

## **THEORIES OF LEARNING AND THEIR IMPLICATIONS FOR ON-LINE ASSESSMENT**

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### **ABSTRACT**

The pedagogy underlying online learning and teaching is being reconceptualised to incorporate the opportunities being offered by the development of online educational settings. The pedagogy of constructivism and in particular socio-constructivism is underpinning much of the online learning and teaching developments currently being developed. The developments in online learning and teaching however are not being matched by developments in computer based assessment. The scope of computers to offer varied, adaptive and unique assessment is still underdeveloped according to Brown, Race and Bull (1999).

This paper briefly reviews the theories of learning and their relationship with traditional forms of assessment and seeks to argue for the need to further develop online assessment tools to further facilitate the growth in process based learning activities such as collaborative and cooperative group work consistent with a socio-constructivist pedagogy.

**Keywords:** On-line assessment, theories of learning, socio-constructivism, assessment of group work.

### **INTRODUCTION**

Most educational establishments, but particularly Universities are based upon disciplines and much of their practices and culture is bound up with perpetuating and promoting the inherited and transmitted wisdom that makes up the discipline base. Disciplines have traditionally strongly influenced the way that academics frame their thinking and professional identities. Members of the community that make up the discipline also transmit accepted wisdom in respect of teaching, learning and assessment within their chosen discipline. While individuals may from time to time seek to challenge or shift the dominant paradigm, it can in practice take generations for permanent changes to occur, (McDermott 1999).

Many academics will have strong ideas about the most appropriate ways to assess students in their own discipline. Online learning, however, offers new opportunities and Computer Assisted Assessment can be seen as going against the established ethos of academic power over the assessment process (Brown et al 1999). Academics using this medium should therefore resist the temptation to simply transfer the issues and practices of face to face or distance education to web-based courses but must, according to O'Reilly and Morgan (1999), 'find new ways to think about assessment'. When considering the potential change that may arise from Information Technology it is therefore important to set those changes in the context of established and emerging theories of how learning occurs. Online learning and therefore online assessment has the potential to increase

access for learners and this is part of its inherent appeal to policy makers in Higher Education.

The increase in access arises from increasing choice, so called 'anytime anywhere' education not only makes courses open to an extended range of distance or international students, but it also provides options to allow learners to gravitate towards personal preferences in terms of modes of study which can range from peer discussion, team work and international collaboration to print based online private study and beyond. New models of assessment beyond the regular use of essays and examinations will need to be provided to not only match these student preferences but should also provide opportunities for the achievement of an expanded range of learning outcomes to fit in with the aspirations and expectations of the extended student body. If assessment models remain unchanged and if print-based options remain open to students then, for some at least, there may be no incentive to go online at all. This paper will therefore initially review some of the theories of learning and then consider how assessment might be employed within those contexts before looking at the potential impact of Computer Assisted Assessment.

### **THERE HAVE BEEN TWO MAIN SCHOOLS OF THOUGHT REGARDING HOW LEARNING OCCURS**

The behaviourists take the view that learning is brought about through stimulus, response and reward, a form of conditioning process or associative learning. Complex associations or 'habitual behaviour strings' in response to the stimulus or 'input' are built up gradually or shaped through the teaching inputs which over time demand increasingly sophisticated chains of behaviour to attain the reward of 'positive feedback' or 'reinforcement'. The 'outputs' – the complex behaviour strings required - are expressed as learning outcomes. The behaviourist school sees clearly articulated assessment criteria as an attempt to define the learning or outputs from this educational or conditioning process, Race (2001).

The other main approach to the study of learning, the cognitive view focuses on gaining insights into the perceptual recognition, inferential reasoning and recall processes, including short and long term memory, and concept formation thought to underpin thinking and learning. This school looks at the ways in which students solve problems as a way of gaining insights into these processes. As two students may solve the same problem in different ways this view recognises that different understandings of knowledge may be equally valid.

'Cognitive development' (e.g. Piaget 1969, Vygotsky 1978) focuses on the qualitative changes that occur in thinking over time and through accumulating experiences, Macalpine (2004). In teaching and learning this strand is particularly influential developing from an influential book by Kolb (1984) on 'Experiential Learning', which was an extension of earlier work by Lewin (1952). Kolb argues that most of what we know we learn from experience and he develops a learning cycle, which breaks down this experiential learning into four stages; conceptualisation, planning, experience and reflection, Kolb (1984).

'Situated cognition' (e.g. Lave and Wenger 1991) emphasizes the social nature of cognition and the importance of learning in an authentic context. Within situated learning it is important that authentic and relevant tasks that relate to the learners' everyday work and cognition are provided for assessment (Fox 2002; Goodyear 2000; Brown, Collins and Duguid 1989; Jonassen and Tessmer 1999; Wenger 2000.) Within an online learning context it is also argued by some that learners must not only be involved with activities rooted in real-world experience, but also that they must be engaged with other people.

'Engagement theory' (e.g. Kearsly and Shneiderman, 1998) says that for successful learning activities to take place students must be engaged in meaningful tasks, with other people, not just computer programs (see also Salmon 2002).

'Schema theory' (e.g. Ausubel 1980) another strand within the broader cognitive school that puts particular emphasis on starting points, arguing that the most important factor influencing learning is what the student already knows, Ausubel (1968). Here the mechanisms by which associations are formed, neural connections made and habitual response chains developed are sought. However, Ausubel's theory and also the work of those working in visual and auditory perception, attest the complex ways in which what we already know determines what we see and hear through processes of inference. Thus the formation of new associations based on new input is coloured by existing conceptual structures in ways not predicted by behavioural theory alone. The learner develops richer schemata by relating new learning to already existing schemata. This cognitive-psychology approach with its notion of anchoring concepts and information processing is seen by some (e.g. Race, 2001) as bringing together useful elements of the cognitive and behaviourist way of thinking about learning. Assessment in this context requires opportunities to apply knowledge in new settings and compare and make links to old schemata.

Within the cognitive-psychology approach other researchers have looked at individuals' learning skills, such as information processing (e.g. Newell and Simon 1972; Gagne 1985), their approaches to learning and their learning styles. (e.g. Pask 1976 and Honey and Mumford 1986). These approaches have significant implications for the behaviourists as they show that the reaction of individual students to a given stimuli may vary depending on a range of personal attributes. The resultant division of students into knowledge seekers or understanding seekers has clear implications when designing learning activities and assessment instruments. Ramsden (1992) gives an alternative review of some of the models of learning while also mentioning some of the differences between surface and deep approaches to learning. The importance of assessment design as an influence on the approach to learning is the theme of work by Gibbs (1999).

An alternative perspective is to consider teaching rather than learning. Gagne (1985) provides an instructional theory in which he describes a series of nine instructional events that form a sequence for supporting learning. At a more basic level teaching is often viewed as either knowledge transmission or as assisting and facilitating the students' discovery of knowledge. In popular terms these two extremes refer to the teacher as either 'the sage on the stage' or 'the guide on the side' Harasim et al (1995). Biggs (1999) brings together a comprehensive survey of the links between teaching and learning (see also Fry et al 1999).

Skinner (1954) presented one of the seminal papers for the behavioural school in which he stressed the importance of repeated practise and the use of reward mechanisms to reinforce what was seen as appropriate responses or behaviour. This can correspond to frequent formative assessment with positive feedback or approaches that use credit accumulation.

*"It appears that the merging of formative and summative assessment processes is an important outcome of effective online assessment. The facility to provide speedy formative feedback in a series of incremental assessments that build upon each other means that the critical formation function of assessment can be maximised" (O'Reilly and Morgan, 1999).*

Another important figure within the behavioural school was Bloom (1956) who put forward the 'Taxonomy of Educational Objectives' which underpins much of the competency based philosophy behind the learning outcomes based model that is gaining ground in tertiary education in the UK. An online assessment system, which incorporates

multimedia and is capable of offering simulations for the assessment of lab' skills or field work is outlined by Mackenzie (1999). Many of the questions in this system are, according to Bull and McKenna (2004), thought capable of testing higher learning levels, such as application, analysis and synthesis. Bennett (1998) predicts that the real growth area for computer assisted assessment is in virtual reality simulations. Outside of higher education such simulations are already extensively used in areas such as aviation and the military to train and assess pilots and air-traffic controllers.

In her influential book 'Rethinking University Teaching' Laurillard (1993) not only reviews the key studies in the research literature on the nature of academic learning, but goes on to develop her own 'conversational framework', which could be viewed as an adaptation or refinement of the experiential learning approach of the cognitive psychologists. It is, however, more commonly associated with the socio-constructivist perspective. While Gergen (1995) also explores the use of the metaphor of dialogue to evaluate a number of educational practices this is at the level where fragments of dialogue are viewed as knowledge as opposed to Laurillard who sees conversation as a necessary process in building knowledge.

In much the same way as Laurillard's conversational model could be viewed as a development from experiential learning, constructivism could be viewed as developing from the cognitive-psychology school; however it is now generally accepted as constituting a separate school of thought.

A constructivist view sees education as student-centred; the students construct knowledge for themselves, building upon what they already know. Within this broad label 'constructivism' are a number of different perspectives. If we consider constructivism as a lens for examining educational practices then the different strands of constructivism could be viewed as different grades for that lens.

Von Glaserfeld (1990) describes and distinguishes between 'trivial or personal constructivism', 'radical constructivism' and 'social constructivism'. Others have added 'cultural' and 'critical' constructivism to these perspectives. The points of contact between these concepts are many as they represent different perspectives on constructivism as a referent to view educational practice (Dougiamas 1998).

At its most basic level trivial constructivism says 'knowledge is actively constructed by the learner, not passively received from the environment' (Dougiamas, 1998 p5) and this reacts against other epistemologies promoting models of communication as a simple transmission of meaning from one person to another. From a radical constructivist perspective, communication need not involve identically shared meanings between participants. It is sufficient for their meanings to be in some way compatible (Hardy and Taylor, 1997). These aspects of constructivism look to the individual learner as constructor, neither trivial nor radical constructivism consider to any great extent, the effect of the environment and interactions within the environment on learning.

Social constructivism recognises that a learner is affected by those around them, including teachers, peers, friends and society in general. Many of the ideas of social constructivism may be traced back to the work of Vygotsky (1978) a pioneering theorist in psychology who considered the roles that society plays in the development of an individual. Salomon and Perkins (1998) model the social entity as a learner and compare and contrast it with the learning of an individual in a social setting. They identify three main types of relationship:

- Individual learning can be less or more socially-mediated learning;
- Individuals can participate in the learning of a collective, sometimes with what is learned distributed throughout the collective more than in the mind of any one individual;
- Individuals and social aspects of learning in both of these senses can interact over time to strengthen one another in a 'reciprocal spiral relationship'.

Teaching and learning strategies using social constructivism as a referent often value meaningful activity over correct answers (Wood et al, 1995) which has significant implications for assessment models, which would then need to consider process as well as or instead of the product.

Cultural constructivism puts learning into a wider context by recognising cultural influences including the tools that are in common use. The term tool in this context not only covers physical tools but also language and other symbolic systems. Saloman and Perkins (1998) identify two effects of tools on the learning mind; firstly they redistribute the cognitive load of a task between people and the tool being used. Thus for example a label, a tool of language, can save long explanations: secondly the tool itself can affect the mind beyond actual use by changing skills, perspectives and ways of representing the world. An example of this second point would be computers, which carry with them a entire philosophy of knowledge construction, symbol manipulation, design and exploration, all of which affects teaching and learning in its widest sense.

*"Higher mental functions are, by definition, culturally mediated. They involve not a direct action on the world but an indirect one, one that takes a bit of material matter used previously and incorporates it as an aspect of action. Insofar as that matter itself has been shaped by prior human practice (eg. it is an artefact), current action incorporates the mental work that produced the particular form of that matter" (Cole and Wertsch, 1996, p. 252).*

Although commentators primarily discuss social constructivism when considering computer mediated learning, elements of cultural constructivism are equally important in that learning and teaching that is mediated by information technology will generate or reinforce skills and knowledge of the medium as well as the subject being taught or studied. It is noted by Bull and McKenna (2004) that some CAA might require 'a certain level of electronic literacy, before students are able to participate.' This aspect should not be overlooked when considering the more common arguments that computer mediated learning increases access to higher education.

Taylor (1996) describes critical constructivism as a social epistemology that addresses the socio-cultural context of knowledge construction and serves as a referent for cultural reform. Thus critical constructivism looks at constructivism within a social and cultural environment but adds a critical dimension aimed at reforming these environments in order to improve the success of constructivism when applied as a referent (Dougiamas 1998). By adding a critical dimension, knowledge however constructed, is more open to question through conversation and critical self-reflection. An important part of this approach is recognising that learners can often think and act in more complex ways when they are in supportive environments. The challenge for the teacher is then to establish and promote environments that encourage dialogue oriented towards achieving reciprocal or mutual understandings (Taylor, 1998). This aspect of constructivism has close parallels with cognitive development discussed above . It can be argued that constructivism occurs well when the learner is engaged in constructing dialogue or creating texts for others to see and answer back to. This can be either in conversation or formal feedback.

*"Constructivism shares constructivism's connotation of learning as 'building knowledge structures' irrespective of the circumstances of learning. It then adds that this happens especially felicitously in a context when the learner is consciously engaged in constructing a public entity ... If one eschews pipeline models of transmitting knowledge in talking among ourselves as well as in theorizing about classrooms, then one must expect that I will not be able to tell you about my idea of constructivism. Doing so is bound to trivialise it. Instead, I must confine myself to engage you in experiences (including verbal*

*ones) liable to encourage your own personal construction of something in some sense like it. Only in this way will there be something rich enough in your mind to be worth talking about" (Papert, 1990).*

The metaphor of dialogue considered by Gergen (1990), Steier (1996) and the conversational framework developed by Laurillard (1993) are all influential aspects in the development of web-based tools to support learning and are all approaching learning from a constructivist standpoint. While online learning is used to support styles of teaching and learning encompassing all of the viewpoints discussed above, it is the pedagogy of constructivism that has been popularly adopted in web-based teaching and learning, O'Reilly and Morgan 1999. In online teaching and learning constructivism at its most basic level is evidenced by the plethora of course discussion lists and conferences that accompany many online courses. Not only must conferencing be carefully integrated with course content (Collins and Berge 1996), but if it is to enhance student learning it should be in some way assessed (Day 1998). While there is increasing interest in exploring ways in which interactions such as discussion fora can be incorporated into assessment practices the mere quantity of a student's participation is no measure of the quality of their contribution. Attempts to assess the value of an individual's contribution to discussions (Garrison et al 2001) and tools that graphically display levels of participation in discussions against defined criteria (Kuminek and Pilkington 2001) are increasingly being developed.

*"Research concerning online discourse (Holt et al 1998) has found that the 'actions of the moderator are peripheral instead of central' and should aim at facilitating and supporting discussion between students", (O'Reilly and Morgan 1999, page 151).*

This is totally consistent with the constructivist perspective and is indicative of the need for online teachers to reconsider their pedagogy if online discourse, arguably one of the strongest features of the online medium is to be used effectively as a learning tool.

## CONCLUSION

Traditional methods of assessment, notably the essay and the closed book examination have evolved little. As teaching and learning has struggled to keep up with the advances in technology, initially online assessment simply converted existing assessment from paper to screen, Brown, Race and Bull (1999). Objective tests are the most extensive area of on-line assessment and include a wide range and style of tests in order to fulfil the varied roles assigned to them by the two schools of learning theory. Regular self testing and formative feedback fits in with the behaviourists, while the cognitivists have developed graded questions to take the assessment beyond memory recall to test some higher level learning outcomes. The scope of computers to offer varied, adaptive and unique assessments is, according to Brown, Race and Bull (1999), still underdeveloped.

Some of the best examples of online assessment have resulted from teachers who, according to O'Reilly and Morgan (1999), have shown a willingness to reconceptualise their pedagogy in the light of issues raised by on-line learning. The more ordinary, and it must be admitted common, examples of online assessment are where this reconceptualisation has not taken place. New models of online assessment provide opportunities for the achievement of an expanded range of learning outcomes which include the accessing and management of information as well as managing and developing oneself, (Nightingale et al 1996). There are also indirect outcomes concerning communication skills and IT skills that arise from the medium itself. Such opportunities should allow the broadening of assessment methods beyond the regular use of essays and examinations.

However for these new models of assessment to be forged the underlying pedagogy needs to be reconceptualised to combine the traditional strength of the subject

disciplines with the opportunities that the online mediums provide. As noted above some subject disciplines see higher education as an induction for the student to be admitted into the community that is that discipline. That viewpoint is fundamentally affected by online learning. The forms of interaction and dialogue available through synchronous and asynchronous communication tools opens up opportunities for learners to become part of a much wider professional or vocational community not bounded by college walls or academic subjects. These wider discourses are what may be called online communities.

Internet technology has also provided opportunities for group projects and international collaboration. Students now have opportunities to learn directly from and about other cultures through shared learning tasks (Alexander and McKenzie 1998). Such collaborative experiences can considerably enrich the contextual perspectives of the participants (Day 1998) as well as expand the boundaries of learning communities and subject disciplines as noted above.

Online or computer assisted assessment ranges from the adaptation of traditional forms of assessment for use online through discussion fora and reflective learning diaries to virtual reality simulations. Although conversation and debate have long been part of the learning process, the ability of computers to capture and store those conversations and debates is allowing them to be incorporated into formal assessment practices. The time lag built into asynchronous discussions allows for reflective thinking, a sign of a deeper approach to learning, which is the aim of most higher education courses. The development of such possibilities for assessment is affecting the pedagogic paradigm. Within the online teaching community there is a shift from the individual cognitive or behaviourist perspective towards social, cultural and critical constructivist pedagogy.

Against this background group work and the associated team skills are increasingly desired by employers of our graduates. In response to those market forces courses at all levels within higher education are increasingly including group work and specifically attempting to develop group skills as part of their curriculum. Group work, even in a traditional face to face setting can be seen as problematic to assess. In an online teaching and learning environment there is enormous potential for cooperative or collaborative work within groups particularly among geographically diverse student populations. At present there does not appear to be an adequate mechanism for identifying and formally assessing group skills in an online environment and this is accordingly an area for future research work.

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## REFERENCES

- Alexander, S. and McKenzie, J. (1998) *Evaluation of IT in University Learning: the CAUT Experience* Australian Government Printing Service: Canberra.
- Ausubel, D. P. (1968) *Educational Psychology: A cognitive view*. Holt, Rinehart & Winston: N.Y.
- Ausubel, D. P (1980) *Schemata, Cognitive Structure and Advance Organisers: A reply to Anderson, Spiro and Anderson*. American Educational Research Journal, 17, pp. 400-404.
- Bennett, R.E. (1998) *Reinventing assessment: speculation on the future of large-scale educational testing*. Research Report. New Jersey: Educational Testing Service. Available from <http://www.ets.org/research/newpubs.html>
- Biggs, J. (1999) *Teaching for Quality Learning at University*. OU Press/SRHE Buckingham.
- Bloom, B. S. Engelhart MB, Frust,EJ. Hill,WH & Krathwohl,D.R. (1956) *Taxonomy of Educational Objectives, Cognitive Domain*. McKay: New York.
- Brown, G. & Atkins, M. (1988) *Effective Teaching in Higher Education*, London Routledge;.
- Brown, J.; Collins, A. and Duguid, P. (1989) *Situated Cognition and the Culture of Learning*. Educational Researcher 18 (1) pp.32-41.
- Brown, S.; Race, P. and Bull, J. (Eds) (1999) *Computer Assisted Assessment in Higher Education* Staff and Educational Development Series. Kogan Page: London.
- Bull, J. and Mckenna, C. (2004) *Blueprint for Computer-Assisted Assessment* Routledge Farmer: London.
- Cole, M. and Wertsch, J.V. (1996) *Beyond the individual-social antimony in discussion of Piaget and Vygotsky*. Human Development 39 00250 – 256.
- Collins, M. and Berge, Z. (1996) *Facilitating interaction in computer mediated online courses*. <http://star.ucc.nau.edu/mauri/moderate/flec.html>
- Day, I (1998) *Communication and the media* Report on Web delivery trial, <http://www-p.roma.unisa.edu.au/10701/index.htm>
- Dougiamas, M. (1998) *A Journey into Constructivism*. (accessed 8/7/04) <http://dougimas.com/writing/constructivism.html>
- Dougiamas, M. (1999) *Moodle—a web application for building quality online courses*. <http://moodle.com/> (accessed 8/7/04).
- Fox, S. (2002) *Studying networked learning: Some Implications from Socially Situated Learning Theory*. In *Network Learning: Perspectives and Issues*, (Eds) Staples, C. and Jones C. Springer-Verlag: London
- Fry, H. Ketteridge, S. and Marshall, S. (1999) *A Handbook for Teaching and Learning in Higher Education - Enhancing academic practise*. Kogan Page: London.
- Gagne, R. (1985) *The conditions of learning* Holt Reinhart and Winston: New York.
- Gergen, K. J. (1995) *Social Constructivism and the Educational Process*. In Steffe, L.P. and Gale, J. (Eds) *Constructivism in Education*. Pp401–422 Erlbaum: New Jersey.
- Gibbs, G. 1999 *Using assessment strategically to change the way students learn, in Higher Education—Choosing and using diverse approaches* (eds) Brown. S & Glasner A. OU Press: Buckingham.

Goodyear, P. (2002) *Psychological Foundations for Networked Learning*. In *Network Learning: Perspectives and Issues*, (Eds) Staples, C. and Jones C. Springer-Verlag: London.

Harasim, L.; Hiltz, S.; Teles, L. and Turoff, M. (1995) *Learning Networks: A field Guide To Teaching And Learning Online*. MIT Press: Cambridge MA.

Hardy and Taylor (1997) *Von Glaserfeld's Radical Constructivism: A Critical Review*. *Science and education* Vol 6, pp. 135–150.

Holley, D. and Oliver, M. (2000) *Pedagogy and new power relationships*. *The International Journal of Management Education*, Vol.1 No. 1, pp. 11-21.

Holt, M.; Rees, F.; Swenson, J. and Klieber, P. (1998) *Evolution of Evaluations For Critical, Reflective and Deliberative Discourse: National Issues Forums Online*. <http://www.coe.uga.edu/adulted/faculty/mholt/paper1.html>

Honey, P. and Mumford, A. (1986) *Using Your Learning Styles*. Honey: Maidenhead  
Jonassen, D. and Tessmer, M. (1999) *Learning With Technology: A Constructivist perspective*. Prentice Hall: London.

Kearsley, G. and Shneiderman, B. (1998) *Engagement Theory: A Framework for Technology-Based Teaching and Learning*. *Educational Technology*, Sept/Oct pp. 20-37.

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

Kuminek, P. A. and Pilkington, R.M. (2001) *Helping The Tutor Facilitate Debate to Improve Literacy Using Computer Mediated Communication*. IEEE International Conference on Advanced Learning Technologies: Issues, Achievemnet and Challenges, Madison, Wisconsin 6-8 August.

Laurillard, D. (1993) *Rethinking University Teaching: A Framework for The Effectivce Use Of Educational Technology*. Routledge: London.

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

Lewin, K. (1952) *Field Theory in Social Science in Selected Theoretical Papers*. (Ed) D.Cartwright. Tavistock: London.

Macalpine, L. (2004) *Designing Learning as Well as Teaching. A Research-Based Model for Instruction That Emphasizes Learner Practice*. *Active Learning in Higher Education* Vol 5, (2), pp. 119-134.

Mackenzie, D. (1999) *Recent Developments in the Tripartite Interactive Assessment Delivery System (TRIADS)* in M. Dawson and R. Sherratt (eds) *Proceedings of the 3<sup>rd</sup> International Computer-assisted Assessment Conference 16-17 June Loughborough University*: pp.235–250 <http://www.lboro.ac.uk/service/ltid/flicaa/conferences.html> (accessed 8 July 2004).

McDermott, R. (1999) *Why Information Technology Inspired But Cannot Deliver Knowledge Management*. *California Management Review* 41 (4) pp. 103-17.

Newell, A. and Simon, H. (1972) *Human Problem Solving*. Prentice Hall: Englewood Cliffs, New Jersey.

Nightingale, P. et al. (1996) *Assessing Learning in Universities*. UNSW Press: Sydney.

O'Reilly, M. and Morgan, C (1999) *Online Assessment: Creating Communities And Opportunities*. In Computer Assisted Assessment in Higher Education. Brown, S.; Race, P. and Bull, J. (Eds) Staff and Educational Development Series. Kogan Page: London.

Papert, S. (1991) *Preface* In Harvel, I and Papert, S. (Eds) *Constructivism, Research Reports and Essays 1985-1990*. p. 1 Norwood: New Jersey.

Pask, G. (1976) *Styles and Strategies of Learning*. British Journal of Educational Psychology. Vol. 46, pp. 12-25.

Race, P. (2001) *The Lecturers' Toolkit*. Kogan Page: London.

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

Skinner, B.F. (1954) *The Science of Learning And The Art of Teaching*. Harvard Educational Review. 24, pp. 88-97.

Salmon, G. (2002) *E-Tivities*. Kogan Page: London.

Salomon, G. and Perkes, D. (1998) *Individual and Social Aspects of Learning*. In Pearson, P. and Iran-Nejad, A. (Eds) *Review of research in Education 23*, pp. 1–24, American Educational Research Association: Washington DC.

Taylor, P (1996) *Mythmaking and Mythbraking in the Mathematics Classroom*. Educational studies in Mathematics. 31, pp. 151-173.

Taylor, P (1998) *Constructivism: Value Added*. In Fraser, B. and Tobin, K. (Eds) *The International Handbook of Science Education*. Kluwer Academic: Dordrecht, The Netherlands.

Von Glaserfeld, E. (1990) *An exposition of constructivism: Why Some like it Radical*. In Davis, R.B., Maher, C.A. and Noddings, N. (Eds) *Constructivist views on the teaching and learning of mathematics*. National Council of Teachers of Mathematics: Reston, Virginia.

Vygotsky, L. S. (1978) *Mind in Society*. Harvard University Press: Cambridge MA  
Wenger, E. (2000) *Communities of Practice and Social Learning Systems*. Organization 7 (2), pp. 225-246.

Wood, T.; Cobb, P. and Yackel, E. (1995) *Reflections on Learning and Teaching Mathematics In Elementary School*. In Steffe, L.P. and Gale, J. (Eds) *Constructivism in Education*. pp. 401–422 Erlbaum: New Jersey.