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Embryonic "Memorising" Models of Student Learning

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Building on earlier work the present study examines the empirical association between contrasting forms of "memorising", as suggested in the phenomenographic literature (but operationalised here in a form amenable to statistical modelling), and also between such forms of "memorising" and other established explanatory sources of variation in student learning. The aim of this work is directed towards the construction and interpretation of multivariate models of student learning that are sensitive to variation in contrasting forms of "memorising". To this end the degree of linear association, in particular, between contrasting forms of "memorising" and conceptions of learning, "deep-level" processes, and other introduced modelling observables is reported. Inventory responses from three samples of entering first-year economics students at the Universities of South Australia, Adelaide, and James Cook University (combined n=1334) form the basis of the present study, and these data are subjected to exploratory factor analysis, cluster analysis, and multidimensional scaling. Findings support a uniform and unambiguous interpretation of an underlying empirical model of "memorising" in which contrasting forms of "memorising" are respectively associated with other modelling observables in a conceptually consonant manner.

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Introduction

Qualitative, and especially phenomenographic, research into student learning repeatedly emphasises the existence of *qualitative* variation in the manner in which students engage both the content and the context of learning. There are, for example, the classic distinctions between, "deep" and "surface" forms of learning engagement (Marton & Säljö, 1976a,b), contrasting conceptions of learning (Säljö, 1979; Marton, Dall'Alba & Beaty, 1993), and contrasting forms of "memorising" learning processes (Dahlin & Regmi, 1995).

The qualitative research findings on "memorising", which have their origins in the posited "paradox of the Chinese learner" (Marton, Dall'Alba & Tse, 1993), are the focus of the present study. This so called "paradox" arose in the observation that there were two stereotypes of Asian (but more particularly Chinese) students; generally (a) they exhibited high levels of academic achievement that clearly incorporated "deep-level" forms of understanding, (b) they were "rote learners" (or, more correctly, they *appeared* to engage in such forms of "learning" as seen from, and interpreted within, a western teaching and learning perspective). "Rote learning" is used here in the sense of the mechanical memorisation of material whose meaning is not comprehended.

The conceptual difficulty with these two stereotypes arises essentially because, in generic terms, the processes associated with "understanding" and "rote learning" are mutually exclusive; the argument is that "deep-level" forms of academic achievement cannot be exhibited as a consequence of "rote learning" engagement. Phenomenographic research has subsequently revealed that "memorising" as an act of "committing to memory" can refer to several *conceptually distinct* processes. The "paradox" is essentially explainable because at least three such distinct forms of "memorising" are conceptually linked to "deep-level" learning:

The first form, one focus of the present study, is termed "memorising after understanding" and refers to committing to memory material whose meaning is understood or comprehended. The second and third forms respectively refer to "memorising with understanding" in which "understanding" is the organising principle for committing something to memory (see Dahlin & Watkins (1997), and "repetition as an aid to understanding" — a process by which repetition (as in the re-reading or recitation of a text, for example) reveals deeper underlying meaning(s) of the object of study. A "grounded theory" of "memorising" has, in effect, arisen from phenomenographic research findings that appears to co-exist quite independently, and interestingly does not explicitly articulate with, for example, the extensive psychological literature on "levels of processing" that has developed from the work of Craik & Lockhart (1972).

The interest here, however, lies in the fact that contrasting forms of "memorising" are also not explicitly reflected in the supporting instrumentation of contemporary models of student learning. The research question here stems from the conjecture that such qualitatively derived contrasting forms of "memorising" may represent sources of variation in a *statistical* sense, and that they may therefore contribute to the construction of explanatory models of students' learning that are more powerful (in operationalised *process* terms) than is presently the case. To illustrate this point it may be observed that the respected model of student learning developed by Biggs (1999, and earlier publications) is underpinned for research purposes by a dated inventory, the Study Process Questionnaire (Biggs, 1987). This inventory has been widely used as a research instrument in quantitative studies of student learning, including many studies involving Asian students (see Richardson (2000) for a comprehensive review), but it contains only *one item* in the "surface strategy" subscale that refers to "memorise by heart".

In similar vein, the most recent version of the Approaches and Study Skills Inventory developed over several years by Entwistle and colleagues (Entwistle, Tait, & McCune, 1999) contains just one item that refers to "memorising" in an "unrelated memorising" subscale of four items. This

particular item "I find I have to concentrate on just memorising a good deal of what I have to learn" is of especial interest in the present study; it is a direct descendant of a practically identical item "I find I have to concentrate on memorising a good deal of what we have to learn" that appeared in the extensively used original version of the Approaches to Studying Inventory (Entwistle & Ramsden, 1983) and its variants (relevant studies also comprehensively reviewed by Richardson (2000)). In the present study an essentially similar item to the two previously cited "I generally have to concentrate on memorising a lot of what I have to learn" is used as an undifferentiated "memorising" *tracer* item in the analyses that follow. The term "tracer" is used here to indicate an observable whose empirical interpretation in relation to other observables is of particular interest.

The focus of the present work is thus (a) on the psychometric operationalisation of contrasting forms of "memorising" and, (b) their association singly, and jointly, with other established sources of explanatory variation in student learning. A starting point for the present study are findings from a study by Meyer (2000a) that, on the basis of confirmatory factor analysis of responses at an item level (n=1344), three contrasting forms of "memorising" may be statistically modelled as conceptually distinct and independent entities in accordance with theoretical expectations. That is, in terms of underlying linear structure, "memorising after understanding", "memorising before understanding", and "memorising as rehearsal", exhibit empirically as an orthogonal factor structure. Furthermore, in terms of location parameters such as mean scores, as well as in terms of covariance structure, such an initial three dimensional model of "memorising", as outlined, is gender-response sensitive.

In terms of linear associations, these three contrasting forms of "memorising" (when augmented for analytical purposes by additional sources of explanatory variation), were respectively interpreted as qualifying three corresponding composite dimensions of variation (common factors) as follows: (a) "memorising before understanding" in terms of a factor interpreted as the factual intake of material that is not comprehended, (b) "memo-

rising after understanding" in terms of a factor interpreted as "deep-level" process, (c) "memorising as rehearsal" in terms of a factor interpreted as learning pathologies; these pathologies are usually empirically identified with "surface-approach" forms of learning engagement but strictly do not define such an approach here in either motivational or intentional terms.

Although these three distinctions emerged quite clearly in an orthogonal factor solution, an oblique solution contributed further insights in the form of a weak linear relationship (r=+0.38) between the learning pathology factor and the factual intake factor. The present study sets out to confirm, extend, and further amplify these earlier findings based on an independent sample of comparable magnitude (n=1334) comprising entering first-year students from three Australian universities.

The Observables

The observables used in the study by Meyer (2000a), retained in the present study, are described in Appendix 1 and are derived from the following two sources:

(a) The Reflections on Learning Inventory (RoLI), presently under development by Meyer & Boulton Lewis (1997a, 1997b, 1999), captures variation in students' contrasting conceptions of learning via "collecting facts", "thinking independently", and "seeing things differently", a belief that "knowledge is discrete and factual, and other proximal effects such as learning being experienced as a "duty" and the three contrasting forms of "memorising" already introduced. The domain of the RoLI has been *substantively* developed from the qualitative variation evident in primary sources of interview excerpts as presented in the phenomenographic literature by various authors in support of, in particular, "categories of description" related to conceptions of learning (Säljö, 1979; Marton, Dall'Alba & Beaty, 1993), and contrasting forms of "memorising" (Marton, Dall'Alba & Tse, 1993; Dahlin & Regmi, 1995; Dahlin & Watkins, 1997).

(b) The original Approaches to Studying Inventory developed by Entwistle and Ramsden (1983), further contributes a selected number of well-established sources of variation in student learning; "disorganised studying", two "deep-level" processes ("relating ideas and "use of evidence"), two learning pathologies ("improvidence" and "globetrotting"), together with subsequent extensions in the form of a third learning pathology ("fragmentation") and "memorising" as a process of rehearsal. These extensions are attributable to a study by Meyer & Watson (1991).

In the present study three further exploratory *tracer* observables are introduced and the exploratory nature of including them is emphasised in terms of incrementally *extending* the previously reported model. The first two tracer observables, "syllabus boundness" and "deep approach" originate operationally from the Approaches to Studying Inventory (Entwistle & Ramsden, 1983) and have thus featured in many reported quantitative studies of student learning (see Richardson, 2000). "Syllabus boundness" captures variation in students' adopting an intentional avoidance of going beyond what they are strictly required to do in a course; it may be interpreted as a form of apathetic process that has been conceptually and empirically linked to "surface-level" learning. In contrast "deep approach" captures variation in students' intention to seek meaning. The aim here is to explore their empirical behaviour in relation to a substantially *different* set of explanatory observables from those embedded in the original Approaches to Studying Inventory and its later variants.

The third tracer observable captures variation in an aspect of prior knowledge; an explicit aspect, contextualised of necessity, within a specific subject or discipline — in this case economics, which forms the response context of the present study. One aspect of such prior knowledge refers here to "economic misconceptions" which are explored as a contribution towards an empirical model variant that is contextually discipline-sensitive (Meyer & Shanahan, 1999). The potential benefits of constructing such a model are, however, applicable to other discipline contexts.

The observables thus outlined were administered as a composite inventory to incoming first-year Australian economics students at the University of South Australia, the University of Adelaide, and James Cook University, at the beginning of the 1999 academic year before the commencement of classes (total n=1334). Students were essentially asked to respond to inventory items via a Likert-type format in terms of their most recent experiences of studying economics, or where possible, a cognate subject in their final secondary school year. The data thus captured represents, in particular, various forms of prior knowledge in terms of conceptions of learning, and approaches to studying, that students bring with them on entry to university and that constitute their "learning histories".

Methods and Findings

A "memorising" factor model

Meyer (2000a) reported on the psychometric properties of a set of twelve "core" items that were conceptually and empirically associated with three contrasting forms of "memorising" (each operationalised in terms of just four items). In essence, the three empirically discrete subscales exhibited reliabilities as follows: "memorise before understanding" (alpha=0.86), "memorising after understanding" (alpha=0.85), "memorising as rehearsal" (alpha=0.66). And, as already noted, an exploratory maximum likelihood factor analysis of item responses, supported by a separate confirmatory factor analysis, favoured an interpretation in terms of three orthogonal common factors representing, in effect, a *process* model of student learning defined embryonically in purely "memorising" terms. The conceptual significance of such a model lies in the fact that (a) it begins to differentiate "memorising" as a mechanism of production of learning outcomes and, (b) in doing so, it addresses a fundamental weakness in process terms, as already noted, in previous empirical attempts to model a "surface" approach to learning.

In the present study the "memorising before understanding" and "memo-

rising after understanding" subscales are each *extended* by an additional exploratory item. The "memorising as rehearsal" subscale contains, as already noted, an additional *tracer* item intended to empirically explore the loading pattern of responses explicitly associated with the term "memorising" in an undifferentiated sense — the question being whether, in terms of common usage of the term, just plain "memorising" is in fact empirically associated with "memorising as rehearsal", "memorising before understanding" or perhaps even "memorising after understanding". This is an important question given the inclusion of the undifferentiated form of "memorising" in several contemporary inventories of student learning beyond those already noted. Results of an exploratory maximum likelihood factor analysis, at an item response level, using squared multiple correlations as communality estimates, and based on an eigenvalue > 1 extraction criterion, are presented in Table 1.

The interpretation of this factor structure is unambiguous in terms of three orthogonal factors that respectively exhibit variation in the contrasting forms of "memorising" already referred to. Alphas for the five-item subscales are comparable to those of the earlier study and notably higher for the "memorising as rehearsal" subscale (from 0.66 to 0.77). It is furthermore clear that undifferentiated "memorising" (the tracer item 41 in Table 1) is empirically associated with rehearsal. An oblique solution (not presented) preserves the exhibited item loadings in Table 1 with a remarkable degree of consistency: in the same order from high to low within each factor (F1: 81-64, F2: 86-53, F3: 67-45) with exhibited inter-factor correlations as follows: F1 vs. F2 (r=+0.15), F1 vs. F3 (r=+0.18), F2 vs. F3 (r=+0.28).

Again, these findings suggest a mild linear association between "memorising before understanding" and "memorising as rehearsal" that is consistent with the earlier Meyer (2000a) study. However, as already noted, confirmatory factor analysis in the earlier case did not, on balance, justify the adoption of the more complex oblique model above the simpler orthogonal model on the basis of the small amount of additional variation (some five percent) explained under oblique rotation.

Table 1 Exploratory varimax factor solution (n=1334)

	F1	F2	F3
Factor 1: Memorising after understanding (alpha=0.87)			
23 You have to make sense of something in order to commit it to memory	80		
33 Before you can commit something to memory you need to be able to explain it to yourself	80		
13 You need to know the meaning of something before you can commit it to memory	78		
43 In order to commit something to memory you first need to be able to interpret it	77		
3 In order to commit something to memory you first have to make sense of it	63		
Factor 2: Memorising before understanding (alpha=0.84)			
27 You have to commit something to memory in order to make sense of it		85	
37 Before you can explain something to yourself you first need to commit it to memory		78	
17 You need to commit something to memory before you can make meaning out of it		78	
7 In order to make sense of something you first have to commit it to memory		62	
47 Something that has been committed to memory can only be explained afterwards		53	
Factor 3: Memorising as rehearsal (alpha=0.71)			
48 I learn things by saying them over and over to myself			66
30 I learn things by reading them over and over			63
63 I learn things by writing them out over and over			55
41 I generally have to concentrate on memorising a lot of what I have to learn*			53
23 I often have to learn some things several times			46

Note: All factor loadings multiplied by 100 and rounded to two decimal places; loadings with absolute values less than or equal to 20 are omitted. Table entries represent all corresponding item-based responses entered into the factor analysis. * Item 41 is a tracer item. Factor extraction is maximum likelihood according to eigenvalue > 1 criterion; first four eigenvalues are 8.76, 6.30, 2.33, 0.28.

An expanded "memorising" factor model

The focus now shifts to an expanded, and conceptually more complex, augmented "memorising" model of student learning which is presented in Table 2. It is clear that the exploratory common-factor model thus represented respectively (and unambiguously) associates each of the contrasting forms

of "memorising" with the additionally introduced observables in a manner that is conceptually consistent. Factor one associates "memorising as rehearsal" with the three learning pathologies, disorganised studying, and syllabus boundness (*a tracer*). Factor two associates "memorising before understanding" with an epistemological belief that knowledge is discrete and factual, an accumulative conception of learning related to collecting facts, motivation by duty, and a form of prior knowledge in terms of subject-specific misconceptions (*a tracer*). Factor three associates "memorise after understanding" with a transformative conception of learning in terms of seeing things differently, an experience of thinking independently, the two "deep-level" processes of relating ideas and use of evidence plus an intentional form of a "deep" approach (*a tracer*).

Of further interest is that Factor one exhibits a moderate correlation with Factor 2 (r=+0.46) and a relatively weaker correlation with Factor 3 (r=+0.16) while Factor one and Factor three are independent of one another (r=0). The moderate correlation between Factor one and Factor two is, in this case, essentially attributable to cross factor loadings (> 20) in respect of "fragmentation", "improvidence", "memorising as rehearsal" and "motivated by duty" as exhibited in the orthogonal solution (not presented). In the orthogonal solution there are no additional cross loadings (> 20) on any of the observables in Factor three apart from the one already indicated in Table 2 ("collecting facts"). The oblique and orthogonal loadings thus further reflect the observation already made in respect of Table 1 that, on balance, "memorising as rehearsal" is associated with "memorising before understanding" rather than with "memorising after understanding".

These findings are entirely consistent with those of the earlier study (Meyer, 2000a). As before, it is speculated that the observed overlap between the composite dimensions of variation respectively associated with "memorising as rehearsal" and "memorising before understanding" may well be sharpened in selected subset responses of the sample. Furthermore, the two independent dimensions of variation respectively associated with "memorising as rehearsal" and "memorising after understanding" *do not* implicate *rehearsal* (in the manner operationalised here) with "deep-level"

Table 2 An oblique "memorising" factor model

	F1	F2	F3
Factor 1: Learning pathology			
GI Globetrotting	**72**		
FA Fragmentation	**70**		
IP Improvidence	**70**		
DS Disorganised studying	**60**		
MAR Memorising as rehearsal	**45**		
Syllabus boundness*	43		
Factor 2: Not understood factual intake			
KDF Knowledge discrete and factual		**83**	
FAC Collecting facts		**65**	**21**
MBU Memorising before understanding		**64**	
DUT Motivated by duty		**53**	
Subject specific misconceptions*		33	
Factor 3: 'Deep'-level process			
SDI Seeing things differently			**81**
IND Thinking independently			**68**
RI Relating ideas			**49**
MAU Memorise after understanding			**49**
UE Use of evidence			**39**
Deep approach*			40
Inter factor correlations			
Factor 1: learning pathology		46	0
Factor 2: not understood factual intake			16

Note: All factor loadings multiplied by 100 and rounded to two decimal places; those with absolute values less than or equal to 20 are omitted. See Appendix 1 for explanation of observables; '*' Indicates tracer observables. The set of observables represented by the factor loadings in bold type corresponds to the structures presented in Figure 1 and Figure 2. Table entries represent all corresponding subscale-based responses entered into the factor analysis. Factor extraction is maximum likelihood according to eigenvalue > 1 criterion; first four eigenvalues are 5.81, 3.29, 1.53, 0.78.

learning processes. At face value this finding does not empirically support the conclusion of Dahlin & Watkins (1997) that rehearsal (or repetition) can "aid understanding"; the conjecture is therefore that a different form of this process can be isolated and operationalised for modelling purposes.

An expanded "memorising" tree model

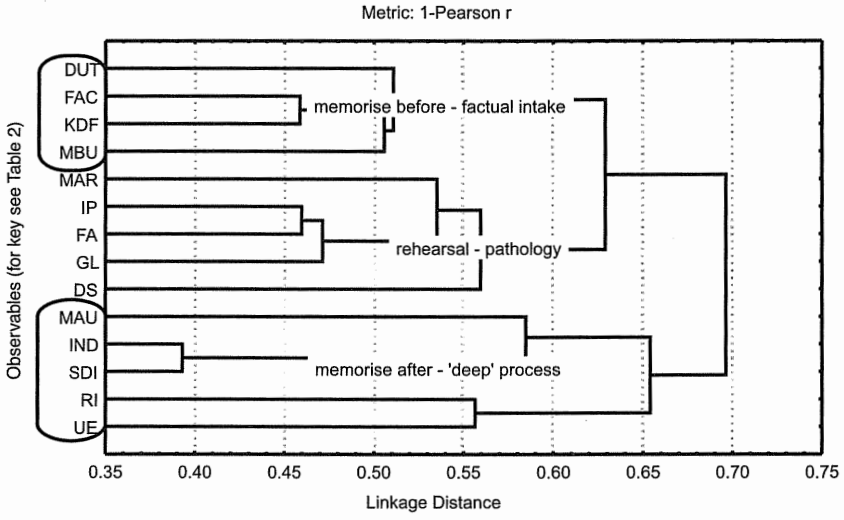
A second exhibited structure of the same set of observables represented in the bold aspect of the factor model in Table 2 is now considered. This bold

aspect corresponds to the observables used in the earlier (Meyer, 2000a) study and is retained here for comparative purposes in preference to the full set of observables in Table 2 given that the three tracer observables all exhibit the lowest loadings within their respective common factors. The tree structure presented in Figure 1 is based on a single linkage (nearest neighbour) clustering algorithm using one minus the correlation between observables (1- Pearson r) as the metric or distance measure. By inspection, it is clear that Figure 1 supports an interpretation of linear structure that is consistent with the factor structure in Table 2; in particular, Figure 1 supports an interpretation of three clusters that respectively correspond, in terms of their composition, to the "rehearsal — learning pathology", "memorise before — factual intake" and "memorise after — deep process" common factors. There is thus another comparable linear view of the observables in which contrasting forms of "memorising" appear to qualify their respective trees.

An expanded "memorising" scaling model

An aim of the larger research project within which the present study is lo-

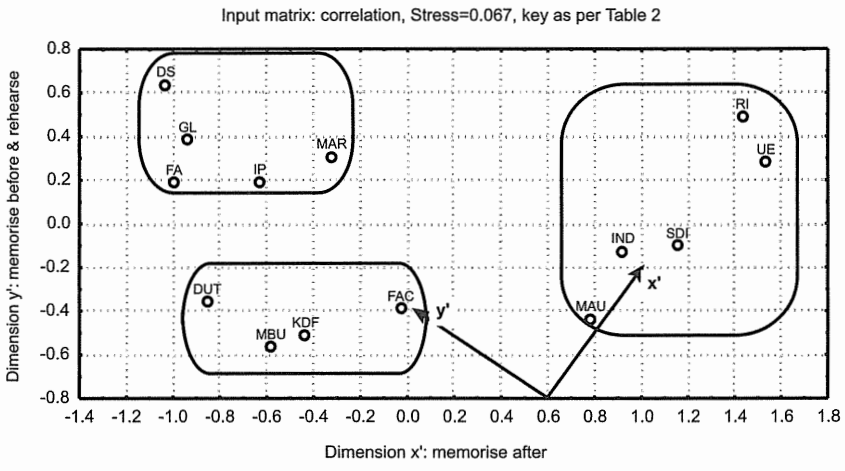
Figure 1 Single linkage tree diagram (whole sample, n=1334)



cated is the modelling of individual differences; in particular with regard to contrasting forms of "memorising". There is therefore an interest in representations of structure that can inform such modelling in terms of unfolding analysis. An intermediate form of structure that represents the observables only, and in a form that locates them within a co-ordinate system, is presented in Figure 2 in the form of a two-dimensional scaling solution. The observables are represented here in a Euclidean space, again using correlation as the input distance in the sense of a measure of similarity. A simple rotation and translation of axes in Figure 2 (x' - y') once again provides an alternative insight into the underlying structure of the data that is consistent with previous interpretations.

Figure 2 may be interpreted in a number of senses: (a) in terms of a near orthogonal solution in which, in line with the factor analysis, the "deep-processing" aspect of "memorising after understanding" is a dimension along the x' axis, while "rehearsal memorisation of discrete factual intake" and "memorise before understanding in a pathological sense" can plausibly be interpreted as lying along the y' axis. (b) In purely spatial terms the import of the encapsulated clusters of observables is simply that individual responses hypothetically located at or near the centres of the three spaces within the

Figure 2 Multidimensional scaling solution (n=1334)



respective boundaries (drawn in Figure 2 to notionally represent the previously identified composite "memorising dimensions") would represent *qualitative individual differences* in learning engagement. Additionally, the open space that lies between the three encapsulated sets of observables in Figure 2 may be regarded as "interference space", in keeping with the nature of the "interference model" represented in Table 2. An "interference model" (Meyer, 2000b, p10) is defined as:

> ...a non-hierarchical (linear or non-linear) observed model that contains either (a) two or more separately distinct and conceptually consonant, but contrasting, dimensions of variation and/or (b) at least one dimension of variation constituted in terms of conceptually "dissonant" sources of variation. In the special case of a common-factor model with theoretically contra-indicated correlations between factors, feature (b) may be exhibited simultaneously across two or more factors.

The import of an "interference model" in terms of individual differences is that, in the case of the factor model in Table 2, students who are located within the model in terms of, for example, "high" location parameters (factor scores) on *both* Factor 1 and Factor 3 exhibit "dissonance"; the two factors in such cases "interfere" with one another. In similar vein the "interference space" in Figure 2 also hypothetically locates, in varying degrees, individual responses that are "dissonant" and which are theoretically and empirically associated with a likelihood of low academic achievement or failure (Meyer, 2000b).

Discussion

The findings of the present study empirically support the conceptual distinction between contrasting forms of "memorising". In operationalising these forms of "memorising" the use of terms such as "memorising" and "understanding" have been expressly avoided in light of the fact that they may, in some students' experiences, be ambiguous or even interchangeable. The question of whether alternative item wordings might yield even sharper insights into the underlying pattern of variation in meaning associated with

these terms in the phenomenographic literature remains open.

What does seem clear is that there is a consistency of structure exhibited via three distinct analytical procedures that is amenable to plausible interpretation in terms of the (memory) "levels of processing literature" (Craik & Lockhart, 1972; Eysenck 1984); namely, that the "rehearsal — factual intake" dimension of variation, which is empirically linked to the "memorise before" dimension, represents a form of "maintenance rehearsal" whereby information is recycled in short term memory. The empirical independence of the "deep-level" process dimension of variation with which "memorising after understanding" is unambiguously associated in all of the analyses presented does not support an interpretation in which "rehearsal" is associated with "understanding"; either in terms of a tracer item (at an item level of response analysis), or in any of the expanded models in terms of "deep-level" processes. Finally, in modelling terms, the question of how psychometrically operationalised forms of the further phenomenographically posited observables of "memorising *with* understanding" and "repetition as an aid to understanding" — both "deep-level" processes — are linked to "rehearsal" (as used here in the sense of "learning") and "memorise after understanding" remains open.

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Appendix 1

The observables in the order in which they appear in Table 1, with a sample item from each

Globetrotting. An inability to substantiate an overall grasp of something in terms of detail (I have difficulty in explaining the detail of some things I feel I have a good general grasp of).

Fragmentation. The lack of an organising principle for processing new information; a particular converse of relating ideas (much of what I have learned seems to consist of unrelated bits and pieces of information).

Improvidence. Over reliance on detail and an inability to integrate it into an overall picture (I have difficulty in fitting together facts and details to form an overall view of something).

Disorganised studying. Difficulty in commencing work to be done, managing time, and concentrating on the task at hand (I find it difficult to get started on work that I know has to be done).

Memorising as rehearsal. A mechanical process of verbal, written or mental rehearsal (saying things over and over to myself is how I remember things that I can't learn any other way).

Knowledge discrete and factual. An epistemological belief that knowledge is discrete and factual (knowledge means knowing the right facts).

Fact based learning. An accumulative conception of learning directed towards the acquisition and reproduction of facts (learning means collecting all the facts that need to be remembered).

Memorise before understanding. Committing to memory material whose meaning is not comprehended (in order to make sense of something I first have to commit it to memory).

Duty. A motivational influence on learning experienced as a moral duty (when I am learning I feel as if I am discharging a moral duty).

Seeing things differently. A transformational conception of learning that involves seeing things from a new perspective (I believe that learning helps me to see things differently to how they looked before).

Thinking independently. A conception of learning based on the capacity to think independently (I know I have learned something when I can form counter arguments of my own).

Relating ideas. An active process of relating new ideas or concepts to what is already known or to other contexts (In learning new concepts or ideas I relate them as far as possible to what I already know).

Memorise after understanding. Committing to memory material whose meaning is comprehended (I need to know the meaning of something before I can commit it to memory).

Use of evidence. A process of reaching or verifying a conclusion or argument based on the available evidence (I examine the evidence carefully before I agree with conclusions reached by other people).