A Correspondence Analysis of Child-Care Students' and Medical Students' Knowledge about Teaching and Learning

Helen Askell-Williams
Flinders University School of Education *helen.williams@flinders.edu.au*

Michael J. Lawson
Flinders University School of Education *mike.lawson@flinders.edu.au*

This paper describes the application of correspondence analysis to transcripts gathered from focussed interviews about teaching and learning held with a small sample of child-care students, medical students and the students' teachers. Seven dimensions emerged from the analysis, suggesting that the knowledge that underlies students' learning intentions and actions is multi-dimensional and transactive. It is proposed that the multivariate, multidimensional, discovery approach of the correspondence analysis technique has considerable potential for data analysis in the social sciences.

Teaching, learning, knowledge, correspondence analysis

INTRODUCTION

The purpose of this paper is to describe the application of correspondence analysis to rich text-based data derived from interviews with teachers and learners about their knowledge about teaching and learning. Correspondence analysis is a non-linear, multidimensional technique of multivariate descriptive analysis that "specialises in 'discovering,' through detailed analysis of a given data set" (Nishisato, 1994 p.7). A description of what teachers and learners know about teaching and learning will assist in developing the educational community's understanding about teaching and learning. If researchers, designers and policy makers are well informed about teachers' and learners' knowledge, they will be better equipped to design and recommend educational programs that meet students' learning needs. If teachers possess high quality knowledge about their own, and their students', knowledge then they will be better equipped to design and deliver high quality teaching. If students possess high quality knowledge about teaching and learning, in particular their own learning, they will be better equipped to engage fruitfully in educational programs.

Background

The domain of investigation into teachers' and learners' knowledge is founded in philosophical and psychological literature: Bandura's (1993; 1997; 2001) social-cognitive theory; Kerr's (1981) philosophy of intentions, plans and actions; philosophies of constructivism (Phillips, 1995; Phillips, 2000; Prawat and Floden, 1994); and the psychological cognitive mediation paradigm (Winne, 1987) converge to provide a model of each person as a learner who actively constructs and acts upon his or her own knowledge. Hence, we argue that teachers and learners come to educational settings with knowledge about teaching and learning, and that such knowledge directly influences teachers' and learners' engagement with educational opportunities. Therefore,

knowledge about teachers' and learners' knowledge about teaching and learning is as essential to educators as is knowledge about students' and teachers' subject-matter conceptions (Chi and Roscoe, 2002; Driver, Asoko, Leach, Mortimer, and Scott, 1994; Shulman, 1987; Wandersee, Mintzes, and Novak, 1996). It follows from the cognitive mediation and psychological and social constructivist paradigms that a primary source of teachers' and learners' knowledge is teachers and learners themselves.

The extensive work of researchers such as Marton (1993) on conceptions, Perry (1970) and Hofer (Hofer, 2000; Hofer and Pintrich, 1997) on epistemologies, Entwistle (1979) and Biggs (1979; 1987) on learners' approaches to learning and studying and Trigwell and Prosser (Trigwell, Prosser, and Taylor, 1994; Trigwell, Prosser, and Waterhouse, 1999) on teachers' approaches to teaching have made substantial contributions to educators' understandings about teachers' and learners' knowledge. However, this paper inquires into people's knowledge about a broader range of constructs drawn from the educational psychology literature, such as knowledge construction, self-efficacy, self-management, metacognition, purposes for learning, and assessment.

An introduction to the correspondence analysis technique

The aim of correspondence analysis is to find a low-dimensional representation of the dependence between predetermined categories in a two-way contingency table (Hair, Anderson, Tatham, and Black, 1995; van der Heijden and de Leeuw, 1985). Correspondence analysis can be conceptualised as being similar to principal components analysis, with the qualification that correspondence analysis is able to deal with frequency, or count, data (Greenacre, 1984; Nishisato, 1994; Weller and Romney, 1990). Examples of the use of correspondence analysis can be found in medical research (Greenacre, 1992), students' and teachers' cognitions about good teachers (Beishuizen, Hof, Putten, Bouwmeester, and Asscher, 2001), cross-cultural patterns of attachment (van IJzendoorn and Kroonenberg, 1988), higher education institution image (Ivy, 2001), personalities (Nishisato, 1994), and marketing research (Bendixen, 1996).

Correspondence analysis is one of many names for similar methods that have evolved in different countries under different authorship. Nishisato (1994) and Greenacre (1984) surveyed the various paths of development of correspondence analysis and closely related, or identical, techniques. Names for similar techniques have included optimal scaling, dual scaling, canonical correlation analysis and homogeneity analysis (Greenacre, 1984; Nishisato, 1994; Tenenhaus and Young, 1985; van der Heijden and de Leeuw, 1985; Weller and Romney, 1990).

The ability of correspondence analysis to deal with frequency data provides a practical methodological strength, for it is possible to work with data that may not meet the restrictions on data necessary for other statistical analyses. Thus, for example, the researcher is not forced into proceeding "as if" the data conform to a normal distribution (Shavelson, 1988). The interpretive strength of correspondence analysis lies with its representation of low-dimensional solutions in graphical displays, which permit the researcher to make comparisons between participants, between variables, and between participants and variables in their relative placement in shared low-dimensional space.

Patterns of inter-dependence

Correspondence analysis employs chi-square distances to calculate the dissimilarity (or similarity) between the frequencies in each cell of a contingency table. The concept underlying the calculation of the chi-square distances is cell-independence. Pairs of cells whose observed and expected values are the same can be considered to be independent of each other. Pairs of cells whose observed and expected values are different can be investigated further to ascertain patterns of interdependence.

The correspondence analysis program standardises and transforms the frequency data in the contingency table by calculating chi-square distances from the row and column profiles (actual minus expected cell values as a proportion of marginal totals). The program then reduces the complexity contained in the row and column profiles by creating a low-dimensional representation of the row and column profiles. It achieves this by factoring the basic structure (through a singular value decomposition) of the chi-square distance matrix, resulting in a set of row vectors, column vectors and singular values (Greenacre, 1984; Weller and Romney, 1990). Finally, the correspondence analysis scales the vectors to create scores for each participant and each variable. These scores are plotted in a visual display (Weller and Romney, 1990).

The correspondence analysis solutions can be compared to multidimensional scaling (MDS) solutions, in that both present a low-dimensional solution in a map that plots point coordinates in relative distance to each other. Major tasks for the researcher with both MDS and correspondence analysis are to select the appropriate numbers of dimensions and to interpret the meaning of those dimensions (Hair et al., 1995).

Normalisation

Correspondence analysis requires the researcher to choose between different methods of normalisation. Correspondence analysis using principal normalisation-columns calculates the Euclidean distances between a column point and the origin, which approximates the chi-square distance between the column category and the average column category. The correspondence analysis program then prepares a graphical representation of the distance coordinates (the principal coordinates of the columns) in low dimensional space. As the Euclidean distance between any two points (variables) in the graphical display approximates the chi-square distance between the corresponding columns of the correspondence table, it is possible to conduct a visual inspection of the actual magnitude of the distances between column points (variables) (Gabriel, 2002; Greenacre, 1984; Nishisato, 1994; SPSS, 2001). Correspondence analysis using principal normalisation-rows does the same as just described, but for the rows of the contingency table. It is therefore possible to conduct a visual inspection of the graphical display to determine the actual magnitude of the distances between, in this case, the row points (participants). Correspondence analysis using the symmetrical normalisation option spreads the inertia (squared correlation between row and column scores) across rows and columns. The resulting graphical representation is of the principal coordinates of the rows, and of the columns, that can be interpreted in terms of the relative, but not actual, magnitude of the distances between points.

The differences between the methods of creating the graphical representations has caused debate in the literature about the most appropriate choice of normalisation and methods of interpretation of the visual display (Gabriel, 2002; Greenacre, 1984; Hair et al., 1995; Nishisato, 1994; SPSS, 2001). Gabriel (2002) calculated goodness-of-fit for the various forms of graphical representation available in correspondence analysis. He concluded that researchers who have a specific interest in actual magnitudes of difference between rows (participants) or columns (variables) should choose the appropriate principal normalisation (row or column). However, researchers whose interest lies in comparing the general orientation of row points and column points, rather than visualising actual magnitudes, are well served by the symmetrical normalisation option:

> The symmetric biplot, in addition to its optimal fit of the data, proportionally fits the form and the variance almost optimally and is an excellent candidate for general usage, unless one requires representation of the actual magnitudes. (Gabriel, 2002 p. 435)

Our concern in the current project lies with interpreting the meaning of the dimensions extracted in the low-dimensional solution, and in interpreting the placement of participants relative to those

dimensions. We therefore selected symmetrical normalisation for the graphical representations and analyses in this paper.

Assumptions

Correspondence analysis is relatively free from assumptions about the nature of the data. It can work with counts (frequencies), and, as mentioned, does not require data that conform to a normal distribution (Greenacre, 1984). The main assumption, or limitation, of correspondence analysis is that all of the relevant variables are included in the analysis (Hair et al., 1995). If a key variable is overlooked in the design stage of the research, then the final scaling solution is impoverished. This is an assumption that is shared with other compositional techniques such as factor analysis, but can be contrasted with decompositional techniques such as multi-dimensional scaling, which employ respondents' (unconstrained) overall judgements of similarity to create the perceptual maps. The multiple readings and codings of the interview transcripts undertaken for this study encourages our belief that the variables included in the analysis are reasonably comprehensive.

METHOD

The Participants

Two participant groups from a larger interview based study were selected with a view to conducting a correspondence analysis: 12 child-care students and their two teachers, and seven medical students and their mentor (a General Medical Practitioner). The reasons behind the selection of these two groups are two-fold. On the one hand, it seems reasonable to propose that these two groups of learners are engaged in what might reasonably be considered to be different levels of demand and achievement in formal, academic learning: that is, different academic press. On the other hand, the two groups have features in common, such as their age range and the structure of their respective courses.

The medical group contained seven adult students enrolled in the third (clinical) year of a graduate entry, four year, medical education program run by a university in South Australia. Thus, these seven participants had completed an undergraduate degree, in some cases had completed post-graduate qualifications, and one participant held a PhD in science. Furthermore, the seven students had undergone a further selection process, based upon interview and performance in the first two years of the medical degree, for entry into an innovative new program of rural, community-based clinical placement. Added to this participant sample was the medical students' General Medical Practitioner mentor, who had day-to-day responsibility for overseeing the students' clinical training placements and range of clinical learning experiences. The high level of academic achievement that the participants in this group had achieved suggested that we could expect these students to have had considerable exposure to formal teaching-learning environments, and to have developed knowledge and strategies to enable them to achieve success in such environments.

The child-care group included 12 adult students taking a pre-qualification, Certificate Level III in Community Services: child-care, run by a Technical and Further Education College in South Australia. This certificate is of one-year duration, and equips students to gain base-level (unqualified) employment as a child-care worker. Participants' prior educational level ranged from minimal secondary schooling to completion of five years of secondary schooling, with the exception of one student who was concurrently enrolled in degree studies at university. Compared to the students in the medical sample, the students in the child-care sample could be expected to have experienced considerably less exposure to formal teaching-learning environments, and had not necessarily achieved success in such environments (as did become evident during the

students' interviews). Included with this participant sample were the students' two teachers, who were responsible for the partial design and delivery of the course material, and for conducting the competency based assessment that led to the students' certification. Both child-care teachers held Bachelor of Education degrees.

All participants are of English or European heritage. Socio-economic class based upon participants' and parents' occupation ranged from unemployed/retired through unskilled, skilled, technical to professional. Ages ranged from 18 to mid 40s.

Although the content of the medical course and the child-care course was vastly different, the two courses had interesting similarities. The structure of the child-care course and the medical course was such that students spent Wednesday of each week in classroom based activities such as lectures, small group discussions, video presentations and, in the case of the medical students, problem-based learning sessions. The other days of the week required the students to attend rostered, on-the-job, training. For child-care students, this training was at a fully operational, metropolitan, public access, child-care centre. For medical students, training was at rural, community based general practice surgeries and public, rural community hospitals.

A second point of similarity between the two courses lies in the area of developing effective interpersonal relationships. Medical practitioners interact with patients, clients' immediate and extended families, related health and other professionals, community organisations (shelters, support groups) and so on. Child-care workers interact with the children in their care, and also with immediate (sometimes estranged) family, extended family, related human service and other professionals, community organisations (libraries, play groups, pre-schools) and so on. Thus the nature of the teaching and learning that the two participant groups engaged with was both different, and similar.

The interviews

We reviewed the teaching and learning literature to compose a set of 18 focus questions to guide the direction of each interview. The focus questions and their broad theoretical foundations are included at Appendix A. Each interview also included extra probing questions according to the idiosyncratic direction that each interview took.

In particular, our aim was to comprehensively capture each participant's understandings about their own learning *in action*. This, 1) was based upon our recognition of the importance of all three vertices of Bandura's (1997) cognition, environment and behaviour triangle of social-cognitive theory, 2) heeds the role that context plays in teaching and learning (Lave, 1988), and 3) adheres to Candy's (1991, p.457) suggestion that "the person in context" be the main unit of analysis. Interviews were therefore conducted at participants' usual place of learning, either during a break in, or immediately after, a learning session. Each interview lasted from about 20 to 90 minutes, with the average being about 45 minutes. Interviews were transcribed verbatim and all participants' names were substituted with pseudonyms.

Coding the interview transcripts

Participants' interview transcripts were coded so that exact frequencies of participants' statements that could be categorised into 38 variables were recorded. The 38 variables were identified in an earlier stage of the research as being key issues in the educational psychology literature as well as being salient to the participants themselves (Askell-Williams, 2001), and are presented in Table 1.

Table 1. Categories of Knowledge about Teaching and Learning

Level 1 Categories	Level 2 Categories and Sub-categories	short labels of variables included in correspondence analysis
The Nature of the Learner	**Motivation**	
	value of the subject matter	
	useful and/or important for present and/or future	useful
	interest #	interest
	like; enjoy; fun #	like
	cost #	cost
	individual achievement goals	
	achieve certification/qualification	certification
	master the subject matter	mastery
	achieve certification and mastery	certification + mastery
	self-fulfillment through achieving goals	self-fulfillment
	personal development through exposure to opportunities	personal development
	self-efficacy	
	strong beliefs in own capabilities	strong self-efficacy
	weak beliefs about own capabilities	weak self-efficacy
	uncertain and/or reflective evaluation of own capabilities	uncertain self-efficacy
	task assessment	
	task is easy #	easy
	task is difficult	difficult
	uncertainty about difficulty of task	uncertain task difficulty
	expectancy	
	expect success	expect success
	hope and/or uncertain expectations for success	hope
	expect failure *	
	Cognition and Metacognition	
	metacognition (thinking about thinking)	metacognition
	individual differences in personality and learning styles	individual differences
	Management	
	self-regulation (thinking about and managing behaviour)	self-regulation
	external regulation (other people organise the students' learning behaviours)	external regulation
	self-regulation responding to external facilitation by teachers and mentors	self x external regulation
The Nature of Teaching and Learning	**Constructing knowledge**	
	constructing knowledge (joining, building up, adding on)	construct
	linking theory with practice and practice with theory	theory x practice
	belonging to a learning community	community of learners
	Transmitting-receiving information	
	transmitting and/or gathering information	transmit/gather
	Schooling activities	
	assessment and feedback	assessment/feedback
	logistics of teaching (human and material resources)	logistics
	facilitate learning (designing and delivering learning experiences)	facilitate
	busywork (activities without intellectual engagement)	busywork
The Nature of the Learning Environment	**Learning in authentic, situated practice**	
	learning through authentic practice (on the job training)	authentic practice
	Learning in class or through individual study	
	learning through studying (at home and classroom based)	studying
	learning through social interaction (discussions, watching, listening)	social learning
	supportive environment (encouragement, safety net, caring)	supportive environment
The Nature of the Subject Matter	**Subject matter purpose**	
	purpose of learning experiences	purpose
	learning is a lifelong endeavour	lifelong learning
	Subject matter content**	

** participants' accounts were so thoroughly embedded in content that this category was not coded separately
* this category did not appear in transcripts
# omitted from Correspondence Analysis due to poor fit

From Table 1 it can be seen that four categories provide the foundational structure for organising the interview data at Level 1, namely the nature of the learner, the nature of teaching and learning, the nature of the learning environment, and the nature of the subject-matter. Next, organising the data at Level 2, are 38 variables drawn from educational psychology, such as motivation and constructing knowledge. It is important to note that any statement recorded in an interview transcript could be coded to more than one variable, thus the total number of codes per transcript exceeds the total number of statements per transcript. This multiple coding procedure was selected after trials of both multiple and discrete coding. We assessed that multiple coding captured more of the richness in the data, even though it made the coding task more complex and time consuming. Note that one variable, *subject matter content*, was ubiquitous and therefore not coded separately. Another variable, *expectancy for failure*, did not appear. Thus the initial run of the correspondence analysis was with 36 variables.

Following coding, the report function in NUD*IST summed the frequencies of occurrence of each variable in each transcript, ready for entry into a contingency table.

The contingency table

We used the correspondence analysis program in SPSS (1995). The initial step in a correspondence analysis is to enter the frequencies of participants' responses in the form of a contingency table, which is a two-way table with, in the present case, 22 participants' names as row headings, and 36 variables as column headings. By way of illustration, Table 2 is a portion of the contingency table.

Table 2. Portion of the 22 X 36 contingency table

Participants	purpose	authentic practice	social learning	supportive environment	meta-cognition	self-regulation	(n=36)	Totals
Anne	24	119	14	20	304	172		1431
Josi	46	171	0	0	159	144		1420
John	19	117	7	0	108	117		735
Rory	38	249	21	0	167	294		2080
Roxy	32	285	27	0	430	169		2005
Sally	15	206	31	3	513	493		3193
Troy	9	297	15	5	175	227		1430
Cait (p=22)	0	78	21	2	47	84		461
Totals	537	2597	317	340	2645	2897		**21860**

From Table 2 it can be seen that in Row 1, Anne made 24 statements about the *purpose of learning*, 119 statements about *learning in authentic practice* and so on, with a total of 1431 statements. Reading down the columns, the participant group as a whole made 537 statements about the *purpose of learning*, 2597 statements *about learning in authentic practice*, and so on. The total number of coded statements for the 22 participants is 21,860.

Initial trials of correspondence analysis

Initial trials of the correspondence analysis identified that some of the variables achieved a poor fit of less than 0.5 (Hair et al., 1995). Fit is determined by the proportion of variance in each variable accounted for by the dimension. It is measured by the squared correlation (Clausen, 1998). The squared correlation is the same as $\cos^2$ for the angle between a line from the centroid to the point and the line of the dimensional axis. If the squared correlation is high, then the angle between the vector of the point and the dimensional axis is small, and the point is therefore situated in the direction of that dimensional axis (Clausen, 1998). If all possible dimensions are included in the final analysis (in the present case 21, being one less than the smaller total of points

in the rows and columns), then the squared correlations sum to one. In a lower dimensional solution, the squared correlations provide an index of fit of the representation of each point in the solution, which is equivalent to communalities in principal components analysis (Clausen, 1998).

It was necessary to achieve a compromise between retaining all of the variables in the analysis and the interpretability of the solution. Therefore, a generous cut off point for total fit of variables was set at 0.4, resulting in the removal of four variables from the analysis. J. P. Keeves (personal communication 28th May, 2003) suggested that a potential reason for the poor fit of the four variables was that those variables did not show reliable patterns of differentiation between participants. Looking at the nature of the variables, and from our in-depth knowledge of the participants' transcripts, this seems to be a reasonable explanation. For example, the first three poorly fitting variables are the motivational variables *interest*, *like*, and *cost*. These three motivational variables seem salient to all participants. The fourth variable, *easy*, occurs with extremely low frequency, and thus can be considered irrelevant in participants' accounts. Therefore, the final run of the correspondence analysis was with 32 variables.

In addition to providing measures of fit for variables, correspondence analysis also provides measures of fit for participants' scores. Fit for participants' scores in a four-dimensional solution range from low (0.170) to high (0.905), with five participants' scores falling below 0.3. Moving to a seven dimensional solution, two participants' scores still fall below a 0.4 cut-off point for fit (0.355 and 0.379). An essential premise of this paper is the importance of finding out about the knowledge held by teachers and learners. We were therefore reluctant to remove participants from the analysis so as to achieve a neat statistical model, especially as this is a relatively small sample study. We are also mindful that Jean-Paul Benzecri, arguably the father of correspondence analysis, conceptualised the correspondence procedure as being a technique that is founded on inductive reasoning, describing in a complete and honest way, the data set at hand and where, "the model must fit the data, not vice, versa" (cited in Greenacre, 1984, p. 10). Therefore, we retained all 22 participants' transcripts in the analysis. However, it is necessary to maintain constant contact between the final dimensional solutions and the original data, such that unwarranted claims are not made. It is possible, of course, to achieve better fit of participants' scores by moving to a higher dimensional solution, however, this must be balanced against the basic aim of employing the correspondence analysis, which is to seek a parsimonious way of representing and understanding the data.

The row and column profiles

Each row and column of the contingency table is characterised by its profile, which is a 'system of proportions' (Benzecri, 1992). To begin, the correspondence analysis program calculates the so called 'row profiles,' which are the relative proportions of each variable within all of the variables mentioned by each participant. The row profiles permit a within-participant comparison of the variables. Table 3 is the row profile for one participant, Anne (medical).

From Table 3, it can be seen that of all of the coded statements in Anne's transcript, 0.017 (or 1.7%) referred to the purpose of learning, 0.083 (8.3%) referred to learning in authentic practice, and so on. The marginal total of 1 equates to 100 per cent of all coded statements in Anne's transcript.

Next, the correspondence analysis program calculates the 'column profiles.' The column profiles are the proportion of each variable mentioned by each participant as a total of all participants' mentions of that variable. Profiling participants across the column variables permits between-participant comparisons. Table 4 is the column profile for Anne's coded statements.

Table 3: Row profile: Anne (medical): Proportion of each variable appearing in Anne's transcript

indicator	proportion	indicator	proportion	indicator	proportion
purpose	0.017	mastery	0.000	individual differences	0.005
studying	0.108	certification x mastery	0.000	construct	0.010
authentic practice	0.083	fulfilment	0.009	transmit/gather	0.083
social learning	0.010	personal growth	0.000	assessment/feedback	0.120
supportive environment	0.014	strong self-efficacy	0.001	logistics	0.010
metacognition	0.212	weak self-efficacy	0.000	facilitate	0.063
self-regulation	0.120	uncertain self-efficacy	0.000	busywork	0.000
external regulation	0.001	difficult	0.000	community of learners	0.000
self x ext. regulation	0.027	uncertain task difficulty	0.000	theory x practice	0.062
useful	0.010	expect success	0.005	lifelong learning	0.002
certification	0.002	hope for success	0.025	margin total	1.000

Table 4: Column profile: Anne (medical): Proportion of Anne statements in all participants' statements across all variables

indicator	proportion	indicator	proportion	indicator	proportion
purpose	0.045	mastery	0.000	individual differences	0.056
studying	0.159	certification x mastery	0.000	construct	0.024
authentic practice	0.046	fulfilment	0.040	transmit/gather informati	0.112
social learning	0.044	personal growth	0.000	assessment/feedback	0.090
supportive environment	0.059	strong self-efficacy	0.005	logistics	0.037
metacognition	0.115	weak self-efficacy	0.000	facilitate	0.125
self-regulation	0.059	uncertain self-efficacy	0.000	busywork	0.000
external regulation	0.059	difficult	0.000	community of learners	0.000
self x ext. regulation	0.048	uncertain task difficulty	0.000	theory x practice	0.043
useful	0.034	expect success	0.019	lifelong learning	0.039
certification	0.028	hope for success	0.242	margin	0.067

From Table 4 it can be seen that Anne contributed 0.045 (or 4.5%) of all participants' statements about the purpose of learning, 0.046 (4.6%) of all participants' statements about learning in authentic practice, and so on. Table 4 also contains the marginal total for Anne, 0.067, which is the proportion of Anne's statements about all variables relative to all participants' statements. The marginal totals provide the mass, or weight, of the contribution of each participant, (and each variable), to the dimensional solution (Greenacre, 1984).

An early result from the profiles generated by the correspondence analysis can be obtained by graphing the proportional marginal totals of each participant, as displayed in Figure 1. It is clear from Figure 1 that there is considerable variation in the total number of statements made by participants, ranging from 0.009 (0.9%) of total statements for Bec (child-care) to 0.159 (16%) of total statements for Sally (medical). It is also possible to discern a pattern of response levels between groups of participants, with the child-care students occupying the lowest 10 positions, through a mixture of child-care students, teachers and medical student in the middle ranges, to the top six positions being held by medical students. In summary, child-care students provided the fewest, and medical students the most, statements about the 32 variables of knowledge about teaching and learning.

It is possible to continue to investigate the numerical information contained in the row and column profiles to search for patterns of occurrence of variables. One way of doing this would be to provide a graph such as that in Figure 1 for each participant across all variables, and then each variable across all participants: 22 x 32 graphs. It is immediately apparent that information presented in such a fashion would soon become too large to manage and extremely difficult to penetrate in a meaningful way. Therefore, the next step in the correspondence analysis is to reduce the complexity contained in the row and column profiles by creating a low-dimensional representation.

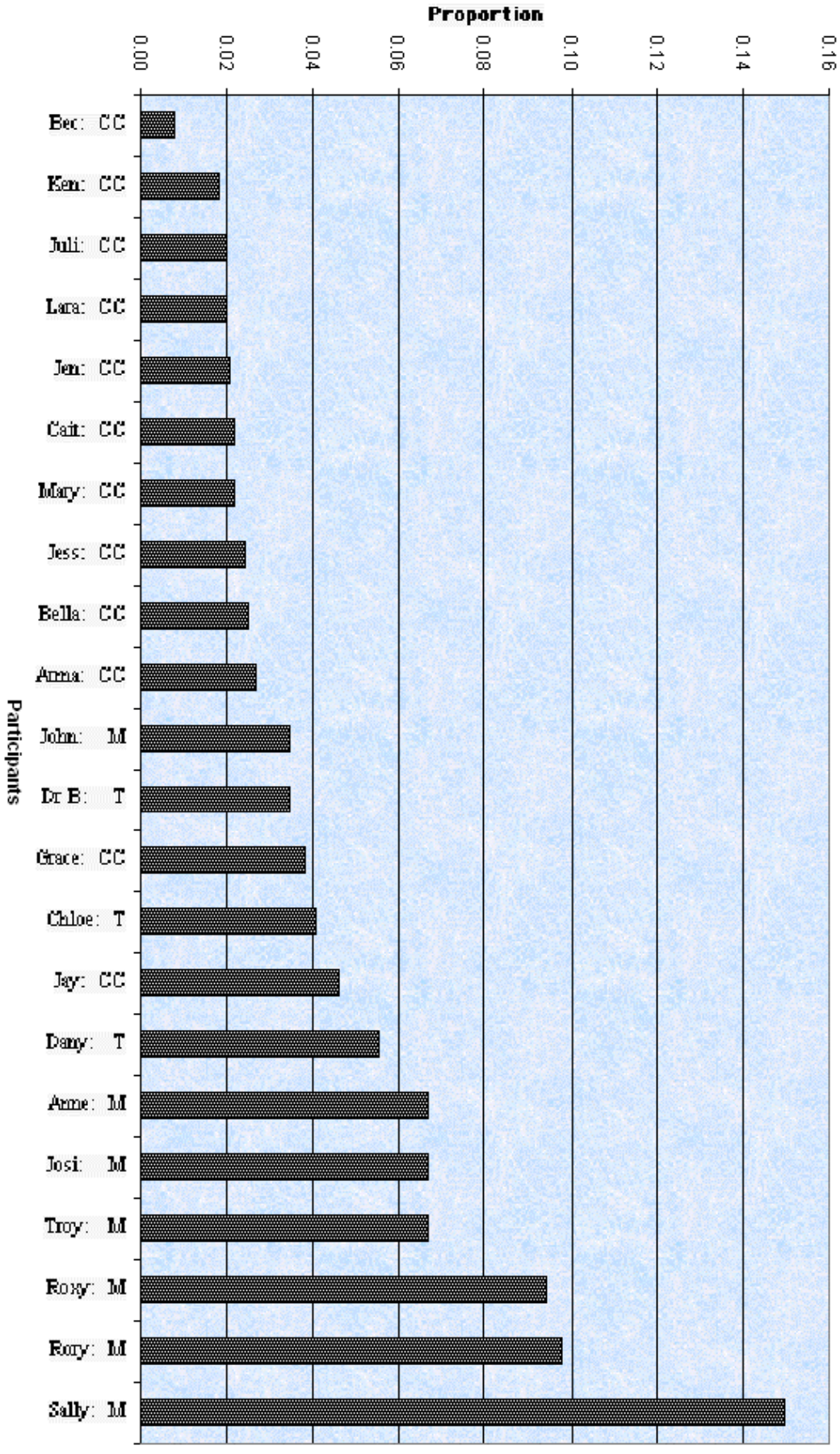


Figure 1. Proportional marginal totals for each Participant

The 32 variable correspondence analysis solution

Table 5, taken from the correspondence analysis (symmetrical normalisation) output for the 22 participants and 32 variables, contains the singular values, inertia, and proportion of variation explained for 21 dimensions. (The maximum number of singular values equals the number of dimensions possible, which is one less than the lesser number of participants and variables.)

From Table 5, the singular value indicates the relative contribution of each dimension to an explanation of the inertia, or variance, in the participant and variable profiles. The singular values can be interpreted as the correlation between the rows and columns of the contingency table, and are analogous to the Pearson correlation coefficient in correlation analysis (SPSS, 2001). As in principal components analysis, the first dimension explains as much variance as possible, the second dimension is orthogonal to the first and displays as much of the remaining variance as possible, and so on (Clausen, 1998; SPSS, 2001). Hair et al. (1995) recommended that singular values of greater than 0.2 indicate that the dimension should be included in the analysis. However, this cut-off point must be balanced against the proportion of variance explained by each dimension, as well as achieving a balance between the interpretability of multiple dimensions and a model that captures the complexity of the data (Benzecri, 1992). The singular value and the inertia are directly related ($I=SV^2$): the inertia is an indicator of how much of the variation in the original data is *retained* in the dimensional solution (Bendixen, 1996).

Table 5. Singular values and proportion of variance explained

Dimension	Singular Value	Inertia	Proportion Explained	Cumulative Proportion
1	0.421	0.177	0.210	0.210
2	0.347	0.120	0.143	0.353
3	0.322	0.103	0.123	0.476
4	0.281	0.079	0.094	0.570
5	0.249	0.062	0.073	0.643
6	0.246	0.060	0.072	0.715
7	0.221	0.049	0.058	0.773
8	0.193	0.037	0.044	0.817
9	0.187	0.035	0.042	0.858
10	0.156	0.024	0.029	0.887
11	0.141	0.020	0.024	0.911
12	0.127	0.016	0.019	0.930
13	0.121	0.015	0.017	0.948
14	0.104	0.011	0.013	0.960
15	0.096	0.009	0.011	0.971
16	0.086	0.007	0.009	0.980
17	0.083	0.007	0.008	0.988
18	0.065	0.004	0.005	0.993
19	0.056	0.003	0.004	0.997
20	0.038	0.001	0.002	0.999
21	0.033	0.001	0.001	1.000
Total		0.843	1.000	1.000

On the one hand, the purpose of running a correspondence analysis is to reduce the complexity in the data. On the other hand, it is not helpful to select such a low dimensional solution that important features are overlooked. One method for assisting in the decision about the most appropriate number of dimensions to interpret is to prepare a scree plot of the proportions of variance explained, in order to observe where the proportion is seen to drop away at a less rapid rate (Clausen, 1998; Hair et al., 1995). Such a scree plot is presented in Figure 2.

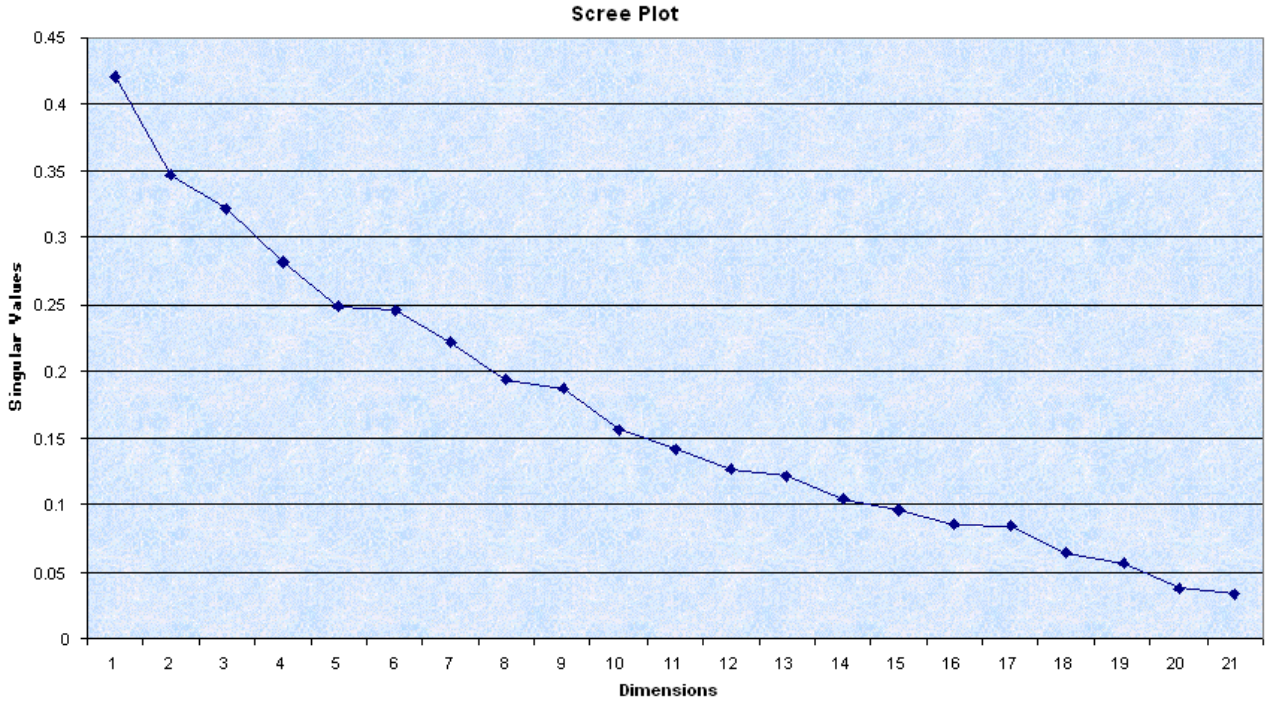


Figure 2. Scree plot of singular values

The scree plot suggests that the proportion of variance explained drops away less rapidly after the tenth dimension. However, we considered that working with 10 dimensions would not achieve the conceptual clarity that we were seeking with the use of correspondence analysis. Consequently, we decided to adopt the singular value of 0.2 as a cut off point as a first step, and to attempt to interpret the first seven dimensions. Although attempting to interpret seven dimensions seems excessive when compared to literature about interpretation of multidimensional scaling solutions, where usually two or three dimensions are interpreted (for example, see Davison, 1983), if comparisons are made to exploratory factor analysis, it is common to search for potential extra factors (Hair et al., 1995). Although most of the correspondence analysis literature deals with two or three dimensions, there are some exceptions, such as Nishisato's (1994) interpretation of seven dimensions of personality.

In order to interpret each dimension the authors met on multiple occasions to review the correspondence analysis solution and to identify the potential latent concepts underlying the combination of variables contributing to each dimension. Our discussions were extensive, comparing each dimensional combination of variables with our knowledge of the literature and contemporary teaching and learning environments. Our discussions can be theoretically conceptualised as a "peer debriefing" process for establishing validity in qualitative enquiry, as described by Creswell and Miller (2000):

> A peer review or debriefing is the review of the data and research process by someone who is familiar with the research or the phenomenon being explored. A peer reviewer provides support, play's devil's advocate, challenges the researcher's assumptions, pushes the researchers to the next step methodologically, and asks hard questions about methods and interpretations (Lincoln & Guba, 1985). (Creswell & Miller, 2000 p. 129)

Our discussions continued until we reached complete agreement upon our interpretations of each dimension.

The graphical displays

To manage the visual presentation of seven dimensions we will present successive two-dimensional displays. Table 6 contains the coordinates, proportional contributions of points (variables) to dimensions, and fit of dimensions to points (squared correlations) that generate the graphical displays.

Table 6. Correspondence Analysis Solution

	A	B	C	D	E	F	G	H
Participants	**Margin**	**Scores on each dimension**						
		Dimension 1	Dimension 2	Dimension 3	Dimension 4	Dimension 5	Dimension 6	Dimension 7
Anne: medical	0.067	0.112	-0.261	0.130	-0.308	0.147	-0.240	0.524
Josi: medical	0.067	-0.477	-0.174	0.062	0.212	-0.512	0.121	-0.088
John: medical	0.035	-0.412	-0.381	-0.023	0.332	-0.132	-0.447	0.268
Rory: medical	0.098	-0.464	-0.136	-0.128	0.252	0.199	-0.530	-0.147
Roxy: medical	0.094	-0.251	0.191	0.223	-0.069	-0.821	0.477	-0.091
Sally: medical	0.150	-1.000	-0.134	-0.286	-0.377	0.403	0.164	-0.144
Troy: medical	0.067	-0.138	-0.111	0.052	0.599	-0.598	-0.560	0.589
Cait: child-care	0.022	0.395	0.467	0.373	0.430	-0.765	-0.050	0.053
Arma: child-care	0.027	0.147	0.692	0.284	-0.448	0.657	0.157	0.003
Grace: child-care	0.038	0.509	0.783	0.232	0.666	0.238	0.426	0.522
Bella: child-care	0.025	1.094	0.301	-1.924	-0.338	-0.417	-0.142	-0.538
Jen: child-care	0.021	0.204	0.791	0.443	-0.564	0.337	-0.301	0.171
Jess: child-care	0.024	0.395	2.100	0.530	-0.487	0.138	-1.328	-1.351
Jay: child-care	0.046	0.547	0.366	-0.092	-0.280	0.686	0.268	1.147
Juli: child-care	0.020	0.822	-0.247	-0.522	-0.007	-0.220	-0.430	0.396
Ken: child-care	0.018	0.600	1.510	0.688	0.137	0.416	0.583	0.295
Lara: child-care	0.020	1.315	-0.279	-1.778	-0.516	-0.215	0.344	0.014
Mary: child-care	0.022	0.165	0.352	0.501	-0.218	-0.884	0.957	-0.507
Bec: child-care	0.008	1.269	-0.017	-2.581	0.023	-0.332	-0.259	0.336
Chloe: teacher	0.041	0.545	-0.561	0.283	0.047	0.398	1.194	-0.534
Dany: teacher	0.055	1.115	-1.301	0.996	-0.752	0.011	-0.475	-0.302
Dr B: teacher	0.035	0.568	-0.423	0.003	1.955	0.895	0.089	-0.754
Variables								
purpose	0.025	0.642	-0.409	0.484	1.062	0.617	0.418	-0.963
studying	0.046	-0.173	0.431	0.176	0.056	0.001	-0.595	0.470
authentic practice	0.122	0.198	0.109	-0.225	0.794	-0.181	-0.129	0.070
social learning	0.015	0.669	-0.824	1.155	-0.598	-0.148	0.216	-0.420
supportive environ.	0.016	1.122	1.426	0.918	-0.179	1.503	0.856	1.698
metacognition	0.125	-0.315	-0.024	0.168	-0.309	-0.223	0.138	0.243
self-regulation	0.136	-0.033	0.315	-0.297	-0.141	0.122	-0.154	0.436
external regulation	0.001	2.244	-0.056	-3.265	-0.633	-0.078	1.524	-0.808
self x ext. regulation	0.039	-0.839	-0.292	-0.203	0.137	-0.053	-0.493	0.013
useful	0.020	-0.261	0.013	0.344	0.492	-1.668	0.033	0.122
certification	0.005	1.140	1.149	-0.804	-0.569	0.175	0.100	0.183
mastery	0.017	-0.098	-0.301	0.338	0.177	-0.515	1.384	-0.341
certification x mastery	0.012	-1.750	-0.401	-0.422	-0.764	0.466	0.640	-0.582
fulfilment	0.016	0.197	1.393	0.220	-0.214	-0.437	-0.443	-0.772
personal growth	0.005	0.924	3.799	1.008	-1.343	0.841	-1.853	-2.468
strong self-efficacy	0.019	-0.645	0.898	0.127	-0.274	0.153	-0.810	-0.932
weak self-efficacy	0.007	-0.164	0.788	0.484	0.580	-1.240	0.530	0.187
uncertain self-efficacy	0.005	0.353	1.997	1.191	-0.275	-1.316	1.089	-1.143
difficult	0.002	-0.177	0.218	0.513	0.618	-2.354	0.483	0.253
uncertain task difficulty	0.003	1.828	-2.248	1.824	-1.710	-0.891	-0.922	-0.722
expect success	0.017	-0.581	-0.434	-0.198	0.986	1.118	-0.215	-0.775
hope for success	0.007	1.039	-1.169	0.916	-1.008	-0.887	-0.503	-0.045
individual differences	0.006	1.248	0.461	1.339	-1.196	-0.004	-1.061	-0.944
construct	0.030	-1.400	-0.161	-0.358	-0.625	0.315	0.317	-0.146
transmit/gather info	0.050	0.908	-0.688	-0.142	-0.580	0.218	0.176	0.063
assessment/feedback	0.090	-0.581	-0.467	-0.125	0.022	0.414	-0.181	-0.152
logistics	0.018	0.573	-1.146	0.735	-0.057	-0.596	-1.369	0.332
facilitate	0.034	1.256	-0.669	0.023	-0.132	0.657	-0.066	-0.123
busywork	0.007	2.604	0.266	-5.142	-0.737	-1.115	-0.087	-0.821
community of learners	0.003	1.284	0.765	0.792	3.452	1.102	0.745	-0.420
theory x practice	0.099	0.031	0.128	0.086	-0.098	-0.202	0.719	-0.226
lifelong learning	0.004	0.363	-1.088	0.656	1.614	-0.789	-1.636	0.793

Table 6. Continued

	I	J	K	L	M	N	O
Participants	**Contribution of points to the inertia of each dimension**						
	Dimension 1	Dimension 2	Dimension 3	Dimension 4	Dimension 5	Dimension 6	Dimension 7
Anne: medical	0.002	0.013	0.004	0.023	0.006	0.016	0.084
Josi: medical	0.036	0.006	0.001	0.011	0.070	0.004	0.002
John: medical	0.014	0.015	0.000	0.014	0.002	0.028	0.011
Rory: medical	0.050	0.005	0.005	0.022	0.016	0.112	0.010
Roxy: medical	0.014	0.010	0.015	0.002	0.256	0.087	0.004
Sally: medical	0.357	0.008	0.038	0.076	0.098	0.016	0.014
Troy: medical	0.003	0.002	0.001	0.086	0.097	0.086	0.106
Cait: child-care	0.008	0.014	0.009	0.014	0.051	0.000	0.000
Arma: child-care	0.001	0.037	0.007	0.019	0.047	0.003	0.000
Grace: child-care	0.023	0.067	0.006	0.060	0.009	0.028	0.047
Bella: child-care	0.071	0.007	0.289	0.010	0.018	0.002	0.033
Jen: child-care	0.002	0.039	0.013	0.024	0.010	0.008	0.003
Jess: child-care	0.009	0.306	0.021	0.020	0.002	0.173	0.198
Jay: child-care	0.033	0.018	0.001	0.013	0.087	0.014	0.274
Juli: child-care	0.032	0.003	0.017	0.000	0.004	0.015	0.014
Ken: child-care	0.015	0.116	0.026	0.001	0.012	0.024	0.007
Lara: child-care	0.081	0.004	0.194	0.019	0.004	0.010	0.000
Mary: child-care	0.001	0.008	0.017	0.004	0.070	0.083	0.026
Bec: child-care	0.029	0.000	0.157	0.000	0.003	0.002	0.004
Chloe: teacher	0.029	0.037	0.010	0.000	0.026	0.238	0.053
Dany: teacher	0.162	0.267	0.169	0.110	0.000	0.050	0.023
Dr B: teacher	0.027	0.018	0.000	0.473	0.112	0.001	0.089
Variables							
purpose	0.025	0.012	0.018	0.101	0.039	0.018	0.106
studying	0.003	0.025	0.004	0.001	0.000	0.066	0.046
authentic practice	0.011	0.004	0.019	0.274	0.016	0.008	0.003
social learning	0.016	0.029	0.062	0.019	0.001	0.003	0.012
supportive environ.	0.048	0.094	0.042	0.002	0.146	0.048	0.209
metacognition	0.029	0.000	0.011	0.042	0.025	0.010	0.033
self-regulation	0.000	0.039	0.037	0.010	0.008	0.013	0.117
external regulation	0.010	0.000	0.027	0.001	0.000	0.008	0.002
self x ext. regulation	0.065	0.010	0.005	0.003	0.000	0.038	0.000
useful	0.003	0.000	0.007	0.017	0.219	0.000	0.001
certification	0.016	0.019	0.010	0.006	0.001	0.000	0.001
mastery	0.000	0.004	0.006	0.002	0.018	0.130	0.009
certification x mastery	0.091	0.006	0.007	0.026	0.011	0.021	0.019
fulfilment	0.001	0.087	0.002	0.003	0.012	0.012	0.042
personal growth	0.010	0.206	0.016	0.032	0.014	0.069	0.136
strong self-efficacy	0.019	0.044	0.001	0.005	0.002	0.051	0.075
weak self-efficacy	0.000	0.013	0.005	0.009	0.046	0.009	0.001
uncertain self-efficacy	0.001	0.057	0.022	0.001	0.034	0.024	0.029
difficult	0.000	0.000	0.002	0.003	0.046	0.002	0.001
uncertain task difficulty	0.026	0.047	0.034	0.034	0.010	0.011	0.008
expect success	0.014	0.009	0.002	0.059	0.086	0.003	0.046
hope for success	0.018	0.028	0.018	0.025	0.022	0.007	0.000
individual differences	0.022	0.004	0.033	0.030	0.000	0.027	0.024
construct	0.138	0.002	0.012	0.041	0.012	0.012	0.003
transmit/gather info	0.098	0.068	0.003	0.060	0.010	0.006	0.001
assessment/feedback	0.072	0.057	0.004	0.000	0.062	0.012	0.009
logistics	0.014	0.067	0.030	0.000	0.025	0.135	0.009
facilitate	0.127	0.044	0.000	0.002	0.059	0.001	0.002
busywork	0.107	0.001	0.546	0.013	0.033	0.000	0.020
community of learners	0.013	0.006	0.007	0.144	0.017	0.008	0.003
theory x practice	0.000	0.005	0.002	0.003	0.016	0.208	0.023
lifelong learning	0.001	0.012	0.005	0.034	0.009	0.040	0.010

Table 6. Continued

	P	Q	R	S	T	U	V	W
Participants	**Contribution of dimension to the inertia of each point**							**Total (fit)**
	Dimension 1	Dimension 2	Dimension 3	Dimension 4	Dimension 5	Dimension 6	Dimension 7	
Anne: medical	0.013	0.059	0.014	0.067	0.014	0.035	0.153	0.355
Josi: medical	0.243	0.027	0.003	0.032	0.165	0.009	0.004	0.484
John: medical	0.132	0.093	0.000	0.057	0.008	0.091	0.029	0.411
Rory: medical	0.238	0.017	0.014	0.047	0.026	0.181	0.013	0.535
Roxy: medical	0.071	0.034	0.043	0.004	0.450	0.150	0.005	0.756
Sally: medical	0.719	0.011	0.045	0.069	0.069	0.011	0.008	0.931
Troy: medical	0.017	0.009	0.002	0.211	0.186	0.161	0.161	0.748
Cait: child-care	0.065	0.075	0.044	0.051	0.143	0.001	0.001	0.379
Arma: child-care	0.016	0.293	0.046	0.099	0.189	0.011	0.000	0.653
Grace: child-care	0.111	0.216	0.018	0.126	0.014	0.045	0.061	0.591
Bella: child-care	0.249	0.015	0.589	0.016	0.021	0.002	0.032	0.925
Jen: child-care	0.027	0.333	0.097	0.137	0.043	0.034	0.010	0.682
Jess: child-care	0.024	0.560	0.033	0.024	0.002	0.158	0.148	0.949
Jay: child-care	0.166	0.061	0.004	0.029	0.155	0.023	0.385	0.824
Juli: child-care	0.295	0.022	0.091	0.000	0.013	0.047	0.036	0.504
Ken: child-care	0.085	0.446	0.086	0.003	0.024	0.047	0.011	0.702
Lara: child-care	0.352	0.013	0.492	0.036	0.006	0.014	0.000	0.912
Mary: child-care	0.011	0.042	0.079	0.013	0.190	0.219	0.056	0.610
Bec: child-care	0.202	0.000	0.638	0.000	0.008	0.005	0.007	0.861
Chloe: teacher	0.126	0.110	0.026	0.001	0.040	0.352	0.063	0.717
Dany: teacher	0.298	0.335	0.182	0.091	0.000	0.032	0.011	0.948
Dr B: teacher	0.076	0.035	0.000	0.603	0.112	0.001	0.070	0.897
Variables								
purpose	0.156	0.052	0.068	0.286	0.085	0.039	0.184	0.870
studying	0.029	0.149	0.023	0.002	0.000	0.202	0.113	0.519
authentic practice	0.065	0.016	0.064	0.697	0.032	0.016	0.004	0.895
social learning	0.135	0.170	0.308	0.072	0.004	0.008	0.028	0.726
supportive environ.	0.160	0.212	0.082	0.003	0.169	0.054	0.192	0.872
metacognition	0.245	0.001	0.053	0.158	0.073	0.027	0.077	0.635
self-regulation	0.003	0.215	0.177	0.035	0.023	0.036	0.263	0.753
external regulation	0.207	0.000	0.335	0.011	0.000	0.056	0.014	0.624
self x ext. regulation	0.424	0.042	0.019	0.008	0.001	0.085	0.000	0.579
useful	0.026	0.000	0.035	0.063	0.637	0.000	0.003	0.764
certification	0.288	0.241	0.110	0.048	0.004	0.001	0.004	0.697
mastery	0.003	0.024	0.027	0.007	0.049	0.351	0.019	0.480
certification x mastery	0.559	0.024	0.025	0.071	0.023	0.044	0.032	0.778
fulfilment	0.012	0.498	0.011	0.010	0.035	0.036	0.097	0.699
personal growth	0.039	0.538	0.035	0.055	0.019	0.091	0.145	0.921
strong self-efficacy	0.165	0.264	0.005	0.020	0.005	0.152	0.182	0.794
weak self-efficacy	0.006	0.119	0.042	0.052	0.211	0.038	0.004	0.472
uncertain self-efficacy	0.013	0.341	0.112	0.005	0.106	0.072	0.071	0.721
difficult	0.004	0.005	0.026	0.033	0.419	0.017	0.004	0.508
uncertain task difficulty	0.187	0.233	0.142	0.110	0.026	0.028	0.015	0.742
expect success	0.130	0.060	0.011	0.250	0.284	0.010	0.122	0.868
hope for success	0.171	0.178	0.102	0.108	0.074	0.023	0.000	0.656
individual differences	0.253	0.028	0.223	0.156	0.000	0.107	0.076	0.843
construct	0.634	0.007	0.032	0.084	0.019	0.019	0.004	0.798
transmit/gather info	0.453	0.214	0.008	0.123	0.015	0.010	0.001	0.825
assessment/feedback	0.418	0.223	0.015	0.000	0.125	0.024	0.015	0.820
logistics	0.075	0.248	0.095	0.001	0.048	0.250	0.013	0.730
facilitate	0.593	0.139	0.000	0.004	0.096	0.001	0.003	0.836
busywork	0.227	0.002	0.677	0.012	0.025	0.000	0.012	0.955
community of learners	0.092	0.027	0.027	0.444	0.040	0.018	0.005	0.652
theory x practice	0.002	0.023	0.010	0.011	0.042	0.526	0.047	0.661
lifelong learning	0.014	0.107	0.036	0.191	0.040	0.172	0.036	0.597

Figure 3 contains the correspondence analysis scaling solution coordinates for variables and participants in Dimensions 1 and 2, with Dimension 1 on the horizontal axis and Dimension 2 on the vertical axis. Dimension 1 accounts for 21 per cent of the variance in the data and Dimension 2 accounts for 14.3 per cent of the variance. It can be seen that one variable, personal development, appears to lie outside of the chart. This is simply a space limitation due to the

extreme score (0.92, 3.8) of that variable. Recall that in symmetrical normalisation, the graphical display is of relative, but not actual magnitudes. Variables that are labelled in italics contribute most to Dimension 1: Variable labels that are underlined contribute most to Dimension 2 (columns I and J in Table 6).

It is important to note that in this case the two-dimensional chart is part of a seven-dimensional solution. Therefore, when interpreting each dimension it is necessary to consider the contribution of variables to that dimension. This is because a variable that appears on the two-dimensional chart might be a major contributor to another dimension but might not be located in the extant two-dimensional plane (Clausen, 1998; Nishisato, 1994). For example, in Figure 3, the variable *community of learners* appears to the right of Dimension 1, and a superficial analysis might suggest that it be included in an interpretation of Dimension 1. However, an inspection of Table 6 demonstrates that *community of learners* contributes more than its expected proportion to Dimension 4, but contributes minimally to Dimensions 1 and 2. Expected contribution is calculated by dividing 1 (the possible total contribution) by the total number of variables, in this case 32, giving an expected proportion of contribution per variable of 0.031 (Hair et al., 1995). Therefore, variables that contribute more than 0.031 are important for the interpretation of that dimension, in so far as they contribute more than would be expected by chance.

It is also necessary to consider the contribution of each dimension to an explanation of the variance in each participant's profile. Some participants' profiles are not well fitted in certain planes (both dimensions each contribute less than a nominal cut off point of 10 per cent to the variance in the participant's score). For example, Roxy's (medical) score is not well fitted by Dimensions 1, 2, 3, or 4. However, 45 per cent of the variance in her profile is accounted for by Dimension 5, and a further 15 per cent is accounted for by Dimension 6 (from Table 6; Columns P to V). Participants whose profiles are poorly fitted are marked with an asterisk in each two dimensional display.

Dimensions 1 and 2

We turn now to an interpretation of the dimensions. The left-hand pole of Dimension 1 appears to contain variables that relate to issues that are recognised in contemporary literature as being important for learning. *Construct* (contributing 0.138 from Table 6) refers to participants' accounts of joining together and adding on to what they know, and is at the heart of constructivist theories of teaching and learning (Anderson, Greeno, Reder, & Simon, 2000; Bransford, Brown, & Cocking, 1999; Phillips, 2000). *Certification* x *mastery* (0.091), and *self-regulation* x *external-regulation* (0.065), are also located at the left-hand pole. The variable *assessment/feedback* (0.072) also contributes more than expected to the left side of Dimension 1, and highlights students' and teachers' attention to the importance of assessment in formal learning environments (Biggs, 1999; Shepard, 2001). Metacognition (0.029) does not quite reach the 0.031 threshold for contribution, but could be considered a minor contributor to this Dimension.

At the right-hand side of Dimension 1 are variables that do indeed seem to be opposite in character to those on the left. For example, *busywork* (0.107) suggests a role for the student where the student is engaged, often in a purposeful, self-regulated fashion, with activities, but does not connect such purposeful activity with an intention to learn (Bereiter & Scardamalia, 1989). *Transmit/gather information* (0.098) suggests traditional models of instruction based upon the flow of knowledge from the teacher, and other resources, to the student. *Facilitate* (0.127) and *supportive environment* (0.048) seem to refer to the responsibilities that the teacher has to create an environment for learning to occur. *Uncertain task difficulty* (0.026) and *purpose* (0.025) are minor contributors to this dimension.

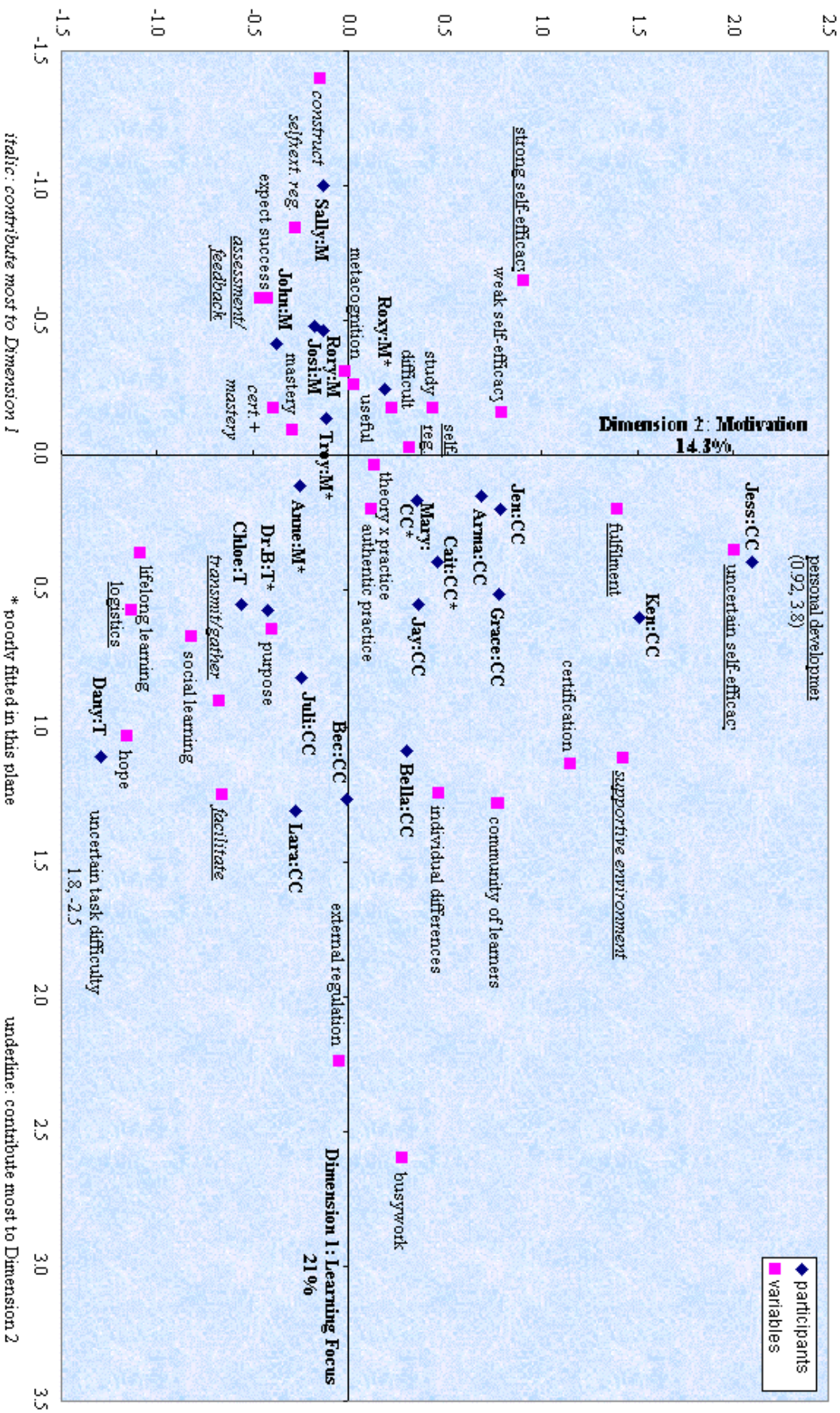


Figure 3. Dimension 1: Learning Focus and Dimension 2: Motivation

In summary, the left-hand pole of Dimension 1 seems to have an intrinsic flavour, dealing with issues that relate to the role of the learner in focussing upon cognitive engagement with, and the management of, learning. The right-hand pole of Dimension 1 seems to contain variables that relate to learning as an externally facilitated, sometimes very task focussed activity, and knowledge as something that is transmitted from external sources. Thus Dimension 1 can be interpreted as a dimension of *Learning Focus*, with a continuum ranging from a focus on *an intention to construct knowledge* at the left-hand pole to focus on *learning as work to be done* at the right-hand pole.

Turning to Dimension 2, six variables contribute more than average to its upper pole: *personal development* (0.206), *uncertain self-efficacy* (0.057), *fulfillment* (0.087), *supportive environment* (0.094), *strong self-efficacy* (0.044) and *self-regulation* (0.039). *Studying* (0.025) is a minor contributor. This cluster of variables contains intrinsic issues relating to learners, but in a different sense to Dimension 1. Here, learners' motivations and assessments of self seem to predominate, once again finding parallels with the work of Bandura (2001) and other theories of motivation that incorporate concepts of self-efficacy (for example, Wigfield & Eccles, 2000) and fulfillment (for example, Mayer, 1998; Ryan & Deci, 2000; Winne, 1991).

At the lower pole of Dimension 2 are variables related to the role of the teacher in organising learning, including the *logistics* (0.067) of organising people and equipment, *facilitate* (0.044), which refers to things that teachers and other people do, such as providing support and encouragement, *transmit/gather information* (0.068), and *assessment* (0.057). An interesting inclusion at this pole is *uncertain task difficulty* (0.047), which, from a reading of the transcripts, reflects both the teacher's dilemma of designing instruction to match varying levels of student ability in heterogenous classes, as well as to students' uncertainty about the difficulty of tasks. Minor contributors to this pole are *social learning* (0.029), which includes statements such as 'learning through class discussions,' and *hope for success* (0.028), which reflects participants' expectancies for success or failure and can be related to their assessment of the difficulty of the task. Together, the variables at the lower pole of Dimension 2 seem to relate to the role of the teacher in organising for effective learning to occur, and so it is possible to assign the label *external* to this pole. In sum, Dimension 2 can be interpreted as *Motivation*, comprised of a continuum of *intrinsic motivations* at the top pole, and *external facilitators and motivators* at the lower pole.

It is worth noting at this point that, unlike a procedure such as cluster analysis, which partitions variables into mutually exclusive clusters, procedures such as correspondence analysis and multidimensional scaling recognise the potential for variables to contribute to more than one dimension (Nishisato, 1994). Hence, it can be seen from Figure 3 for example, that *transmit/gather information* contributes more than expected to both Dimensions 1 (0.098) and 2 (0.068), as does *assessment/feedback* (0.072 and 0.057). However, whereas *transmit/gather* lies at the *external* poles of both Dimensions 1 and 2, *assessment/feedback* lies at the *internal* end of Dimension 1 and the *external* end of Dimension 2, pointing to a transaction between the internal and external nature of teaching and learning, and teacher and learner.

The interpretation of Dimensions 1 and 2 so far has resembled the search for latent factors in a principal components, or factor analysis. However, correspondence analysis has much more to offer, as is demonstrated by its ability to place participants' scores in the same multidimensional space as the variables. It is immediately apparent from Figure 3 that participants' scores form distinct clusters. Three of the medical students' scores (Roxy, Troy, Anne) are poorly fitted in this Dimension 1 and 2 plane. The remaining medical students' scores cluster to the left of Dimension 1, closest to the *intention to construct knowledge* pole, while none of the child-care students' or teachers' scores are located near this pole. However, six of the child-care students' scores are

located near at the *learning as work to be done* pole of Dimension 1. Two child-care students' scores (Cait, Mary) are not well fitted in the Dimension 1 and 2 plane.

Interestingly, all of the medical students' scores are poorly fitted by Dimension 2 (from Table 6), indicating that Dimension 2 contributes very little to the medical students' scores. However, Dimension 2 accounts for five childcare students at the *intrinsic motivations* pole.

One teacher's scores (Dr. B) are poorly fitted in the Dimension 1 and 2 plane, while the two child-care teachers' (Dany, Chloe) scores are located in the lower right quadrant, closest to *extrinsic facilitators and motivators*, and *learning as work to be done* variables.

The symmetrical normalisation method chosen for this correspondence analysis permits the placement of variable and participant scores in the same graphical display. It will be recalled that in such displays the distances between participant and variable scores are not Euclidean distances, and therefore it is incorrect to measure the exact distance between, say, Sally, and *metacognition*. However, it is appropriate to consider the relative placement of participant and variable scores, and especially to consider the relative placement of participants' scores to the meaningfully interpreted poles of dimensions (Gabriel, 2002; Greenacre, 1994).

It seems reasonable to conclude that, even with the removal of poorly fitting scores from the Dimension 1 and 2 plane, participants' scores cluster into three distinct groups: medical students at the *constructing knowledge* pole of Dimension 1; child-care students at the *learning as work to be done* pole of Dimension 1, and at the *intrinsic motivation* pole of Dimension 2; and teachers at the *learning as work to be done* pole of Dimension 1 and at the *extrinsic facilitators and motivators* pole of Dimension 2. It is interesting to note that the two teachers who are located with the child-care students at the *learning as work to be done* pole of Dimension 1, are indeed the child-care students' own teachers, suggesting some congruence between the teachers' and their own students' perspectives.

Dimensions 3 and 4

Figure 4 is the graphical display of variables and participants in Dimensions 3 and 4. From Figure 4 it can be seen that *busywork* (Table 6, column K, 0.546) is a dominant contributor to the left-hand pole of Dimension 3. *Self-regulation* (0.037) is a second major contributor and e*xternal regulation* (0.027) is a minor contributor to this pole. The location of these three variables at the same pole raises the interesting possibility that students can be effectively utilising their own and externally sourced skills of regulation, such as time and resource management, to complete tasks that do not require much in the way of cognitive engagement to construct knowledge. The right-hand pole of Dimension 3 has *supportive environment* (0.042), *social learning* (0.062), *individual differences* (0.033) and *uncertain task-difficulty* (0.034) as its major contributors and *logistics* (0.03) as a minor contributor. Dimension 3 can be interpreted as an *Organising for Learning* continuum, with *group management* at the right-hand pole, and *individual management* at the left-hand pole.

Turning to Dimension 4, at the top of Figure 4, the variables *community of learners* (0.144), *lifelong learning* (0.034), *purpose* (0.101), *expect success* (0.059) and *authentic practice* (0.274) all point to integrating learning with the everyday fabric of life: over time, in communities of practice and with positive outcomes. At the lower pole of Dimension 4 are *uncertain task difficulty* (0.034), *construct* (0.041), *transmit/gather* (0.06), *metacognition* (0.042) *personal development* (0.032), and at a slightly lower contribution, *certification x mastery* (0.026), *individual differences* (0.03) and *hope for success* (0.025). This lower pole seems similar to the negative pole of Dimension *1 (an intention to construct knowledge*), however, the inclusion *of uncertain task difficulty, individual differences and personal development* in this cluster suggests

an interaction between constructing knowledge and variables that seem concerned with issues that are salient to each individual learner. The relationship of the variables at the two poles of Dimension 4 suggests a continuum of *Context*, with *authentic, situated practice* describing the upper pole, and *learning by studying* describing the lower pole.

The positioning of participants' scores in Dimensions 3 and 4 tells a different story to the readily identifiable clusters that emerged in Dimensions 1 and 2. Certainly, the higher dimensions account for fewer participants' scores. From Table 6, columns R and S, it can be observed that each of Dimensions 3 and 4 account for less than 10 per cent of the variance in half of the participants' scores. Dimension 3 accounts very little for medical students' scores, rather, positioning a child-care teacher (Dany) at the *group management* pole (this seems to make intuitive sense), and three child-care students (Bec, Bella, Lara) at the *individual management* pole. Another two child care students' scores almost reach the nominal 10 per cent cut off point for inclusion in this Dimension, namely Jen (0.097) at the group management pole and Juli (0.091) at the individual management pole.

Dimension 4 accounts for more than 10 per cent of the variance in only one (Troy) medical student's score, and positions his, one child-care student's (Grace), and one teacher's (Dr. B.) scores at the *authentic, situated practice* pole. At the other end of the Dimension 4 continuum, *learning by studying*, is located only Jen's (child-care) score, although the scores of Arma (child-care, 0.099) and Dany (teacher, 0.091) could be included in this Dimension.

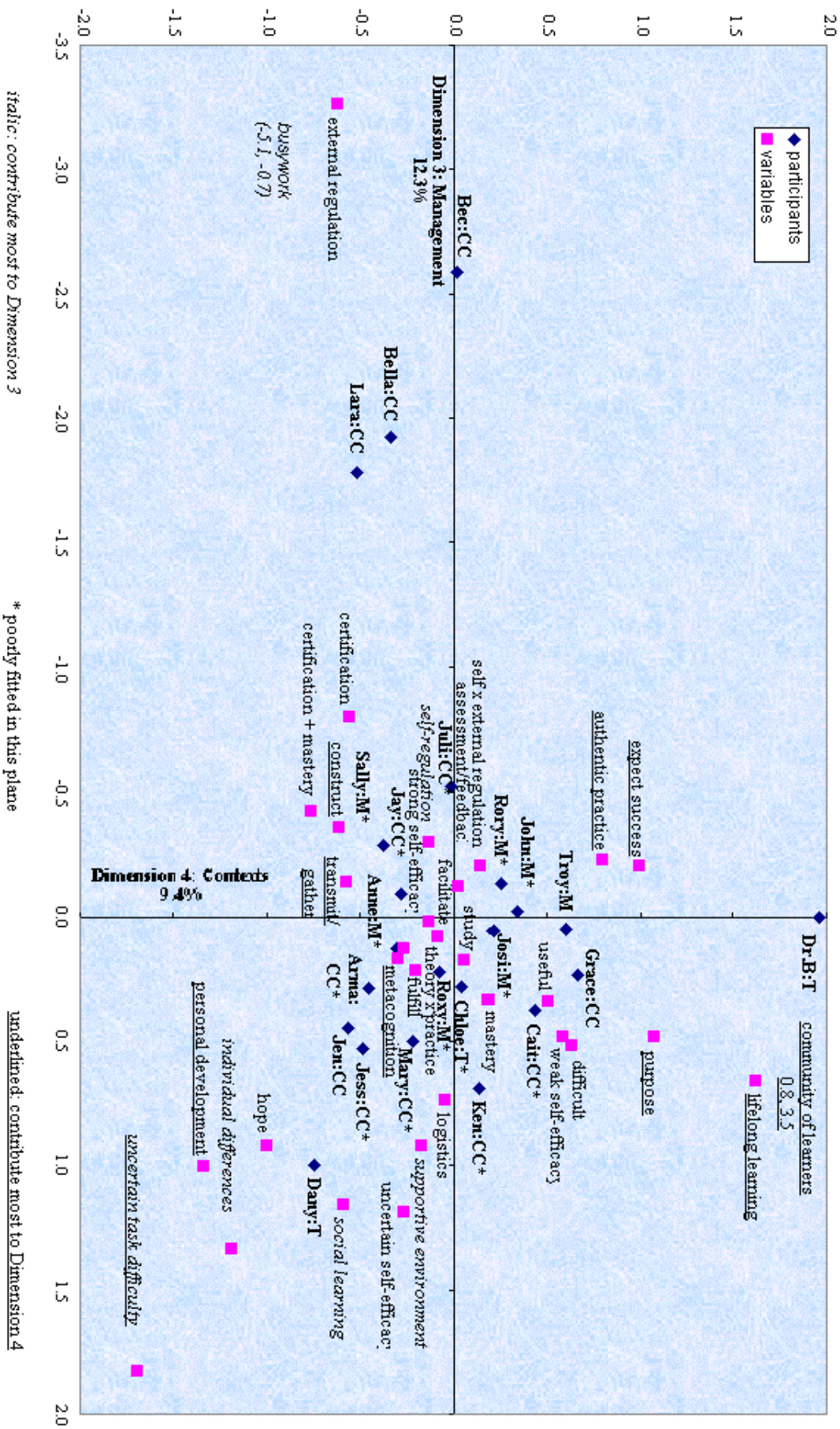
In sum, there may be some indication of group differences in Dimension 3, which picks up so little of the variance in the medical students' scores but places child-care students and teachers at opposite poles. It seems reasonable to propose that Dimension 3, with issues of self-and external regulation of individuals and groups, is the domain of the child-care cohort. Dimension 4 seems to be mostly capturing idiosyncratic differences between individuals, thus adding a richness of interpretation to the picture of group differences and similarities uncovered by Dimensions 1, 2 and possibly 3.

Dimensions 5 and 6

Dimensions 5 and 6 are represented in Figure 5. As the analysis moves to higher dimensions, progressively less of the variance contained in participants' transcripts remains to be explained by each dimensional solution. From the annotated axes in Figure 5, it can be seen that Dimensions 5 and 6 are explaining 7.3 per cent and 7.2 per cent, respectively, of the variance. However, in a domain as complex as teaching and learning, it is worth persisting with the analysis in the search for understandings that might be masked under more general theories or categories.

At the left-hand side of Dimension 5 are the variables *difficult* (0.046) *useful* (0.219), *uncertain self-efficacy* (0.034), *weak self-efficacy* (0.046) and *busywork* (0.033) as major contributors, and minor contributors *metacognition* (0.025), and *logistics* (0.025). With the exception of *busywork*, the variables at the left pole of Dimension 5 appear related to the expectancies and values as described by Wigfield and Eccles (2000). It seems that participants are weighing up their own capabilities against the demands of the learning environment and deciding, that although the learning that they are engaged in is useful for their goals, learning is sometimes difficult and participants are uncertain about their ability to do well.

At the right-hand side of Dimension 5 are the variables *expect success* (0.086), *supportive environment*, (0.146) *facilitate* (0.059), *purpose* (0.039), and *assessment/feedback* (0.062). These variables suggest a combination of individual and contextual features necessary for successful learning. This pole has a more positive flavour than the opposite pole of this Dimension.



italic: contribute most to Dimension 3

* poorly fitted in this plane

underlined: contribute most to Dimension 4

Figure 4. Dimension 3: Management for Learning and Dimension 4: Contexts of Learning

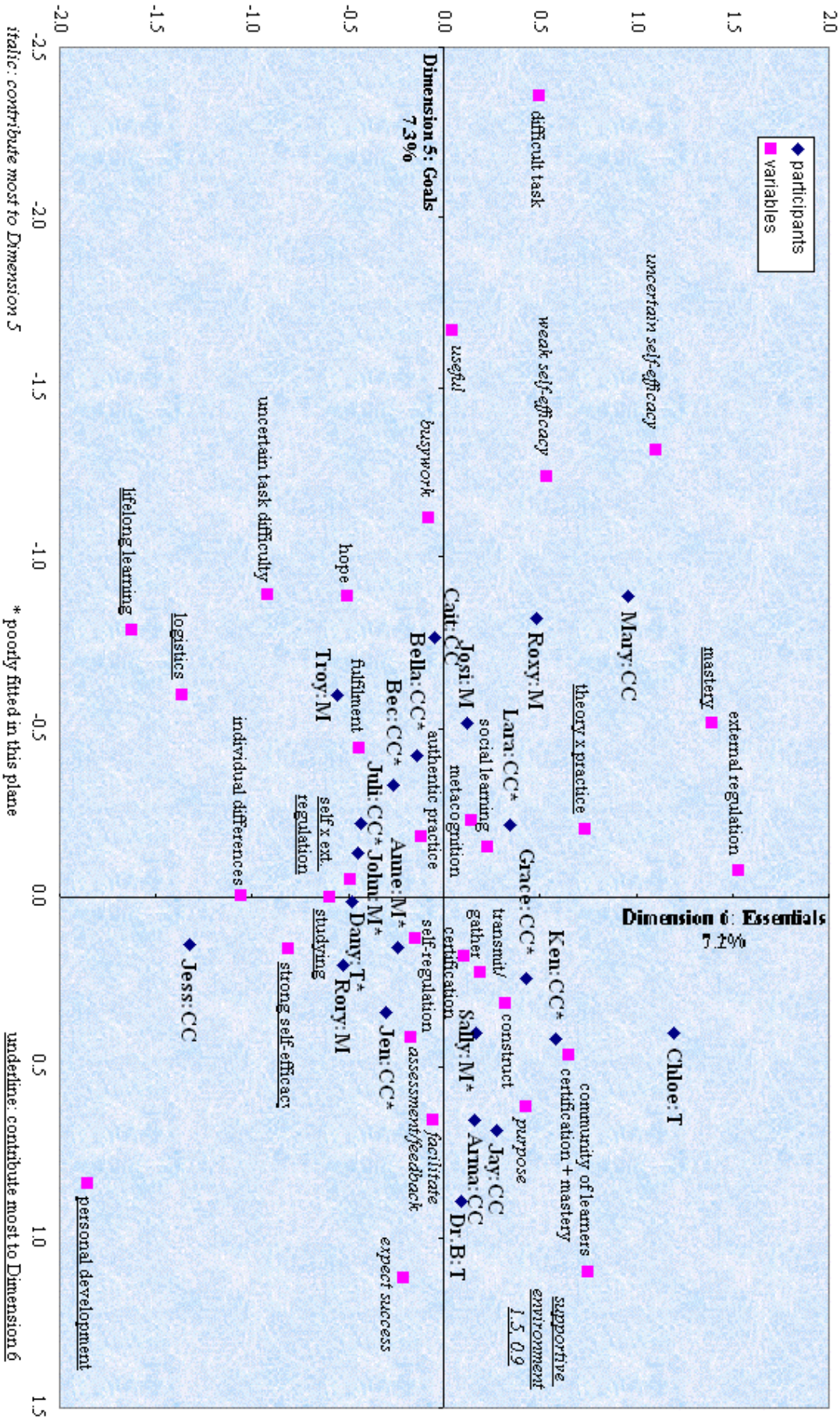


Figure 5. Dimension 5 Expectations and Dimension 6: Goals

Together, the two poles of Dimension 5 appear to make a continuum of *Expectations*, ranging from *positive expectancy* at the right-hand pole, to *uncertain/reflective expectancy* at the left–hand pole.

Dimension 6 has at its top pole *mastery* (0.13), *supportive environment* (0.048) and *theory x practice* (0.208) as major contributors. At its lower pole are *personal development* (0.069), *lifelong learning* (0.04), *logistics* (0.135), *strong self-efficacy* (0.051), *studying* (0.066), and *self x external regulation* (0.038) as major contributors, with *individual differences* (0.027) as a minor contributor. Dimension 6 can be interpreted as capturing different *Goals*, with *achieving mastery* at the top pole of the display, and more *abstract and long-term* personal development goals at the lower pole of the display. Furthermore, Dimension 6 is a good example of the value of investigating higher dimensions, for the variables *mastery* and *theory x practice* do not emerge until the sixth dimension, and so would be lost from the analysis if a lower dimensional solution were accepted.

Whereas Dimensions 3 and 4 account for little of the variance in the medical students' scores, Dimensions 5 and 6 do contribute to some of the medical students' scores. Dimension 5 accounts relatively better for the scores of Roxy (medical), Josi (medical) and Troy (medical). Interestingly, Dimension 5 is the first dimension that accounts for a substantial proportion of the variance in Roxy's score (45 per cent). The three medical students' scores are located at the left-hand (*uncertain/reflective expectancy)* pole of that dimension. Dimension 5 also accounts substantially for the scores of the child-care students Cait, Arma, Jay and Mary, and Dr B (teacher). Cait's and Mary's score are located at the *uncertain/reflective expectancy* pole, and Arma's, Jay's and Dr B's scores are located at the *positive expectancy* pole.

Dimension 6 accounts relatively better for the scores of Rory (medical), Roxy (medical), Troy (medical), Jess (child-care), Mary (child-care), and Chloe (teacher). Whereas in Dimension 5 Roxy's and Troy's scores are clustered at the same pole, in Dimension 6 Roxy's and Troy's scores take opposite poles of the continuum of *Goals*, from *achieving mastery* (Roxy) to *abstract and long term goals* (Troy). Rory's (medical) score is located near Troy's. Jess' (child-care) score and Mary's (child-care) score take opposite poles of Dimension 6 *(Goals).*

Both Chloe's (teacher) and Dr. B's (teacher) scores are in the upper-right-hand quadrant of the graphical display of Dimensions 5 and 6. For Chloe, this is accounted for by Dimension 6 (*Goals-achieving mastery*): For Dr. B. it is accounted for by Dimension *5 (Expectations-positive expectancy*) .

It seems that the only clustering of participant cohorts in Dimensions 5 and 6 occurs with the placement of three medical students at the uncertain-reflective pole of Dimension 5. Otherwise, as the analysis moves to higher dimensions, it does seem to be accounting more for idiosyncratic differences between participants, rather than more general factors (Nishisato, 1994).

Dimension 7

We turn now to a discussion of Dimension 7. The graphical displays assist with the interpretation of the dimensions. However, it must be remembered that the presentation of seven dimensions in the form of successive two-dimensional charts is somewhat artificial, especially as some participants and variables might lie outside of any particular two-dimensional plane. Hence our interpretation of the dimensions has relied heavily upon the underlying statistics in Table 6. As an alternative to a two–dimensional representation, we will present Dimension 7 in the form of a single-dimensional profile as displayed in Figure 6.

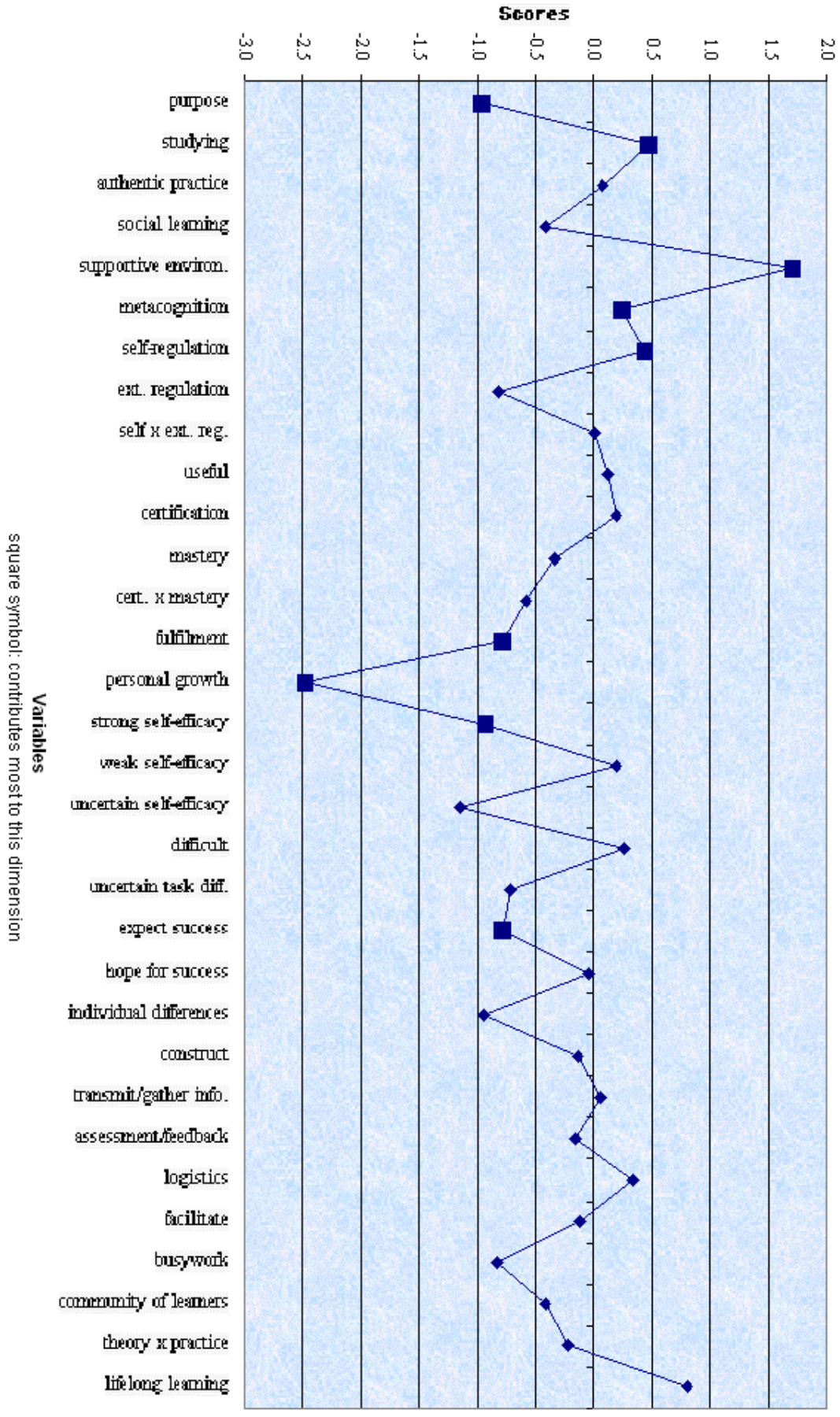


Figure 6. Knowledge about teaching and learning: Dimension 7

Dimension 7 accounts for 5.8 per cent of the variance in the participant transcripts. It is displayed in Figure 6, from which it can be seen that the negative pole of Dimension 7 has *purpose* (0.106) *fulfillment* (0.042), *personal development* (0.136), *strong self-efficacy* (0.075) and *expect success* (0.046) as its major contributors and *uncertain self-efficacy* (0.029) as a minor contributor.

At the postive pole of Dimension 7 lie *studying* (0.046), *supportive environment* (0.209), *metacognition* (0.033), and *self-regulation* (0.117). It is difficult to find an interpretation of this dimension that is different to what has been canvassed in the six lower dimensions. However, Dimension 7 is the first dimension to make a substantial contribution to Anne's (medical) score, accounting for 15.3 per cent of the variance in her profile. Dimension 7 also contributes substantially to Jay's (child-care) score, contributing 38.5 per cent of the variance. Thus it seems worth persevering with including Dimension 7 in the analysis.

Dimension 7 appears to capture variables that are *Essentials for Learning*, ranging from *actions* such as *studying* and *self-regulation* at the positive pole, and *attitudes* such as goals for *personal development* and *strong self-efficacy* at the negative pole. Anne's (medical), Troy's (medical) and Jay's (child-care) scores are located at the positive pole, and Jess' (child-care) score is located at the negative pole.

SUMMARY AND CONCLUDING DISCUSSION

The foregoing discussion has described the substantial reduction of over 20, 000 coded statements in 22 participants' transcripts to seven dimensions, and the graphical representation of participants' scores and variables in successive planes in that seven dimensional space. Nevertheless, the description provided above remains complex. In order to make the dimensional solutions more accessible, we have collated the bare essentials of the correspondence analysis solutions into Table 7, from which it can be summarised that the seven dimensions and their differentiation between participants is as follows:

Dimension 1: Learning Focus, differentiating between child-care students and their teachers at the *Learning as work to be done* pole and medical students at the *An intention to construct knowledge* pole

Dimension 2: Motivation, differentiating between child-care students at the *Intrinsic motivation* pole and their teachers at the *Extrinsic facilitators and motivators pole*

Dimension 3: Management for Learning, differentiating between teachers at the *Group management* pole and child-care students at the *Individual management* pole

Dimension 4: Contexts of Learning, highlighting individual differences

Dimension 5: Expectations, highlighting individual differences

Dimension 6: Goals, highlighting individual differences

Dimension 7: Essentials for learning, highlighting individual differences

Thus, it is now possible to propose that, not only does the participant sample as a whole possess a broad range of knowledge about teaching and learning, but also that there appear to be identifiable patterns of responses between participants with different kinds of teaching and learning backgrounds. In particular, the differences seem to be in the areas of, working at learning activities compared to working at constructing knowledge, the salience of internal motivations and external motivators, and management of learning in groups and in individual settings. Of course, it is important to note that the correspondence analysis solution does not mean that, for example, child-care students did not talk about, say, *an intention to construct knowledge*, or that medical students did not talk about *intrinsic motivations*. Rather, the correspondence analysis extracts differences in the greater or lesser proportions that groups or individuals talked about the different variables.

Table 7. Summary of all dimensions

Positive pole variables	Contribution to dimension	Negative pole variables	Contribution to dimension
Dimension 1: Learning Focus (accounts for 21% of total variance in participants' profiles)			
Learning as work to be done		**An intention to construct knowledge**	
Accounting for more than 10% of the variance in 6**child-care** students' and 2 **teachers'** scores		Accounting for more than 10% of the variance in 4**medical** students' scores	
facilitate	0.127	construct	0.138
busywork	0.107	certification x mastery	0.091
transmit/gather information	0.098	assessment/feedback	0.072
supportive environment	0.048	self- x external-regulation	0.065
uncertain task difficulty	0.026	metacognition	0.029
purpose	0.025		
Dimension 2: Motivation (accounts for 14.3% of total variance in participants' profiles)			
Intrinsic motivations		**Extrinsic facilitators and motivators**	
Accounting for more than 10% of the variance in 5**child-care** students' scores		Accounting for more than 10% of the variance in2 **teachers'** scores	
personal development	0.206	transmit/gather	0.068
supportive environment	0.094	logistics	0.067
fulfilment	0.087	assessment	0.057
uncertain self-efficacy	0.057	uncertain task difficulty	0.047
strong self-efficacy	0.044	facilitate	0.044
self-regulation	0.039	social learning	0.029
studying	0.025	hope for success	0.028
Dimension 3: Management for Learning (accounts for 12.3% of total variance in participants' profiles)			
Group management		**Individual management**	
Accounting for more than 10% of the variance in 2**teachers'** scores		Accounting for more than10% of the variance in 3**child-care** students' scores	
social learning	0.062	busywork	0.546
supportive environment	0.042	self-regulation	0.037
uncertain task-difficulty	0.034	external regulation	0.027
individual differences	0.033		
logistics	0.030		
Dimension 4: Contexts of learning (accounts for 9.4% of total variance in participants' profiles)			
Authentic, situated practice		**Studying**	
Accounting for more than 10% of the variance in 1**medical**-, 1 **child-care students'** and 1 **teacher's** scores		Accounting for more than 10% of the variance in 1**child-care** student's score	
authentic practice	0.274	transmit/gather	0.060
community of learners	0.144	metacognition	0.042
purpose	0.101	construct	0.041
expect success	0.059	uncertain task difficulty	0.034
lifelong learning	0.034	personal development	0.032
		individual differences	0.030
		certification x mastery	0.026
		hope for success	0.025
Dimension 5: Expectations (accounts for 7.3% of total variance in participants' profiles)			
Positive expectancy		**Uncertain/reflective expectancy**	
Accounting for more than 10% of the variance in2 **child-care** students' and 1 **teacher's** scores		Accounting for more than 10% of the variance in 3**medical**- and 2 **child-care** students' scores	
supportive environment	0.146	useful	0.219
expect success	0.086	difficult	0.046
assessment/feedback	0.062	weak self-efficacy	0.046
facilitate	0.059	uncertain self-efficacy	0.034
purpose	0.039	busywork	0.033
		metacognition	0.025
		logistics	0.025
Dimension 6: Goals (accounts for 5.8% of total variance in participants' profiles)			
Achieving mastery		**Abstract and long term goals**	
Accounting for more than 10% of the variance in 1**medical**-, 1 **child-care** students' and 1 **teacher's** scores		Accounting for more than 10% of the variance in 2**medical**- and 1 **child-care** students' scores	
theory x practice	0.208	logistics	0.135
mastery	0.130	personal development	0.069
supportive environment	0.048	studying	0.066
		strong self-efficacy	0.051
		lifelong learning	0.040
		self x external regulation	0.038
		individual differences	0.027
Dimension 7: Essentials for Learning (accounts for 5.8% of total variance in participants' profiles)			
Actions		**Attitudes**	
Accounting for more than 10% of the variance in 2**medical**- and 1 **child-care** students' scores		Accounting for more than 10% of the variance in 1**child-care** student's score	
supportive environment	0.209	personal development	0.136
self-regulation	0.117	purpose	0.106
studying	0.046	strong self-efficacy	0.075
metacognition	0.033	expect success	0.046
		fulfilment	0.042
		uncertain self-efficacy	0.029

It is now possible to say, for example, that Sally (medical) spoke relatively more about metacognition, that Troy (medical) spoke relatively more about learning in authentic, situated practice, and that the medical students generally spoke more about an intention to construct knowledge. Conversely, the dimensions of motivation and management appear more salient to the child-care students and their teachers. In addition, not only are group differences apparent, but across the seven dimensions there are idiosyncratic differences between participants that appear unrelated to their group membership. From this, it would be inappropriate for educators to assume that adult learners enter educational settings with a full range of knowledge about teaching and learning, or that such knowledge necessarily conforms to what educators themselves know about teaching and learning.

It is worth at this point revisiting the underlying premise of our research, which is that people's successful engagement with educational opportunities is mediated by their knowledge about teaching and learning. The significance of our research lies in its ability to provide conceptual frameworks that can inform the design of educational programs that seek to meet the learning needs of individuals and groups of learners. In particular, this paper has highlighted the multi-dimensional nature of teachers and learners knowledge, suggesting that it might be necessary to move beyond conceptualising teachers and learners as having uni-dimensional dispositions such as 'surface' approaches or 'higher' conceptions. Rather, teachers and learners appear to hold multi-dimensional knowledge that has the potential to interact between dimensions and between contexts.

From a methodological perspective, we would like to draw attention to value of correspondence analysis for providing elegant graphical representations to assist in understanding the richness of the information contained in large data sets. Furthermore, correspondence analysis is particularly suited to the type of data that is commonly available in the social sciences: frequency data.

REFERENCES

Anderson, J. R., Greeno, J. G., Reder, L. M., & Simon, H. A. (2000). Perspectives on learning, thinking and activity. *Educational Researcher, 29*, 11-13.

Askell-Williams, H. (2001). *Interviews with teachers and learners.* Paper presented at the Annual Educational Research Conference, Flinders University, Adelaide, South Australia, Nov.

Bandura, A. (1993). Perceived self-efficacy in cognitive development and functioning. *Educational Psychologist, 28*, 117-148.

Bandura, A. (1997). *Self-efficacy. The exercise of control*. New York: W. H. Freeman.

Bandura, A. (2001). Social cognitive theory: An agentic perspective. In S. T. Fiske (Ed.), *Annual Review of Psychology* (Vol. 52, pp. 1-26). Palo Alto, California: Annual Reviews.

Beishuizen, J. J., Hof, E., Putten, C. M. v., Bouwmeester, S., & Asscher, J. J. (2001). Students' and teachers' cognitions about good teachers. *British Journal of Educational Psychology, 71*, 185-201.

Bendixen, M. (1996). A practical guide to the use of correspondence analysis in marketing research (electronic version). *Marketing Research On-Line, 2003*, 16-38. Retrieved on June 27th 2003 from http://mro.massey.ac.nz/ca.html

Benzecri, J.-P. (1992). *Correspondence analysis handbook*. New York: Marcel Dekker.

Bereiter, C., & Scardamalia, M. (1989). Intentional learning as a goal of instruction. In L. B. Resnick (Ed.), *Knowing, learning and instruction. Essays in honor of Robert Glaser.* (pp. 361-392). Hillsdale, NJ: Erlbaum.

Biggs, J. B. (1979). Individual differences in study processes and the quality of learning outcomes. *Higher Education, 8*, 381-394.

Biggs, J. B. (1987). *Student Approaches to Learning and Studying*. Victoria: Australian Council for Educational Research.

Biggs, J. B. (1999). What the student does: teaching for enhanced learning. *Higher Education Research and Development, 18*(1), 57-75.

Bransford, J. D., Brown, A. L., & Cocking, R. R. (Eds.). (1999). *How people learn: Brain, mind, experience, and school*. Washington, DC: National Academy Press.

Candy, P. C. (1991). *Self-direction for lifelong learning: a comprehensive guide to theory and practice*. San Francisco: Jossey-Bass.

Chi, M. T. H., & Roscoe, R. D. (2002). The processes and challenges of conceptual change. In M. Limón & L. Mason (Eds.), *Reconsidering conceptual change: Issues in theory and practice* (pp. 3-27). Dordrecht: Kluwer.

Clausen, S.-E. (1998). *Applied Correspondence Analysis. An Introduction*. Thousand Oaks, CA: Sage.

Creswell, J. W., & Miller, D. L. (2000). Determining validity in qualitative enquiry. *Theory Into Practice, 39*(3), 124-130.

Davison, M. L. (1983). *Multidimensional Scaling*. New York: John Wiley & Sons.

Driver, R., Asoko, H., Leach, J., Mortimer, E., & Scott, P. (1994). Constructing scientific knowledge in the classroom. *Educational Researcher, 23*(7), 5-12.

Entwistle, N., Hanley, M., & Hounsell, D. (1979). Identifying Distinctive Approaches to Studying. *Higher Education, 8*, 365-380.

Gabriel, K. R. (2002). Goodness of fit of biplots and correspondence analysis. *Biometrika, 89*(2), 423-436.

Greenacre, M. (1992). Correspondence analysis in medical research. *Statistical Methods in Medical Research, 1*, 97-117.

Greenacre, M. (1994). Correspondence Analysis and its Interpretation. In M. Greenacre & J. Blasius (Eds.), *Correspondence Analysis in the Social Sciences* (pp. 3-22). London: Academic Press.

Greenacre, M. J. (1984). *Theory and applications of correspondence analysis*. London: Academic Press.

Hair, J. F., Anderson, R. E., Tatham, R. L., & Black, W. C. (1995). *Multivariate Data Analysis*. (4th ed.). Upper Saddle River, NJ: Prentice Hall.

Hofer, B. K. (2000). Dimensionality and disciplinary differences in personal epistemology. *Contemporary Educational Psychology, 25*, 378-405.

Hofer, B. K., & Pintrich, P. R. (1997). The development of epistemological theories: Beliefs about knowledge and knowing and their relation to learning. *Review of Educational Research, 67*(1), 88-140.

Ivy, J. (2001). Higher education institution image: a correspondence analysis approach. *The International Journal of Educational Management, 15*(6), 276-282.

Kerr, D. H. (1981). The structure of quality in teaching. In J. F. Soltis (Ed.), *Philosophy and education* (Vol. I, pp. 61-93): University of Chicago Press.

Lave, J. (1988). *Cognition in practice: mind, mathematics, and culture in everyday life*: Cambridge University Press.

Marton, F., Dall'Alba, G., & Beaty, E. (1993). Conceptions of Learning. *International Journal of Educational Research, 19*(3), 277-299.

Mayer, R. (1998). Cognitive, metacognitive, and motivational aspects of problem solving. *Instructional Science, 26*, 49-63.

Nishisato, S. (1994). *Elements of dual scaling: An introduction to practical data analysis*. Hillsdale, NJ: Erlbaum.

Perry, W. G. (1970). *Forms of intellectual and ethical development in the college years: A scheme*. New York: Holt, Rinehart and Winston.

Phillips, D. C. (1995). The good, the bad, and the ugly: The many faces of constructivism. *Educational Researcher, 24*(7), 5-12.

Phillips, D. C. (2000). An opinionated account of the constructivist landscape. In D. C. Phillips (Ed.), *Constructivism in education. Opinions and second opinions on controversial issues* (Vol. Part 1, pp. 1-16): University of Chicago Press.

Prawat, R. S., & Floden, R. E. (1994). Philosophical perspectives on constructivist views of learning. *Educational Psychology, 29*(1), 37-48.

Ryan, R. M., & Deci, E. L. (2000). Self determination theory and the facilitation of intrinsic motivation, social development and well being. *American Psychologist, 55*, 68-78.

Shavelson, R. J. (1988). *Statistical reasoning for the behavioural sciences*. (2nd ed.). Boston: Allyn and Bacon.

Shepard, L. A. (2001). The role of classroom assessment in teaching and learning. In V. Richardson (Ed.), *Handbook of Research on Teaching* (pp. 1066-1101). Washington, DC: American Educational Research Association.

Shulman, L. (1987). Knowledge and teaching: Foundations of a new reform. *Harvard Education Review, 57*(1), 1-22.

SPSS (1995). SPSS (Version 6.1.1). Chicago: SPSS Inc.

SPSS (2001). *SPSS Categories Reference Guide*. (11.0 ed.). Chicago: SPSS Inc.

Tenenhaus, M., & Young, F. W. (1985). An analysis and synthesis of multiple correspondence analysis, optimal scaling, dual scaling, homogeneity analysis and other methods for quantifying categorical multivariate data. *Psychometrika, 50*(1), 91-119.

Trigwell, K., Prosser, M., & Taylor, P. (1994). Qualitative differences in approaches to teaching first year university science. *Higher Education, 27*, 75-84.

Trigwell, K., Prosser, M., & Waterhouse, F. (1999). Relations between teachers' approaches to teaching and students' approaches to learning. *Higher Education, 37*, 57-70.

van der Heijden, P. G. M., & de Leeuw, J. (1985). Correspondence analysis used complementary to loglinear analysis. *Psychometrika, 50*(4), 429-447.

van IJzendoorn, M. H., & Kroonenberg, P. M. (1988). Cross-cultural patterns of attachment: A meta-analysis of the strange situation. *Child Development, 59*, 147-156.

Wandersee, J. H., Mintzes, J. J., & Novak, J. D. (1996). Research on alternative conceptions in science. In D. L. Gabel (Ed.), *Handbook of research on science teaching and learning* (pp. 177-210). New York: Macmillan.
Weller, S. C., & Romney, A. K. (1990). *Metric Scaling: Correspondence Analysis*. Newbury Park, CA: Sage.
Wigfield, A., & Eccles, J. S. (2000). Expectancy-value theory of achievement motivation. *Contemporary Educational Psychology*, *25*, 68-81.
Winne, P. H. (1987). Why process-product research cannot explain process-product findings and a proposed remedy: The cognitive mediational paradigm. *Teaching & Teacher Education*, *3*(4), 333-356.
Winne, P. H. (1991). Motivation and teaching. In H. Waxman & H. Wahlberg (Eds.), *Effective teaching: Current research* (pp. 295-314). Berkeley, CA: McCutchan.

APPENDIX A

Level 1 Categories of teaching and learning

1: The nature of the learning environment
2: The nature of teaching and learning
3: The nature of the learner
4: The nature of the subject matter

Level 1 Categories	Background theories	Questions for learners	Questions for teachers
3	Achievement goals	What do you want to achieve from what you are doing in this lesson/topic/course? Why do you want to achieve this?	What do you want your student/s to achieve from what they are doing in this lesson/topic/course? Why do you want them to achieve that?
3	Self-efficacy, expectancies for success and attributions for success/failure	How well do you expect to perform in this lesson/topic/course? Why do you have those expectations? Can your performance be changed and if so, how?	How well do you expect your student/s to perform in this lesson/topic/course? Why do you have those expectations? Can your sudents' expected performance be changed and if so, how?
1, 2, 3	Psychological and social constructivism; cognition and metacognition	What thinking processes will you be using in this lesson/topic/course?	What thinking processes will student/s be using in this lesson/topic/course?
2, 3	Self-regulation	In what ways are you responsible for the learning in this lesson/topic/course? In what ways is your teacher responsible for the learning in this lesson/topic/course?	In what ways are you responsible for the learning in this lesson/topic/course? In what ways are your student/s responsible for the learning in this lesson/topic/course?
2, 3	Assessment & feedback	How will you know that you have learned what you are meant to?	How will you know that your student/s have learned what they are meant to?
4	Curriculum content	What specific things are you meant to learn from this lesson/topic/course? What broad understandings or ideas do you think you are meant to get from this lesson/topic/course?	What specific things do you want your student/s to learn from this lesson/topic/course? What broad understandings or ideas do you want your student/s to get from this lesson/topic/course?
4	Curriculum purpose	Why are you learning this? When, where and how will you use the learning in this lesson/topic/course?	Why are you teaching this? When, where and how will your student/s use the learning in this lesson/topic/course?
1, 2, 3	Teaching and learning strategies	How does what you are doing help you to learn what you are meant to?	How will your teaching and learning strategies help your student/s to learn?
3	Value and Interest	Is this what you want to learn? Why, or why not, do you want to learn it?	Is this what your student/s want to learn? Why or why not do they want to learn it?
1, 2, 3	Psychological and social constructivism. Teaching and learning strategies.	Who and/or what helps you to learn? How do they/it help you to learn?	Who and/or what helps your student/s to learn? How do they/it help your students to learn?