Radical existentialism meets cognitive science: a review of converging qualitative and quantitative perspectives in research into tertiary students' learning

***Frances Quinn, John Pegg and Sarah Stein*[1]**
[1] *Higher Education Development Centre, University of Otago*

Abstract

This paper presents an exploration of some research perspectives in student learning in higher education. In this area there is a strong qualitative tradition of researching how students learn in real contexts, as well as quantitative research applying cognitivist models and psychometric instruments to student learning. The paper aims to analyse the points of convergence between these different research paradigms, relating to students' approaches to learning and learning outcomes. The results of this exploration show that from independent origins, within different research paradigms, emerged some remarkably similar ideas relating to students' approaches to learning and learning outcomes. Cross-fertilisation across research programs within and between different paradigms has occurred, which has enriched research into student learning in higher education.

Introduction

Studies into student learning in higher education, from different perspectives and methodologies, have converged to offer strong support for two fundamentally different approaches that tertiary students take to their learning. These concepts are now referred to as 'deep' and 'surface' learning approaches, and over the past decade they have played a central role in much subsequent tertiary education research. As stated by Webb (1997 p.195):

> *The notion of 'deep' and 'surface' approaches to learning has been a foundation stone upon which much of the research, theory and practice of higher education has stood for twenty years. It has become the canon for educational development.*

Deep learning approaches are associated with meaningful learning. Learners, when adopting a deep approach, are motivated by intrinsic interest to understand the material and how it relates to other information and ideas. The strategies that are associated with satisfying this intrinsic motivation include reading widely, looking for connections, patterns and underlying principles, thinking about and questioning new ideas and integrating them into overall understanding and awareness. An example of a deep approach to learning was expressed by a first-year biology student at UNE:

> *Understand it. Yes. Not learn it or memorise it, I want to understand it … When you're just, like, memorising something you don't understand what's happening and you don't understand why*

> *it's happening. Yeah. I want to understand it. And understand everything that's happening which makes a difference … when I come to the lecture I don't necessarily believe what they say. I like to think about it and compare it with what other opinions I've heard … What I have struggled with is the concept that inanimate matter can do that without guidance.*

By contrast, surface learning approaches are characterised by the intention of meeting external requirements. Learners using a surface approach are motivated extrinsically to satisfy task demands, with a minimal expenditure of effort. Strategies associated with this pragmatic intention include rote-learning for accurate reproduction of information, with a focus on the essentials and individual aspects of the material. An example of a surface approach expressed by a first year biology student reflects these characteristics:

> *I just want to get through the exam … well when I first learnt it, it was like sort of who cares? I often have to get ... encouragement to make me realise that it is [relevant] … otherwise its just two separate things. Like I don't think of it as actually really ever happening. It's just what I have to learn … I just wrote down things I thought I'd forget and then read through the lecture and that's all … I'm just learning it, like rote learning it and I'm not … understanding it. I don't necessarily really understand what I'm writing.*

The concepts of deep and surface approaches to learning have been so central to research into tertiary student learning partly because of their connection with learning outcomes. Many studies have shown that deep approaches are associated with the highest quality outcomes, and surface approaches with less desirable outcomes (for reviews see Prosser & Trigwell 1999; Ramsden 1992). Moreover, the apparent strength of this relationship has underpinned much research into learning in higher education; for example, 'national programs of reform have been developed and funded around the associations between approaches to learning and the quality of the learning outcome' (Gibbs 1992 cited in Prosser & Trigwell 1999 p.92).

Of particular interest are the points of convergence between extremely different research paradigms and programs in relation to learning approaches and outcomes. The aim of this paper is to identify and review the parallels and cross-fertilisation between different research traditions, especially between idiographic and nomothetic perspectives. The terms idiographic and nomothetic were coined by the neo-Kantian philosopher Windelband. Idiographic research is focused on context-specific, subjective experiences of individuals' learning (Burns 1997 p.3), and is usually qualitative, while nomothetic research is aimed at discovery of general explanations and prediction of phenomena (Burns 1997 p.3) and is often quantitative.

Idiographic Research into Students' Learning Approaches and Outcomes

Much idiographic research using qualitative, interview-based methodology has contributed to the understanding of learning approaches. Arguably the most influential investigation of student learning in higher education is the research of Marton, Säljö and colleagues at Gothenberg University in Sweden, during the mid 1970s. These researchers took what was then a radical existentialist perspective (Biggs 1979 p.384) in focusing on the subjective experiences of students.

Marton and Säljö (1976a) asked some university students to read a passage of text. They then interviewed the students about both the meaning of the passages and the processes they used when reading them. Analysis of the interviews distinguished two 'levels of processing', which reflected a difference in students' learning focus. Surface-level processing was used by students who were focusing on learning the text ('*the sign'*), and who perceived learning as a 'reproductive' activity and used rote-learning. By contrast, deep-level processing was used by students who focused on understanding the meaning of the text *('what is signified')* (Marton & Saljo 1976a pp.7-8). A deep-surface dichotomy in learning processes (later called approaches) was strongly evident in the results of this study.

As well as investigating study processes, the research program of Marton and colleagues (reviewed by Dahlgren 1984) was simultaneously investigating learning outcomes. Qualitative analyses of student responses identified, in general, four levels of learning outcome that empirically represented qualitatively different ways of understanding (Dahlgren 1984 p.26). Although response categories were specific to the content, a pattern of structural differences was identified in many cases. For example, categories were frequently hierarchically related. Responses at the highest level contained elaborate understanding of the 'intentional content' of the argument, and responses at the next lowest level contained only part of the intentional content. Responses at the lowest two levels either missed the point, or simply restated part of the question (Marton & Saljo 1976a). These were associated with surface processing.

The alternate perspective taken by Marton and colleagues in these early studies developed into the research approach of phenomenography, which has been highly influential in higher education (e.g. Bruce & Gerber 1997; Prosser & Trigwell 1999; Ramsden 1992). The research focus of phenomenography is simply 'the variation in ways people experience phenomena in their world' (Marton & Booth 1997 p.121). Phenomenographic research uses qualitative analysis, usually of interview data, to identify this range of variation in individuals' conceptions and to interpret it by way of a small number of categories that describe the variation (Marton & Booth 1997 p.125). The categories of description that are the 'outcome space' of

phenomenographic analysis are frequently hierarchical, reflecting a hierarchy of qualitatively different and increasingly complex conceptions of phenomena (Marton & Booth 1997 p.125).

Nomothetic Research into Students' Learning Approaches and Outcomes

While idiographic research perspectives have been highly influential in higher education research since the mid 1970s, there is also a long history of nomothetic studies applying cognitivist models to student learning (e.g. Biggs 1979; Entwistle & Entwistle 1970). These studies have therefore been conducted from a very different ontological and epistemological framework to the idiographic research of Marton and colleagues. The three strands of nomothetic research discussed here include Piagetian and neo-Piagetian studies, information processing research and psychometric studies of student learning.

Piagetian and Neo-Piagetian Research

Piaget's well known and influential stage concept of cognitive development recognised usually four stages, and a number of sub-stages, to describe qualitative differences in children's cognitive development (van Geert 1998 p.636). Piaget asserted that developmental stages reflect real qualitative differences rather than arbitrary conveniences, that they occur in an invariant hierarchical sequence, and that they are defined in terms of an integrated structural whole.

Piaget's theory has attracted extensive criticism on many grounds (e.g. Ausubel 1963; Case 1992; Flavell 1963; Sternberg & Ben-Zeev 2001), particularly for its monolithic, rigid and simplistic structure, and the neglect of the influence of context on learning (Flavell 1963 p.442). Many of the criticisms of Piaget's theory, however, have in turn been criticised for barely addressing the fundamentals of the theory and the many worthwhile issues it contains (Lourenco & Machado 1996). Ausubel (1963 p.113), while forthright in his criticism of Piaget's methodology and reporting of results, argued that many of the criticisms of Piagetian stages are 'irrelevant'. Moreover there is no doubt that Piaget's theory continues to have a profound and widespread influence on research into human development and education. As stated by one prominent cultural constructivist researcher, 'Piagetian and neo-Piagetian theory has dominated educational research in the second half of the twentieth century and continues to do so' (Cobern 1993 p.52).

One influential research program directly influenced by Piaget was Ausubel's cognitive view of meaningful learning. The existence of different cognitive developmental stages was accepted by Ausubel (1963 p.115), albeit slightly differently from the Piagetian view. In his account of learning, Ausubel (1963) distinguished explicitly between rote and meaningful learning, and his distinction between these two types of learning

rested on learning ‘set’, or intention, as well as learning process (Ausubel 1963 pp.21-24). Rote learning was described as learning with the intention to ‘internalise material verbatim, as a discrete and isolated end in itself’ (p.22) and which uses processes that do not relate new material to existing concepts (p.24). Meaningful learning, by contrast, was described as learning with the intention to relate new material to existing concepts in potentially useful ways; in Ausubel’s words (p.22), using a meaningful ‘approach to learning’. Meaningful learning uses processes that facilitate the relating of new to old knowledge (p.23).

Research into learning outcomes has also been conducted within a broadly neo-Piagetian tradition. In the mid 1970s Collis and Biggs were collecting examples of different Piagetian stages from school classrooms:

> *Out of this work a taxonomy evolved which seemed to coincide with a generalised version of Marton’s notion of levels and seemed to provide a means of measuring learning quality. We called this the SOLO taxonomy because it refers to the Structure of the Observed Learning Outcome. (Biggs 1979 p.384)*

At the core of SOLO is a hierarchy of generic categories (modes and levels) describing increasingly more complex types of learning response, which can be applied to any specific learning context. The SOLO taxonomy was initially conceived as a single, unbranched hierarchy of five levels of learning responses centring on concrete thinking, which were considered as corresponding to, but ‘logically distinct’ from, Piagetian stages (Biggs 1979 p.384). The SOLO levels are hierarchical, with each succeeding level subsuming its precursor, hence, performance at any given level implies mastery of preceding levels. Underlying the hierarchy of levels in SOLO is the argument that learners show a consistent sequence in learning any skill or cognitive task, and that the SOLO levels reflect this sequence (Biggs & Collis 1991 p.64).

Information Processing Research

The second of the nomothetic traditions discussed here is information processing research. This seeks to understand the processes by which people encode, store and retrieve information, and the way these processes change with development. Different forms of memory are central in much information processing research, in particular, the relation of working memory to processing efficiency and development. Research into tertiary student learning from the information processing perspective includes a widely cited study by Craik and Lockhart (1972, cited in Dyne et al. 1994 p.374) investigating the different levels of processing in memory. As described by Dyne et al. (1994 pp.374-375), Craik and Lockhart postulated two types of rehearsal strategies that related to differences in depth of encoding processes. They found that Type 1 rehearsal emphasised attending to phonetic features of a stimulus by superficial processes such as rote repetition, leading to a weak memory trace. By contrast, Type 2 rehearsal emphasised attending to the semantic aspects of a stimulus by elaborative processing, leading to a strong more accessible memory trace.

Further research into information processing includes Biggs's (1969) coding model of cognitive behaviour. This model related stable personality traits to coding and rehearsal strategies, which in turn were thought to be associated with differences in study behaviour and learning outcomes. This underpinned Biggs's early psychometric research into students' approaches to learning, (e.g. Biggs 1987).

Psychometric Research

Psychometric research focuses on measuring and explaining individual differences, often with a focus on predicting success (Kirby & Biggs 1980 p.2) and investigating relatively stable aspects of cognition (Demetriou et al. 2002 p.2). Many inventories and taxonomies of learning styles, strategies and approaches have been developed. These used multivariate statistical techniques such as factor analysis and structural equation modelling to investigate the relationships between different variables of hypothesised relevance to student learning.

In Australia, Biggs investigated cognitive behaviour in the context of learning in the late 1960s – early 1970s, initially from an information-processing perspective, but later adopting psychometric methodologies. Biggs (1970a, 1970b) developed a Study Behaviour Questionnaire (SBQ) with which he investigated the study behaviour of first-year students in an Australian university. Factor analysis of the SBQ responses identified two main study strategies which he called 'simplifying' and 'opening out' strategies (Biggs 1970a).

According to Biggs, a student using the simplifying strategy would:

> *merely assimilate as much as possible, deliberately withholding complex interpretation: the memory load can be lessened by narrowing the field of relevant information to one set textbook say, or to the musts in the reading list…he behaves like a piece of carefully and economically placed blotting paper. (Biggs 1970a p.163)*

By contrast, the 'opening out' strategy was described as a more sophisticated study behaviour by which:

> *the content would become organised according to structures generated by the student. He would welcome the opportunity of being thrown on his own resources in a fairly open end [sic] situation (cf. Hudson 1968) and to be confronted with novelty and complexity; he would read widely and, in general, would indulge in "open system" thinking. (Biggs 1970a pp.162-163)*

Biggs (1970b) pointed out that he had envisaged these study strategies deriving from stable personality characteristics, and the SBQ led to the development of an instrument to investigate student approaches to learning; the Study Process Questionnaire (SPQ) (Biggs 1978). The SPQ was derived from principal

components analysis of the 10 scales of the SBQ. From this, Biggs described dimensions of Internalising and Reproducing approaches to learning (Biggs 1978) which were conceptually similar to the deep and surface approaches of Marton and Säljö (1976a). Biggs later (1987) aligned his terminology with the work of Marton and Säljö, renaming his two parallel learning approaches as surface and deep approaches.

At the same time as Biggs' early psychometric research in the early 1970s, Entwistle and colleagues in the United Kingdom were independently investigating student learning in higher education using a psychometric approach (e.g. Entwistle & Brennan 1971; Entwistle & Entwistle 1970). This research found a number of weak correlations between personality traits, study methods and academic performance of first year tertiary students in England (e.g. Entwistle et al. 1971). Later, Entwistle and Thompson (1974) recognised some limitations of this nomothetic approach and augmented it with semi-structured interviews, in distinguishing between three different kinds of motivation for academic success. Entwistle et al. (1979) added to their developing Approaches to Studying Inventory (ASI) new scales describing Marton and Säljö's deep and surface processing, and scales derived from previous work of Biggs. A series of studies refined the ASI, with factor analyses consistently showing two approaches to learning which were consistent with both Biggs's and Marton and Säljö's deep and surface approaches. These were later renamed as deep and surface approaches in recognition of these parallels (Tait & Entwistle 1996 p.105).

Convergence within and between Idiographic and Nomothetic Perspectives

The research programs outlined above demonstrate many areas of convergence in both learning approaches and outcomes research. These have occurred both within and between the idiographic and nomothetic perspectives, and provide substantial evidence for the robustness and validity of the central recurring concepts.

The first point of interest is in the similar, if not parallel, constructs relating to the two fundamentally different approaches to learning, that have emerged from all of the research programs outlined above. In chronological order, Ausubel (1963), from a neo-Piagetian research base, distinguished between meaningful and rote 'approaches to learning'. From an information processing perspective, Biggs (1970a) postulated 'opening out' and 'simplifying' study strategies, and Craik and Lockhart (1972, cited in Dyne et al. 1994 p.374) described 'elaborative' and 'superficial' ' levels of processing'. The idiographic study of Marton and Saljo (1976a) from a radically different paradigm found 'deep' and 'surface' 'levels of processing', with the term 'levels of processing' adopted from Craik and Lockhart on the basis of the 'metaphorical resemblance' between the concepts (Marton et al. 1984 p.42). However, neither the work of Ausubel nor Craik and Lockhart were cited in Marton & Saljo's original, seminal paper. Later, psychometric research from Biggs (1979) described

'utilising' and 'internalising' approaches which he noted as similar to the deep and surface concepts of Marton and colleagues, and later renamed as 'deep' and surface' approaches to learning. Biggs later stated that the interpretation of his factors 'was in terms of the SAL [student approaches to learning] framework, not the original IP theory' (Biggs et al. 2001 p.135), which explicitly acknowledged the influence of Marton and Säljö's deep-surface distinction on the SPQ. In the same year Entwistle et al. (1979) also incorporated ideas from Biggs and Marton and colleagues in describing 'meaning' and 'reproducing' learning approaches using psychometric techniques and instruments.

The second area of interest is in the conceptual development of the SOLO model, and its similarity to other forms of assessing learning outcome. Although the intellectual lineage of SOLO clearly encompasses features of Piagetian stage theory and falls within a broad neo-Piagetian framework, the development of SOLO differs fundamentally from this antecedent and has been influenced by research from other traditions. One important influence on the development of SOLO was research from an information processing perspective. The authors of SOLO (Biggs & Collis 1982) drew attention to the similarity between SOLO and four levels of quality in conceptual structure of written responses found from an earlier information processing model. The information processing model emphasised that response quality was context-dependent rather than consistent for individuals, and descriptions of the response levels (Schroder et al. 1967 cited in Biggs & Collis 1982 pp.13-14) show marked similarities to later descriptions of the SOLO levels. In addition, the information processing concept of working memory is a fundamental explanatory construct for the SOLO model (Biggs & Collis 1982).

The authors of the SOLO taxonomy also explicitly acknowledge some 'conceptual debts' (Biggs 1979 p.382) to the idiographic research of Marton and colleagues (i.e. Marton & Saljo 1976a; Marton & Saljo 1976b). This relationship parallels the cross-links between the research of Biggs and Marton and colleagues into learning approaches. The first four levels of the original SOLO model published from a Piagetian framework, were 'virtually identical' with Marton's four hierarchically related levels of learning (Biggs & Collis 1982 p.14). According to Biggs (1980 p.105), this conceptual overlap was coincidental, but the coincidence clearly contributed to the thinking behind subsequent articulations of the SOLO model.

Biggs (1979) suggested that the SOLO model was closer to Marton's levels than to developmental stages, and stated that 'it was discussions with Marton and his colleagues that led the writer to make this minor, but nevertheless important, paradigm shift away from the Piagetian framework' (Biggs 1979 p.385). In making this shift, Biggs recognised the 'vital' importance of distinguishing between the developmental stage of an individual and the 'structure of the outcome of his or her learning' (1980 p.105). This distinction was fully realised in later versions of SOLO and remains a fundamental distinction between SOLO and classical stage theory. Clearly, the hierarchically related levels of SOLO are also not dissimilar to the structural differences

and logical relations so frequently found between categories of description in phenomenographic analyses (e.g. Dahlgren 1984 p.26; Hazel et al. 2002).

It is also clear that apparently coincidental parallels between research programs into student learning are still occurring. One current example is the concept of 'knowledge objects' that have been identified from phenomenographic research (Entwistle & Marton 1994), and that parallel some aspects of the SOLO model and cognitive science theories of mathematics education.

The term 'knowledge object' was coined from analyses of interview transcripts to describe a form of understanding that is 'so tightly integrated that it was experienced as an entity with form and structure' (Entwistle & Marton 1994 p.168). The concept of 'mental objects' had earlier emerged from 'process-object encapsulation' theories emanating from cognitive science research into mathematics education, which have in common the idea that cognitive growth occurs 'through actions on existing objects that become interiorised into processes and then encapsulated as mental objects' (Pegg 2003 p.246). The relationship between the process-object encapsulation theories and the two-learning-cycle model of SOLO has been explored by Pegg and Tall (2001, cited in Pegg 2003 p.247; Pegg & Tall 2002, 2005) who suggested that the transition from a relational to a unistructural form of understanding in the next cycle represents the generation of a knowledge entity: 'as the procedure is practiced, the procedure itself becomes an entity –it becomes a *thing*. It, itself, is an input or object of scrutiny…' (Davis 1984, quoted in Tall et al.2000). The phenomenographic and cognitive science literature relating to knowledge or mental objects appear to be entirely separate, with neither research program explicitly acknowledging the other.

Accommodation of Different Paradigms

The issue of potential conflict between contrasting and perhaps competing research paradigms was raised by Entwistle and Hounsell (1979 p.363), who contended that:

> *The methodologies of competing paradigms could be used alongside one another, each providing distinctive yet equally valid types of evidence. It is our belief that progress in this field is more likely to come from evolution than revolution.*

A similar line was taken by Marton and Svensson (1979 p.484) who argued that aspects of the traditional and alternative perspectives were complementary, as 'what we can see from one point of view we cannot see from another'. The growing acknowledgement of the value of idiographic explorations in natural contexts was apparent in research programs that had originated from a cognitivist perspective, within the traditional paradigm. Researchers such as Biggs and Entwistle who originally adopted a nomothetic focus associated with cognitive psychology both embraced more alternate perspectives.

In arguing for the necessity of reconciling different but complementary perspectives in research, Marton and Svensson (1979) pointed to the SOLO model as an example of work that straddled the divide between the quantitative-qualitative dimension of different research perspectives:

> *We can also find an intermediate model of description related to the qualitative-quantitative dichotomy. This is very clearly represented in Biggs' (1979) work. The SOLO levels, which are indeed based on thorough qualitative analyses and descriptions of the pupil's understanding of various learning tasks are utilised by him as a measure of quality of learning, using an ordinal scale which is correlated with instructional as well as individual variables considered as potential explanatory constructs.*
> *(Marton & Svensson 1979 p.477)*

As predicted by Entwistle and Hounsell (1979), research into tertiary student learning has clearly evolved. Cross-fertilisation from different research programs within and between paradigms has occurred, which according to Biggs (1993 p.3) has enriched research in student learning in higher education. The conceptual similarities between the knowledge objects emanating from phenomenography, and the encapsulated mental objects which are described in process – object encapsulation theories and explained by the SOLO model, are yet another strong point of convergence between idiographic and nomothetic research perspectives that warrant further exploration.

REFERENCES

Ausubel, D. 1963, *The Psychology of Meaningful Verbal Learning*, Grune & Stratton, New York.

Biggs, J. 1969, 'Coding and cognitive behaviour', *British Journal of Psychology,* vol.60, no.3, pp.287-305.

Biggs, J. 1970a, 'Faculty patterns in study behaviour,' *Australian Journal of Psychology,* vol.22, no.2, pp.161-174.

Biggs, J. 1970b, 'Personality correlates of certain dimensions of study behaviour', *Australian Journal of Psychology,* vol.22, no.3, pp.287-297.

Biggs, J. 1978, 'Individual and group differences in study processes', *British Journal of Educational Psychology,* vol.48, no.266-279.

Biggs, J. 1979, 'Individual differences in study processes and the quality of learning outcomes', *Higher Education,* vol.8, pp.381-394.

Biggs, J. 1980, 'Developmental processes and learning outcomes', in *Cognition, Development and Instruction,* eds J. Kirby & J. Biggs, Academic Press, New York.

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

Biggs, J. 1993, 'What do inventories of students' learning processes really measure? A theoretical review and clarification', *British Journal of Educational Psychology,* vol.63, pp.3-19.

Biggs, J. & Collis, K. 1982, *Evaluating the Quality of Learning,* Academic Press, New York.

Biggs, J. & Collis, K. 1991, 'Multimodal learning and the quality of intelligent behaviour', in *Intelligence: Reconceptualisation and Measurement,* ed H. Rowe Ed. Lawrence Erlbaum Associates, Hillsdale.

Biggs, J., Kember, D. & Leung, D. 2001, 'The revised two-factor Study Process Questionnaire: R-SPQ-2F', *British Journal of Educational Psychology,* vol.71, pp.133-149.

Bruce, C. & Gerber, R. 1997, 'Editorial: Special Issue - Phenomenography in higher education', *Higher Education Research and Development,* vol.16, no.2, pp.125-126.

Burns, R. 1997, *Introduction to Research Methods,* 3rd edn, Longman, South Melbourne.

Case, R. (ed) 1992, The Mind's Staircase: Exploring the Conceptual Underpinnings of Children's Thought and Knowledge, Lawrence Erlbaum Associates, Hillsdale.

Cobern, W. 1993, 'Contextual constructivism: The impact of culture on teaching and learning', in *The Practice of Constructivism in Science Education,* ed K. Tobin, Lawrence Erlbaum Associates, Hillsdale.

Dahlgren, L.O. 1984, 'Outcomes of learning', in *The Experience of Learning,* eds F. Marton, D. Hounsell & N. Entwistle, Scottish Academic Press, Edinburgh.

Demetriou, A., Christou, C., Spanoudis, G. & Platsidou, M. 2002, *The Development of Mental Processing: Efficiency, Working Memory and Thinking,* vol.67, Blackwell Publishing, Boston.

Dyne, A., Taylor, P. & Boulton-Lewis, G. M. 1994, 'Information processing and the learning context: an analysis from recent perspectives in cognitive psychology', *British Journal of Educational Psychology,* vol.64, no.3, pp.359-372.

Entwistle, N. & Brennan, T. 1971, 'The academic performance of students: 1-Types of successful students', *British Journal of Educational Psychology,* vol.41, pp.268-276.

Entwistle, N. & Entwistle, D. 1970, 'The relationships between personality, study methods and academic performance', *British Journal of Educational Psychology,* vol.40, pp.132-141.

Entwistle, N., Hanley, M. & Hounsell, D. 1979, 'Identifying distinctive approaches to studying', *Higher Education,* vol.8, pp.365-380.

Entwistle, N. & Hounsell, D. 1979, 'Editorial: Student learing in its natural setting, *Higher Education,* vol.8, pp.359-363.

Entwistle, N. & Marton, F. 1994, 'Knowledge objects: Understandings constituted through intensive academic study', *British Journal of Educational Psychology,* vol.64, pp.161-178.

Entwistle, N., Nisbet, J., Entwistle, D. & Cowell, M. 1971, 'The academic performance of students: 1-Prediction from scales of motivation and study methods', *British Journal of Educational Psychology,* vol.41, pp.258-267.

Entwistle, N. & Thompson, J. 1974, 'Motivation and study habits', *Higher Education,* vol.3, pp.379-396.

Flavell, J. 1963, *The Developmental Psychology of Jean Piaget*, D. Van Nostrand Company, New York.

Hazel, E., Prosser, M. & Trigwell, K. 2002, 'Variation in learning orchestration in university biology courses', *International Journal of Science Education,* vol.24, no.7, pp.737-751.

Kirby, J. & Biggs, J. 1980, 'Introduction', in *Cognition, Development and Instruction,* eds J. Kirby & J. Biggs, Academic Press, New York.

Lourenco, O. & Machado, A. 1996, 'In defense of Piaget's theory: A reply to 10 common criticisms', *Psychological Review,* vol.103, pp.143-164.

Marton, F. & Booth, S. 1997, *Learning and Awareness*, Lawrence Erlbaum Associates, Mahwah, NJ.

Marton, F., Hounsell, D. & Entwistle, N. (eds) 1984, *The Experience of Learning*, Scottish Academic Press, Edinburgh.

Marton, F. & Saljo, R. 1976a, 'On qualitative differences in learning: I-Outcome and process', *British Journal of Educational Psychology,* vol.46, pp.4-11.

Marton, F. & Saljo, R. 1976b, 'Symposium: Learning processes and strategies-II. On qualitative differences in learning-II. Outcome as a function of the learner's conception of the task', *British Journal of Educational Psychology,* vol.46, pp.115-127.

Marton, F. & Svensson, L. 1979, 'Conceptions of research in student learning', *Higher Education,* vol.8, pp.471-486.

Pegg, J. 2003, 'Assessment in mathematics: A developmental approach', in *Mathematical Cognition*, Information Age Publishing.

Pegg, J. & Tall, D. 2002, 'Fundamental cycles of cognitive growth', Proceedings of the 26th Conference of the International Group for the Psychology of Mathematics Education, Norwich, UK, eds A.D. Cockburn & E. Nardi, vol.4, pp.369-376.

Pegg, J. & Tall, D. 2005, 'The fundamental cycle of concept construction underlying various theoretical frameworks', *International Reviews on Mathematical Education,* vol.37, no.6, pp.468-475.

Prosser, M. & Trigwell, K. 1999, *Understanding Learning and Teaching: The Experience in Higher Education,* The Society for Research into Higher Education & Open University Press, Buckingham.

Ramsden, P.1992, *Learning to Teach in Higher Education*, Routledge, London.
Sternberg, R. & Ben-Zeev, T. 2001, *Complex Cognition: The Psychology of Human Thought*, Oxford University Press, New York.

Tait, H. & Entwistle, N. 1996, 'Identifying students at risk through ineffective study strategies', *Higher Education,* vol.31, pp.97-116.

Tall, D., Thomas, M., Davis, G., Gray, E. & Simpson, A. 2000, 'What is the object of the encapsulation of a process?' *Journal of Mathematical Behaviour,* vol.18, no.2, pp.1-19.

van Geert, P.1998, 'A dynamic systems model of basic developmental mechanisms: Piaget, Vygotsky, and beyond', *Psychological Review,* vol.105, no.4

Webb, G. 1997, 'Deconstructing deep and surface: Towards a critique of phenomenography', *Higher Education,* vol.33, pp.195-212.