created. So building a framework for understanding becomes the learner's key cognitive challenge. This kind of thinking stood in sharp contrast to the model of learning as the strengthening of associations.

The cognitive account saw knowledge acquisition as proceeding from a declarative form to a procedural, compiled form. As performance becomes more

expert-like and fluent so the component skills become automatized. Thus, conscious attention is no longer required to monitor the low-level aspects of performance and cognitive resources are available for more strategic levels of processing. The computer tutors developed by Anderson and co-workers (Anderson *et al.* 1995) are all based on this 'expertise' view of learning.

Increasingly, mainstream cognitive approaches to learning and teaching have emphasized the assumptions of constructivism that understanding is gained through an active process of creating hypotheses and building new forms of understanding through activity. In school-level educational research the influence of Piaget has been very significant, in particular his assumption that conceptual development occurs through intellectual activity rather than by the absorption of information. Piaget's constructivist theory of knowledge (1970) was based on the assumption that learners do not copy or absorb ideas from the external world, but must construct their concepts through active and personal experimentation and observation. This led Piaget to oppose the direct teaching of disciplinary content – although he was arguing against the behaviourist bottom-up variety, rather than the kind of meaningful learning advocated by Bruner (1960).

Collins *et al.* (1989) argued that we should consider concepts as tools, to be understood through use, rather than as self-contained entities to be delivered through instruction. This is the essence of the constructivist approach in which the learners' search for meaning through activity is central. Nevertheless, it is rather too simplistic to argue that constructivism has emerged directly from a cognitive perspective. In fact, in its emphasis on learning-by-doing, and the importance of feedback, it leans partly towards the behaviourist tradition. In its emphasis on authentic tasks, it takes much of the situativity position. The emergence of situated cognition was itself partly dependent on the influence on mainstream cognitive theory of Lave's socio-anthropological work (Lave 1988). Vygotsky's (1978) emphasis on the importance of social interaction for the development of higher cognitive functions continues to influence constructivist pedagogy. Duffy and Cunningham (1996) distinguish between cognitive constructivism (deriving from the Piagetian tradition), and socio-cultural constructivism (deriving from the Vygotskian approach).

A challenge for the design of curricula in higher and further education continues an unresolved theme in pedagogy – the fundamental tension between what Newell (1980) called weak methods, a focus on generic skills, and strong methods, which are domain specific. Many studies have shown that students' abilities to understand something new depends on what they already know. Educators cannot build expertise by having learners memorize experts' knowledge. New knowledge must be built on the foundations of already existing frameworks, through problem-solving activity and feedback.

Activities of constructing understanding have two main aspects:

- Interactions with material systems and concepts in the domain.
- Interactions in which learners discuss their developing understanding and competence.

The emphasis on task-based learning and reflection can be seen as a reaction to the rapid development of multimedia and hypermedia in the 1980s and early 1990s, in which a tendency for technology-based practice to resurrect traditional instructionist approaches was evident. Here the main focus was on the delivery of materials in which information can be more effectively transmitted by teachers and understood by learners. Indeed, for a while in the early 1990s, these trends were working in opposite directions: the research community was uniting around some key ideas of learning that emphasized the importance of the task-based and social context, while the policy makers were seizing on the potential of e-learning to generate efficiencies through powerful methods of delivering information. There are recent signs that, while still not perfectly congruent, these are no longer in opposition. Since the development of the Web, both have converged on communication as a key-enabling construct.

The situative perspective

The social perspective on learning has received a major boost from the gradual reconceptualization of all learning as 'situated'. A learner will always be subjected to influences from the social and cultural setting in which the learning occurs, which will also, at least partly, define the learning outcomes. This view of learning focuses on the way knowledge is distributed socially. When knowledge is seen as situated in the practices of communities then the outcomes of learning involve the abilities of individuals to participate in those practices successfully. The focus shifts right away from analyses of components of subtasks, and onto the patterns of successful practice. This can be seen as a necessary correction to theories of learning in which both the behavioural and cognitive levels of analysis had become disconnected from the social. Underlying both the situated learning and constructivist perspectives is the assumption that learning must be personally meaningful, and that this has very little to do with the informational characteristics of a learning environment. Activity, motivation and learning are all related to a need for a positive sense of identity (or positive self-esteem), shaped by social forces.

Barab and Duffy (2000) have distinguished two rather different accounts of situated learning. The first can be regarded as a socio-psychological view of situativity. This emphasizes the importance of context-dependent learning in informal settings and leads to the design of constructivist tasks in which every effort is made to make the learning activity authentic to the social context in which the skills or knowledge are normally embedded ('practice fields'). Examples of this approach are problem-based learning (Savery and Duffy 1996) and cognitive apprenticeship (Collins *et al.* 1989; Jarvela 1995). Here, the main design emphasis is on the relationship between the nature of the learning task in educational or training environments, and its characteristics when situated in real use.

The second idea is that with the concept of a community of practice comes an emphasis on the individual's relationship with a group of people rather than the relationship of an activity itself to the wider practice, even though it is the practice

itself that identifies the community. This provides a different perspective on what is 'situated'. Lave and Wenger (1991) characterized learning of practices as processes of participation in which beginners are initially relatively peripheral in the activities of a community and as they learn the practices their participation becomes more central. For Wenger (1998), it is not just the meaning to be attached to an activity that is derived from a community of practice: the individual's identity as a learner is shaped by the relationship to the community itself. The concept of vicarious learning (Mayes *et al.* 2001) is also based on the idea of learning through relating to others. Strictly, this occurs through observing others' learning, as for example in a master class. A great deal of conventional classroom-based learning is vicarious, and there are obvious ways in which this kind of learning is enhanced through computer-mediated communication (CMC).

There are perhaps three levels at which it is useful to think of learning being situated. At the top level is the social-anthropological or cultural perspective that emphasizes the need to learn to achieve a desired form of participation in a wider community. The essence of a community of practice is that, through joint engagement in some activity, an aggregation of people comes to develop and share practices. This is usually interpreted as a stable and relatively enduring group, scientists for example, whose practices involve the development of a constellation of beliefs, attitudes, values and specific knowledge built up over many years. Yet a community of practice can be built around a common endeavour that has a much shorter time span. Greeno *et al.* (1998) give examples of communities of practice that more closely resemble the groups studied in the social identity literature (e.g. Ellemers *et al.* 1999). Some examples are a garage band, an engineering team, a day care cooperative, a research group or a kindergarten class. It is worth noting that these are exactly the kind of groups described as activity systems in the approach that has come to be known as activity theory (Cole and Engeström 1993; Jonassen and Rohrer-Murphy 1999).

For long-term stable communities there are two different ways in which the community will influence learning. First, there is the sense most directly addressed by Wenger – someone aspires to become a legitimate participant of a community defined by expertise or competence in some field of application. The learning in this case is the learning of the practice that defines the community. This is the learning involved in becoming an accredited member of a community by reaching a demonstrated level of expertise, and then the learning involved in continuous professional development. This may be formal, as in medicine, or informal, by being accepted as a wine buff or a political activist. The second sense is that of a community of learners, for whom the practice is learning per se. That is, a very broad community identified by a shared high value placed on the process of continuous intellectual development.

At the next level of situatedness is the learning group. Almost all learning is itself embedded in a social context – the classroom, or the tutorial group, or the virtual computer-mediated communication discussion group or even the year group. The learner will usually have a strong sense of identifying with such groups, and a strong

need to participate as a full member. Such groups can have the characteristics of a community of practice but here the practice is the learning itself, in a particular educational or training setting. Or rather it is educational practice, which may or may not be centred on learning. While there have been many studies of learning in informal settings (e.g. Resnick 1987), there are comparatively few ethnographic studies of real groups in educational settings to compare with the many studies of group dynamics in work organizations (see Greeno *et al.* 1998).

Finally, learning is experienced through individual relationships. Most learning that is motivated by the other levels will actually be mediated through relationships with individual members of the communities or groups in question. The social categorization of these individuals will vary according to the context and nature of particular dialogues. Sometimes their membership of a group will be most salient, in other situations their personal characteristics will be perceived as more important. Such relationships will vary according to the characteristics of the groups involved, the context within which they operate and the strength of the relationships (Fowler and Mayes 1999). Over the last few years e-learning has begun to place more and more emphasis on a pedagogy based on learning relationships. Such an approach supports the development of discussion boards, chat rooms, instant messaging and forms of communication that include the more exotic web-based tools that are collectively referred to as 'social software'.

E-learning and the learning cycle

It is possible to view these differing perspectives as analysing learning at different levels of aggregation. An associationist analysis describes the overt activities, and the outcomes of these activities, for individual learners. A cognitive analysis attempts a level of analysis that describes the detailed structures and processes that underlie individual performance. The situative perspective aggregates at the level of groups of learners, describing activity systems in which individuals participate as members of communities. There will be few current examples of approaches that derive from taking just one level of analysis and neglecting the others. Most implementations of e-learning will include blended elements that emphasize all three levels: learning as behaviour, learning as the construction of knowledge and meaning, and learning as social practice.

We conclude that each of the three perspectives described above are integral to learning. It seems appropriate to regard them as perspectives rather than theories, since each is incomplete as an account of learning. It is tempting to regard them not as competing accounts but as stages in a cycle (cf. Mayes and Fowler 1999). The three perspectives address different aspects of the progression towards mastery of knowledge or skill, with the situative perspective addressing the learner's motivation, the associative perspective focusing on the detailed nature of performance, and the cognitive on the role of understanding and reflecting on action. Each of these perspectives is associated with a particular kind of pedagogy, and each is capable of being enhanced through e-learning. A handout summarizing the three

perspectives and their implications for teaching and assessment is provided in Appendix 1.

There is quite a long tradition of describing learning as a cycle through stages, with each cycle focusing in turn on different perspectives (Fitts and Posner 1968; Rumelhart and Norman 1978; Kolb 1984; Mayes and Fowler 1999). Such a representation of learning also carries the advantage of describing learning as iterative. Welford (1968), for example, reports work that demonstrated that practice will lead to performance improvements that proceed almost indefinitely even on simple perceptual-motor tasks. Learning should not be thought of as being completed when an assessment has been successfully passed. However, as it proceeds from novice to expert, the nature of learning changes profoundly and the pedagogy based on one stage will be inappropriate for another. Depicting our three perspectives as a cycle invites the e-learning designer to consider what kind of technology is most effective at what stage of learning. Fowler and Mayes (1999) attempted to map broad pedagogies onto types of technology, distinguishing between the technology of presenting information (primary), the technology of supporting active learning tasks and feedback (secondary), and the technology of supporting dialogue about the application of the new learning (tertiary). Such a model is attractive as a design framework since it gives maximum scope for using technology strategically: addressing different pedagogical goals in different ways.

When we consider the current landscape of e-learning another kind of model suggests itself, based perhaps on a simple dimension of locus of control. At one end of this dimension we have institutional virtual learning environments (VLEs), with their emphasis on standardization. These are at the institution-in-control end of this dimension. At the other end is an environment that empowers learners to take responsibility for their own learning to the point where they make their own design decisions. The currently popular notion of the personalization of learning environments moves us part of the way along this dimension, although it depends whether the personal choices offered allow the learner to shape the learning environment in a way that really influences pedagogic control. Some of the rapidly developing web tools for learning (Web 2.0) do provide the fully empowered e-learner with great flexibility in control of their own learning through processes allowing rich dialogue with others with whom the learner can identify (see Box 1.1). More than any previous educational technology, current tools allow the rapid identification of like-minded others, and allow learning relationships to drive both direct communication and the sharing of relevant information.

We might bring these ideas together in the following way. The stages represent a cycle that starts with the social. Motivation to start and continue learning will be derived from communities and peers. This represents the situative perspective and it is served by the various technologies that allow the identification of, and communication with, others who will share in, or contribute to in some way, the learning experience. Gradually, personal ownership of the learning activities becomes necessary for the derivation of meaning and the construction of understanding. Learning tasks come into play. These will involve the production of outputs that can

Box 1.1 The TESEP project

TESEP (Transforming and Enhancing the Student Experience through Pedagogy) is a Scottish e-learning transformation project that is attempting to show how institutions can use e-learning effectively through the application of a pedagogy that puts 'learners in control'. It is attempting to drive the development of e-learning partly through a 'demand-side' philosophy that first tries to fully empower the learners by raising their awareness and skill level in Internet-based learning. It places learners as far as possible in the role of teachers of their peers, expecting them to locate and tailor, with guidance and feedback from their tutors, appropriate learning objects. Teaching staff engage with the transformation through a cascading process of staff development, where the same principles of pedagogy that encourage us to view learners as teachers apply to teachers as learners.

only be achieved through understanding. This brings the cognitive perspective into focus. The learner will interact with subject matter, but in a way that manipulates it actively. What are usually regarded as the pedagogical inputs, learning objects, should rather be outputs, created by the learner. To reach this point, however, it will at times be necessary to subject oneself as a learner to the discipline of bottom-up mastery of the components of a task, so an associationist perspective will underpin pedagogy at key moments. As learning progresses, so the learner will benefit from checking progress with peers, and engaging in dialogue about the refinements of the developing understanding, and the associated skills, so the cycle can continue for as long as necessary.

Other chapters in this book offer a range of different approaches to learning design underpinned by the general principles discussed here. In Chapter 5, Oliver *et al.* take the notion of constructive alignment and use it to explore learning designs where activities are designed to support learning outcomes that involve conceptual change. In Chapter 6, Conole uses the three perspectives described here in a taxonomy for describing and designing learning activities.

Conclusions

We have offered a mapping of theoretical accounts of learning onto pedagogical principles for design. We have attempted to frame this account within a familiar curriculum design model, with the following stages: describing intended learning outcomes; designing teaching methods and learning environments to achieve them; making assessments to measure how well they have been achieved; and making an evaluation of whether the stages are properly aligned. Most of this will now be familiar territory. For the training of skills we adopt an associative account, with

its emphasis on task analysis and practice; for deep learning of concepts a constructivist pedagogy is emphasized, with a learner actively involved in the design of his or her own learning activity. Giving meaning to the whole process is an engagement with the social setting and peer culture surrounding it.

As our understanding of e-learning matures, so our appreciation of the importance of theory deepens. This view is one that rather challenges the conventional rationale of learning design. For most educational outcomes, theory points us clearly in a particular direction. Learners, in communities and other groups, but also individually, should be encouraged to take responsibility for the achievement of their own learning outcomes. As e-learning tools become truly powerful in their capability, and global in their scope, so it becomes more feasible to remodel the educational enterprise as a process of empowering learners to take reflective control of their own learning. This view challenges current assumptions about how far institutions can put a boundary around a learning experience.

A VLE may be seen as representing a twentieth-century instantiation of the role of institutions in attempting to manage the process. In peer-to-peer social networks we see a glimpse of a twenty-first-century view. Now that peer-to-peer learning is facilitated in a powerful way, and on a global scale, through new social networking tools such as blogs, wikis, social bookmarking and folksonomy, we see how learning can be socially situated in a way never previously possible. The Internet gives every course in every institution a potentially global span. Learning theory emphasizes the importance of this, but it does not provide us with a clear understanding of how to exploit it efficiently within the context of a mature educational infrastructure. Positioning empowered individual learners at the centre of the e-learning design process will clearly impact on the role of the educator but it is not yet clear how that role will evolve. What is clear is that theory and practice must be aligned within a coherent and workable model of education.

References

Anderson, J.R. and Lebiere, C. (1998) *The Atomic Components of Thought*, Mahwah, NJ: Lawrence Erlbaum.

Anderson, J.R., Corbett, A.T., Koedinger, K.R. and Pelletier, R. (1995) 'Cognitive tutors: lessons learned', *Journal of the Learning Sciences*, 4 (2): 167–207.

Barab, S.A. and Duffy, T.M. (2000) 'From practice fields to communities of practice', in D.H. Jonassen and S.M. Land (eds) *Theoretical Foundations of Learning Environments*, Mahwah, NJ: Lawrence Erlbaum.

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

Bruner, J. (1960) *The Process of Education*, Cambridge, MA: Harvard University Press.

Cole, M. and Engeström, Y. (1993) 'A cultural-historical approach to distributed cognition', in G. Salomon (ed.) *Distributed Cognitions: Psychological and Educational Considerations*, New York: Cambridge University Press.

Collins, A., Brown, J.S. and Newman, S.E. (1989) 'Cognitive apprenticeship: teaching the crafts of reading, writing and mathematics', in R.B. Resnick (ed.) *Knowing, Learning and Instruction: Essays in Honour of Robert Glaser*, Mahwah, NJ: Lawrence Erlbaum.

Duffy, T.M. and Cunningham, D.J. (1996) 'Constructivism: implications for design and delivery of instruction', in D.H. Jonassen (ed.) *Educational Communications and Technology*, New York: Simon & Schuster Macmillan.

Ellemers, N., Spears, R. and Doosje, B. (eds) (1999) *Social Identity: Context, Commitment, Content*, Malden, MA: Blackwell.

Fitts, P. and Posner, M.I. (1967) *Human Performance*, Monterey, CA: Brooks/Cole.

Fowler, C.J.H. and Mayes, J.T. (1999) 'Learning relationships: from theory to design', *Association for Learning Technology Journal*, 7 (3): 6–16.

Gagné, R. (1985) *The Conditions of Learning*, New York: Holt, Rinehart & Winston.

Greeno, J.G., Collins, A.M. and Resnick, L. (1996) 'Cognition and learning', in D.C. Berliner and R.C. Calfee (eds) *Handbook of Educational Psychology*, New York: Simon & Schuster/Macmillan.

Greeno, J.G., Eckert, P., Stucky, S.U., Sachs, P. and Wenger, E. (1998) 'Learning in and for participation in work and society', paper presented at US Dept of Education and OECD Conference on How Adults Learn, Washington DC, April 1998.

Hinton, G.E. (1992) 'How neural networks learn from experience', *Scientific American*, 267 (3): 144–51.

Jarvela, S. (1995) 'The cognitive apprenticeship model in a technologically rich learning environment: interpreting the learning interaction', *Learning and Instruction*, 5 (3): 237–59.

Jonassen, D.H. and Land, S.M. (2000) *Theoretical Foundations of Learning Environments*, Mahwah, NJ: Lawrence Erlbaum.

Jonassen, D.H. and Rohrer-Murphy, L. (1999) 'Activity theory as a framework for designing constructivist learning environments', *Educational Technology Research and Development*, 47 (1): 61–80.

Kolb, D.A. (1984) *Experiential Learning: Experience as the Source of Learning and Development*, Englewood Cliffs, NJ: Prentice-Hall.

Lave, J. (1988) *Cognition in Practice: Mind, Mathematics and Culture in Everyday Life*, Cambridge: Cambridge University Press.

Lave, J. and Wenger, E. (1991) *Situated Learning: Legitimate Peripheral Participation*, Cambridge: Cambridge University Press.

Mayes, J.T. and Fowler, C.J.H. (1999) 'Learning technology and usability: a framework for understanding courseware', *Interacting with Computers*, 11: 485–97.

Mayes, J.T., Dineen, F., McKendree, J. and Lee, J. (2001) 'Learning from watching others learn', in C. Steeples and C. Jones (eds) *Networked Learning: Perspectives and Issues*, London: Springer.

Newell, A. (1980) 'One final word', in D.T. Tuma and F. Reif (eds) *Problem Solving and Education: Issues in Teaching and Research*, Mahwah, NJ: Lawrence Erlbaum.

Piaget, J. (1970) *Science of Education and the Psychology of the Child*, New York: Orion Press.

Resnick, L.B. (1987) 'Learning in school and out', *Educational Researcher*, 16: 13–20.

Resnick, L.B. and Resnick, D.P. (1991) 'Assessing the thinking curriculum: new tools for education reform', in B.R. Gifford and M.C. O'Connor (eds) *Changing Assessment: Alternative Views of Aptitude, Achievement and Instruction*, Boston: Kluwer.

Rumelhart, D.E. and Norman, D.A. (1978) 'Accretion, tuning and structuring: three modes of learning', in J.W. Cotton and R.L. Klatzky (eds) *Semantic Factors in Cognition*, Hillsdale, NJ: Erlbaum.

Savery, J.R. and Duffy, T.M. (1996) 'Problem-based learning: an instructional model and its constructivist framework', in B.G. Wilson (ed.) *Constructivist Learning Environments: Case Studies in Instructional Design*, Mahwah, NJ: Educational Technology Publications.

Vygotsky, L.S. (1978) *Mind in Society*, Cambridge, MA: Harvard University Press.

Welford, A.T. (1968) *Fundamentals of Skill*, London: Methuen.

Wenger, E. (1998) *Communities of Practice: Learning, Meaning, and Identity*, Cambridge: Cambridge University Press.

Wilson, B.G. and Myers, K.M. (2000) 'Situated cognition in theoretical and practical context', in D.H. Jonassen and S.M. Land (eds) *Theoretical Foundations of Learning Environments*, Mahwah, NJ: Lawrence Erlbaum.