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ABSTRACT

This paper discusses the process through which a powerful multidimensional measure of affect and cognition in relation to adult learning of computing skills was derived from its early theoretical stages to its validation using structural equation modeling. The discussion emphasizes the importance of ensuring a strong substantive base from which to develop reliable items for a measure, as well as the usefulness of gathering qualitative data both in the factor and item design stages to supplement the confirmatory factor analyses. The Computer Anxiety and Learning Measure (CALM) was developed and then validated using a sample of 794 undergraduates in the Sydney (Australia) area. About 70% of the sample came from an English-speaking background, and they represented four university faculties. The original 100 items were reduced to 65 through a combination of exploratory and confirmatory factor analyses and the evaluation of item face validity by three independent raters. Eleven first-order and two second-order factors were subsumed into four subscales. Results from the multimethod techniques used to validate this instrument provide strong support for the validity and reliability of the CALM measure, which appears to have wide applicability for the assessment of anxiety and negative cognitions of adult learners about computer use. Two appendixes contain information on goodness of fit statistics and standardized estimates for the individual CALM items. (Contains 1 figure, 7 tables, and 48 references.) (SLD)

The Designing of CALM (Computer Anxiety and Learning Measure): Validation of a multidimensional measure of anxiety and cognitions relating to adult learning of computing skills using structural equation modeling

Paper presented at the annual meeting of the
American Educational Research Association
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Overview

This paper discusses the process through which a powerful multidimensional measure of affect and cognition in relation to adult learning of computing skills was derived from its early theoretical stages to its validation using structural equation modeling. The discussion emphasises the importance of ensuring a strong substantive basis from which to develop reliable items for a measure, as well as the usefulness of gathering qualitative data both in the factor and item design stages to supplement the confirmatory factor analyses.

Objectives

The specific objectives of the research were:

1. To design a reliable and valid instrument for measuring negative affect and cognitions in relation to learning computing skills whose multidimensional constructs were based on sound theoretical grounds and were informed by qualitative data.
2. To demonstrate the invariance of the factor structure of the instrument across four different faculty groups.

Theoretical Framework: Substantive and Methodological

As Bandalos and Benson (1990 p. 51) point out, there has existed in the area of computer anxiety research for some time a degree of "inconsistency in the hypothesized dimensionality of the construct, computer anxiety. If specific dimensions are hypothesized to underlie computer anxiety, a clear explication of these dimensions may allow for a more nearly precise measurement of this construct".

The aim of the present study, therefore, was to design a scale which did clearly explicate these dimensions and which would measure, with considerable validity and reliability, the multiple dimensions of computer anxiety in a training situation. This was achieved by incorporating into a model of computer anxiety for beginning adult learners a number of factors which had emerged reliably from previous anxiety research together with additional dimensions which were derived from theories of motivation and learning.

Further insights about the nature and correlates of computer anxiety and negative cognitions were gleaned from three sources of qualitative data: the first, from interviews conducted with researchers who have designed and administered measures of anxiety; the second, from students who have undertaken introductory computer training courses and from their instructors; and the third, from those responsible for the design and administration of

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Further insights about the nature and correlates of computer anxiety and negative cognitions were gleaned from three sources of qualitative data: the first, from interviews conducted with researchers who have designed and administered measures of anxiety; the second, from students who have undertaken introductory computer training courses and from their instructors; and the third, from those responsible for the design and administration of computer training courses in different university faculties. The qualitative approaches used in this study were based on the work of Bouma (1996), Cohen & Manion (1994), Miles and Huberman (1994), and Wiersma (1991).

The dimensions included in the theoretical model were as follows: Competence with Computers; Handling Computer Equipment; Receiving Feedback on Computing Skills; and Learning about Basic Computer Functions; Positive Sense of Control (cognitions about being able to master computers); Fear (fearful cognitions about damaging the computer and public embarrassment in computing situations); Computing Self-Concept (perceptions of self-image in relation to computers); and, Worry, Happiness, Distractability, and Physiological Symptoms (of anxiety in computing situations).

In the first instance, two factors defining Sense of Control were hypothesized: Positive Cognitions (or self-talk) about being able to master computers, and Negative Cognitions expressing fear about learning to use the computer. These were derived from the original Computer Thoughts Survey (CTS) of Rosen, Sears & Weil (1987a & b), and supported by the argument of Bagozzi (1994) who maintains that all the cognitive and affective elements of one's attitudes consist of aggregations of positive, negative, and positive and negative atomistic mental representations of knowledge (or knowledge units held in memory). In the second approach, a model positing the existence of one substantive factor plus a "negative item method effect" was tested (Marsh, 1994) on the premise that negatively worded items in a survey do not measure the opposite of the same construct as do positively worded items, and are, therefore, too "weak" to include in a total scale score.

Contrary to the evidence in regard to positive and negative sense of control perceptions, the research literature on general self-concept strongly argues that, rather than representing a substantive negative factor (negative self-concept), negatively worded items in an instrument merely contain a measurement-method "artefact" (Benson & Hocevar, 1985; Marsh, 1986; 1994). Much of this literature, however, is derived from research with young children, while the present sample consisted of adults in a tertiary education setting and who were predicted, therefore, to be better able to cope with the cognitive demands of negatively worded items. The same approach to model testing was adopted in this scale as in the previous one. In other words, both a single factor and a two-factor model with regard to self-concept about one's proficiency with computers were tested.

In the case of both the Sense of Control and Computing Self-Concept scales, items were written to assess different responses in relation to cognitions. These were expressed semantically in Sense of Control as positive and negative self-talk ("I can master the computer" or "Everyone else but me knows what they are doing"), and in the Computing Self-Concept scale as a positive or negative perceptions of self-image in relation to computing situations ("I can help others solve computer problems" or " I am not the type to do well with computers").

In all, therefore, the theoretical sources for the constructs came from the research literature in three areas:

1. Clinical anxiety, especially that relating to cognitive-behavioural training (Barlow, 1988; Beck & Emery, 1985; Michelson & Ascher, 1987); the impact of emotions on learning and achievement (Pekrun, 1992); and the effects of interfering self-doubts (Sarason, 1960, 1972, 1984; Schwartzer, 1996).
2. Educational psychology, notably self-efficacy theory (Bandura, 1977, 1986, 1988, 1993, 1997) and self-worth theory of achievement motivation (Covington, 1984, 1992).
3. Theoretical literature relating to computer anxiety (Rosen & Maguire, 1990; Rosen, Sears, & Weil, 1993; Rosen, & Weil, 1995a & b).
4. Pre-existing instruments of computer anxiety and attitudes (Loyd & Gressard, 1984; Maurer & Simonson, 1984; Heinssen, Glass & Knight, 1987; Rosen, Sears and Weil, 1987a & b; Meier, 1988), as well as those measuring clinical anxiety (Sarason & Sarason, 1987; Sarason, 1991; Spielberger, 1972a & b; 1975a & b; Spielberger, Pollans & Worden, 1984).

Method

Participants

The Computer Anxiety and Learning Measure (CALM) was validated using a sample (n = 794) of undergraduate students enrolled in four different faculties of a regional university in the Greater Western area of Sydney: Education, Health, Arts and Social Sciences, and Business and Technology. Approximately 70% of the sample came from an English speaking language background. The remaining 30% of the students came from a wide range of language backgrounds (42 languages), with the most common being Chinese (n=28), Greek (n=7), Italian (n=25), Spanish (n=20), Arabic (n=18), Vietnamese (n=16), Croation (n=12) and Lebanese (n=10). 170 males and 285 females had attended co-educational schools, while 183 males and 98 females came from single-sex schools. A number of students moved between the two types of schools, and some respondents failed to indicate the type of school attended. Four hundred and forty-two respondents had attended government schools, and 268 had attended non-government schools. A small number moved between the two sectors of education. Four hundred and six respondents entered the university of the basis of their score on the Tertiary Entrance Rank (TER), the usual high school matriculation path, 255 entered on the basis of an alternative special entry test, while 102 entered on other criteria (such as overseas qualifications or mature age). There were missing data for approximately 31 students. Participants came from families within the working and middle classes in terms of socioeconomic status.

As can be seen from the above description, this sample was demographically diverse enough to be generalisable to other Western settings such as inner-city, industrial and non-affluent suburban areas. At the time that the CALM was administered, these students were about undertake a semester-long introductory computer training course in their respective faculties, required by the university for graduation.

Measures

Confirmatory factor analyses using LISREL 7 (Joreskog & Sorbom, 1989) were conducted on the a priori models of the CALM subscales. Preliminary exploratory factor analyses (SPPSX) had been conducted earlier to refine the original model.

Subsequent to the tests of goodness-of-fit for the a priori models reported earlier, tests of factorial invariance were conducted to determine the stability and generalisability of the results across independent groups.

As parallel data exist for each of the faculty groups in the sample, confirmatory factor analysis provides a particularly powerful test of the equivalence of solutions across these groups (for further discussion see Bollen, 1989; Marsh & Hocevar, 1985; Marsh, 1993, 1994). Using such analyses, it is possible to fit the data subject to the constraint that any one, any set, or all parameters are equal in the multiple groups. "The minimal condition for 'factorial invariance' is the equivalence of all factor loadings in the multiple groups (Marsh, 1994, p. 11). Following Marsh's (1994) hierarchical ordering of invariance testing, three tests were conducted:

- **<u>Model 1</u>**: Total non-invariance with no between-groups invariance constraints.
- **<u>Model 2</u>**: Factor loadings invariant across groups.
- **<u>Model 3</u>**: Total invariance with all parameters (factor loadings, factor correlations, factor variances, and uniquenesses) constrained to be the same for all groups.

When the focus of the confirmatory factor analysis is to test invariance across multiple groups, it is advised that analyses be conducted using covariance matrices, not correlation matrices that are standardised in relation to responses by each group separately (for further discussion see Joreskog & Sorbom, 1989). In the present investigation, therefore, the invariance of factor solutions based on responses by students from three faculty groups were tested using covariance matrices. The three groups consisted of students from the faculties of Business and Technology, Arts and Social Sciences, and Education combined with a smaller sample of students in the Faculty of Health.

The logic behind combining these samples was twofold: as the Faculty of Health had only 79 students compared with 165 in the Faculty of Education, and had a similar relative proportion of males to females as the Education group, (Education males = 17%; Health males = 20%), it was considered appropriate to combine the two so that factorial invariance tests could be conducted on sufficiently large samples to satisfy the requirements for optimal sample size needed for invariance testing using the LISREL program (that is, over 200 students in each group). Secondly, both samples represented "helping" professions so that students enrolled in them were likely to be more similar than from other faculties. Because these three faculty group initial intakes are self-selected to be quite different, these tests of factorial invariance provide a good test of the generalisability of the factor solution of the Computer Anxiety and Learning Measure. As the group sizes were modest (Business and Technology = 282, Arts and Social Sciences = 268, and Education combined with Health = 244) and were not optimal for using polychoric and/or asymptotic matrices (as used for testing the a priori models for the full group), it was necessary to run subsequent analyses using covariance matrices. The Tucker-Lewis Index (TLI) and Relative Noncentrality Index (RNI) were used to assess goodness-of-fit.

In summary, therefore, analyses of the a priori models and the tests of invariance were conducted using different matrices. This was due both to differences in sample size between the full group (n = 794) and separate faculty groups (n = between 235 and 273), where asymptotic covariance matrices are appropriate for large samples but not for small), and to the fact that covariance matrices are required for invariance testing.

Results

An original 100 items were reduced to 65 items through a combination of exploratory and confirmatory factor analyses, as well as an evaluation of item face validity by three independent raters. Eleven first-order and two second-order factors were subsumed into four subscales: Gaining Initial Computing Skills, Sense of Control, Computing Self-Concept, and State Anxiety in Computing Situations. The overall goodness-of-fit indices (AGFI, RNI and

TLI)[1] for the models of each subscale ranged from .96 to .99. Root mean square residuals of below .05 (.047, .049, .034, and .048, respectively, for each of the four final subscales) provided additional indices of the goodness-of-fit of the models for each scale Furthermore, analyses of factorial invariance (Marsh, 1994) demonstrated that the model of computer anxiety and cognitions presented in the CALM can be applied with considerable confidence across different faculty groups on the basis of very good fit of the model (RNI and TLI ranging between .93 to .99).

Separate faculty group analyses were conducted to test the model fit in each faculty. Irrespective of differences in academic focus between the faculty groups, it was shown that the goodness-of-fit for the models of anxiety in each scale were very comparable and relatively high, reaching the Tucker-Lewis index of acceptable fit (.90) for Faculties 1 and 3 for the Sense of Control scale, and exceeding it considerably in most other cases. In sum, both the RNI and TLI indices were at least .9 for each of the three groups analysed separately. Table 1a presents the results for total group analyses for the a priori model based on asymptotic covariance matrices, and Table 1b presents results of invariance tests of the models using covariance matrices (see Appendix 1)

Gaining initial computing skills

This scale was defined by four factors related to general anxiety about gaining initial computing skills: Learning about Basic Computer Functions; Competence with Computers; Handling Computer Equipment; and Receiving Feedback on Computing Skills. Four models were tested for the Gaining Initial Computing Skills scale:

- **Model 1** was the four factor model submitted to EFA using exactly the original 32 items.
- **Model 2,** based on the results of Model 1, extracted those items which conformed to the criteria outlined above. This left 22 items.

  Using these 22 items, alpha coefficients for each factor were:

  Factor 1: .88

  Factor 2: .78

  Factor 3: .88

  Factor 4: .88

  As the results from Model 1 indicated a high correlation (mean r= > .6) between each of the four factors and as it was hypothesized that all items in the Gaining Initial Computing

[1] AGFI: Adjusted Goodness of Fit; RNI: Relative Non-Centrality Index; TLI: Tucker-Lewis Index.

Skills scale logically related to aspects of gaining initial computing skills in formal class settings, two additional models were tested.

- **Model 3**, therefore, was a unidimensional one in which all items from the previous (second) model were included as one factor.
- **Model 4** predicted that there was one higher-order factor, general anxiety about Gaining Initial Computing Skills, in addition to four first-order factors (Learning about the Basic Functions of Computers; Competence with Computers; Handling Computer Equipment; and Receiving Feedback on Computing Competence). This model was believed to be the most appropriate fit as it was in keeping with the substantive grounds for the items in the Gaining Initial Computing Skills scale, and would also account for the correlation between factors, referred to earlier.

Table 2
Four Models of General Anxiety about Gaining Initial Computing Skills

Goodness-of-Fit Indicators for Confirmatory Factor Analysis							
Model	X^2	*df*	AGFI	RMSR	X^2/df ratio	RNI	TLI
Model 1	1543.75	438	.935	.057	3.61	.929	.918
Model 2	569.44	203	.968	.046	2.81	.976	.968
Model 3	2294.85	209	.873	.108	10.99	.841	.824
Model 4	587.60	205	.967	.047	2.87	.971	.967

Note 1.

Model 1: Four factors (32 items)

Model 2: Four factors (the "best" 22 items)

Model 3: One factor (22 items)

Model 4: Higher-order factor plus four first-order factors

Note 2.

AGFI = adjusted goodness-of-fit index — RMSR = root mean square residual

TLI = Tucker-Lewis index — RNI = relative noncentrality index

If one were to use the chi-square/degrees of freedom ratio as the strongest indicator, the "best" fit to the data is Model 2 (ratio of 2.8) with the AGFI and TLI very strong at .968 (see Table 2. Note: the large sample size inflates the chi-square along with the large number of parameters estimated). However, on substantive grounds, namely, the correlation between factors, Model 4 is preferred. The chi-square/degrees of freedom ratio in this case is only marginally higher (ratio of 2.87) with the AGFI and TLI still very high at .967. Support for this model is also provided by the high correlation between the first-order factors (ranging from .65 to .94) as well as the target coefficient of .97 (the ratio of chi-square of the first-order factor model to the chi-square of the higher-order factor model), which indicates that the more restrictive higher-order model provides an excellent fit to the data.

The correlations among the four a priori factors are positive and range between .63 and .84 (mean r = .75). While moderate, such correlations provide support for arguing the separation of the four factors in the Gaining Initial Computing Skills scale in that an average of 44% of the variance in the factors is unexplained. A higher-order model attempts to explain the correlations among the first-order factors. In this scale, the correlation between the higher-order factor and the first-order factors ranges between .78 and .94 (mean r = .87). Such a strong correlation supports the existence of an underlying factor which may justify the use of a total score in this scale. However, examination of the residuals indicates that from 12% to 39% of the variance is unexplained by the higher-order model. It is clear that one cannot adequately summarise the four factors with a higher-order one. Thus, caution needs to be exercised when using a total score to recognise that, while providing a useful overview and demonstrating a logical substantive relationship between the first-order factors, such a score would be an oversimplification of an individual's anxiety in Gaining Initial Computing Skills. Far more information would be obtained by recognising the multidimensionality of this factor.

While statistically significant, the substantive difference between the first-order and the higher-order model needs to be considered carefully (for detailed discussion of the evaluation of higher-order models see Marsh, 1987; Marsh & Hocevar, 1985). Clearly, there is virtually no difference in the goodness-of-fit indices (TLIs of .967 and .968). The residuals range between .06 and .22.

As with the Gaining Initial Computing skills scale, LISREL 7 was used to perform confirmatory factor analyses on the data in the Sense of Control scale. Three models were fit to the data.

- **Model 1** used the factor structure derived from the initial substantive model from which items had been generated, and which had been supported by exploratory factor analyses, albeit somewhat "pruned". In this model, two substantive factors (positive and negative) were posited.
- **Model 2** examined the possibility that there was only one factor underlying both the negative and positive items, that is, it was unidimensional.
- **Model 3** predicted two factors, one "substantive" one on which all 12 items were allowed to load, and a "negative item" method factor for the 6 negative items only. Here the factor loadings for the two factors and the error/uniquenesses associated with each item were freely estimated. This allowed for all the negative items to load on one separate method factor.

Sense of control

The two factors hypothesized to define this construct were Positive and Negative Cognitions (or self-talk) about being able to master computers. An alternative model was tested as well, that comprising one general factor plus a negative item artefactor.

Table 3

Three Models of Sense of Control

Goodness-of-Fit Indicators for Confirmatory Factor Analysis							
Model	X^2	*df*	AGFI	RMSR	X^2/df ratio	RNI	TLI
Model 1	204.73	53	.976	.490	3.86	.980	.975
Model 2	1445.40	54	.833	.144	26.77	.819	.778
Model 3	161.86	48	.979	.420	3.37	.985	.980

Note 1.

Model 1: Two factors (12 items)

Model 2: One factor only (12 items)

Model 3: Two factors: one substantive factor and one method "artefactor"

Note 2.

AGFI = adjusted goodness-of-fit index RMSR = root mean square residual

TLI = Tucker-Lewis index RNI = relative noncentrality index

As seen in Table 3, Model 2 is clearly a very poor one with a chi-square/degrees of freedom ratio of 26.77, an AGFI of .833 RMSR of .144 and TLI of .778. Using the criteria of parsimony and the chi-square/degrees of freedom ratio as the strongest indicators, the "best" fit to the data is Model 3 (chi-sq/degrees of freedom ratio of 3.37) with the AGFI high at .979 and TLI at .980. It is worth noting that Model 1, however, is only marginally weaker in a statistical sense, with an AGFI of .976 and a TLI of .975 (Note: the large sample size, along with the large number of parameters estimated, inflates the chi-square so that the AGFI and TLI are taken to be more appropriate indicators of fit).

The relatively modest correlation (PHI = .52) between the latent factors, with only 27% of their variation shared, however, also supports Model 1 substantively. The two-factor model of the Sense of Control scale (Model 1) was chosen on substantive grounds.

Computing self-concept

Exploratory factor analyses were performed on the 20 items in this scale (shown below in Table 4).

As with the previous scale, Sense of Control, it was originally hypothesized that there would be two factors in this scale; one which measured a Positive Computing Self-Concept ("I am good at computing"), and the other which measured a Negative Computing Self-Concept ("I am no good at computing").

LISREL 7 confirmatory factor analyses were performed on the Computing Self-Concept scale. Three models were fit to the data:

- **Model 1** predicted that there were two factors (positive and negative) as in the exploratory factor analyses in which the factors were allowed to be correlated.
- **Model 2** was a unidimensional factor estimation.
- **Model 3** estimated two factors: One a "real" or substantive factor; the other a "method" factor which accounts for the negatively worded items. Here factor loadings for each factor and the error/uniqueness associated with each item were freely estimated. This allowed for all the negative items to load on one separate method factor.

Table 4

Three Models of Computing Self-Concept

Goodness-of-Fit Indicators for Confirmatory Factor Analysis							
Model	X^2	*df*	AGFI	RMSR	X^2/df ratio	RNI	TLI
Model 1	165.53	43	.978	.041	3.85	.983	.979
Model 2	387.71	44	.950	.068	8.80	.953	.941
Model 3	114.91	39	.983	.034	2.94	.990	.985

Note 1

Model 1: Two factors (11 items)

Model 2: One factor only (11 items)

Model 3: Two factors: one substantive factor and one method "artefactor"

Note 2:

AGFI = adjusted goodness-of-fit index; RMSR = root mean square residual

TLI = Tucker-Lewis index; RNI = relative noncentrality index

Table 4 shows that Model 3 provides an excellent fit to the data with an AGFI of .983 and a TLI of .985. It is also the most parsimonious model. Furthermore, the chi-sq/degrees of freedom ratio is the lowest of the three models.

Statistically, the evidence supports a model for the Computing Self-Concept scale of one self-concept factor and an additional "method effect" constituted by negatively worded items. This is supported by the relatively strong correlation between the two hypothesized factors (PHI = .84), indicating that approximately 71% of the variation between the latent factors is shared. However, as with the Sense of Control scale, it is clear that there is little statistical difference between Model 3 and the two-factor (positive and negative), Model 1, whose AGFI was .978 and whose TLI was .979. On substantive grounds again, the one-factor model is chosen in this case (see discussion earlier).

State anxiety in computing situations

The research literature in the area of anxiety of a clinical nature typically reports three component of anxiety: cognitive, emotional and somatic. These components, therefore, were hypothesised to comprise the state anxiety that individuals would experience in computing situations. Specifically, in the CALM instrument, the cognitive component was hypothesised to consist of two factors - Worry and Distractability; the emotional component was hypothesised to consist of one factor - Happiness; and the somatic component was hypothesised to consist of the Physiological Symptoms factor.

Using LISREL 7, confirmatory factor analyses were conducted on the revised set of items from the exploratory factor analyses in the State Anxiety in Computing Situations scale. Two models were fit to the data:

- **Model 1** predicted that there were four first-order factors in the State Anxiety in Computing Situations scale, comparable to the exploratory factor analyses.
- **Model 2** predicted that, in addition to the four first-order factors in model one, there was one second- or higher-order factor.
-

Table 5
Two Models of State Anxiety in Computing Situations

Goodness-of-Fit Indicators for Confirmatory Factor Analysis							
Model	X^2	*df*	AGFI	RMSR	X^2/df ratio	RNI	TLI
Model 1	345.30	164	.986	.045	2.10	.988	.988
Model 2	372.55	166	.985	.048	2.24	.987	.987

Note 1

Model 1: Four factors (20 items)

Model 2: Higher-order factor plus four first-order factors

Note 2.

AGFI = adjusted goodness-of-fit index; RMSR = root mean square residual;

TLI = Tucker-Lewis index; RNI = relative noncentrality index;

The four factor model clearly provides a very good fit to the data, as shown in Table 5. However, using the ratio of chi-square of the first-order factor model to the chi-square of the higher-order factor model as a criterion (Marsh and Hocevar, 1985), the value of the target coefficient (.93) indicates that the more restrictive factor model also provides a very good fit to the data. There was moderate to high correlation between the first-order factors (ranging from .43 to .8) which was considered sufficient to support the existence of a higher-order factor as well, although the Distractability factor had the lowest correlation with each of the other factors (ranging between .43 and .51). As with the Gaining Initial Computing Skills scale, there is virtually no statistical difference between the two models. The results clearly support the multidimensionality of this scale at the same time as providing evidence of the underlying substantive relationship among the four factors. The comparative weakness of the Distractability factor was recognised and efforts to remedy this were implemented, as mentioned above.

Factor 1 (Worry) accounts for all of the variance in that scale (i.e., a higher-order factor loading of 1.00), while factor 3 (Distractability) accounts for only 30% of the variance (i.e., a higher-order factor loading of $.53^2$. Factors 2 (Happiness) and 3 (Physiological symptoms) account for over half of the variance in those factors. Some of this inconsistency may be explained by the number of items in each factor, with factor 1 having 7 items, and factor 3 having only 2 items.

It would appear that the Distractability construct only partly fits within a Worry state context, although the literature would support its very strong substantive connection. As Wine (1971) and Heckhausen (1991) have demonstrated, the negative effects of worry on performance are seen in terms of task irrelevant responses such as interfering self-related thoughts. From a substantive point of view, therefore, it would be valuable to be able to determine an individual's overall state of anxiety in a computing context, and examine scores on each of the cognitive, emotional and somatic components of state anxiety.

The final Computer Anxiety and Learning Measure (CALM) that was derived from both EFAs and CFAs in the present study comprised 65 items. Eleven first-order factors provided a good fit to the data. Two second-order factors explained the correlations between the four oblique factors in the Gaining Initial Computing Skills and State Anxiety in Computing Situations scales, respectively. In summary, the latent constructs in the model of computer anxiety that have evolved from the present research can be represented in the following way, as shown in Table 6.

Clearly, with Tucker-Lewis indices for each scale of the Computer Anxiety and Learning Measure ranging between .968 and .988 (see Appendix 1, Table 1a), the support for the a priori models is very strong indeed. As can be seen in Table 1b (see Appendix 1b), conclusions based on the Tucker-Lewis index of goodness-of-fit indicate that the best fit for each scale is for models imposing complete invariance - the most parsimonious and, therefore, those favoured by the Tucker-Lewis index (which penalises model complexity). There was considerable consistency between results for the three invariance models. Such strong support for invariance provides excellent support for all of the a priori models.

In conclusion, therefore, it appears that the model of computer anxiety presented in the Computer Anxiety and Learning Measure can be applied with considerable confidence across different faculty groups on the basis of the very good fit of the invariance model.

Table 6

Factors Defining Computer Anxiety for Adult Learners Using the Computer Anxiety and Learning Measure: A Model of CALM

Gaining Initial Computing Skills:

Four first-order factors -
* Learning about Basic Computer Functions
* Competence with Computers;
* Handling computer Equipment;
* Receiving Feedback on Computing Skills

One second-order factor -
* Gaining Initial Computing Skills

Sense of Control:

One factor -
* Sense of Control plus negative-item artefactor, or

Two factors -
* Positive Sense of Control and Fear (alternative model)

Computing Self-Concept:

One factor -
* Computing Self-Concept plus negative-item artefactor, or

Two factors -
* Positive and Negative Computing Self-Concept (alternative model)

State Anxiety in Computing Situations:

Four first-order factors -
* Worry
* Happiness
* Distractability
* Physiological Symptoms

One Second-order factor -
* State Anxiety in Computing Situations

The final version of CALM that has emerged from the exploratory and confirmatory factor analyses described in this paper is shown in Figure 1. The factor loadings and reliabilities derived from the LISREL 7 analyses for the sixty-five items retained in the final instrument are shown in Table 7 (see Appendix 2).

In conclusion, although the Computer Anxiety and Learning Measure appears statistically and substantively "robust", the generalisability of the model of computer anxiety presented in this study has yet to be demonstrated. While the original sample was representative of the composition of the population of interest, namely, adults undertaking initial computer literacy skills training courses, the model needs to be replicated with a more diverse sample and with a non-student population. It is important to note, however, that the tests of factorial invariance across different faculties reported earlier give considerable support for the stability and generalisabilty of the findings. Future research would need to examine whether the CALM model is invariant across different groups in similar learning /training environments (cf. Marcoulides, Mayes & Wiseman, 1995).

Discussion

Results from the multimethod research techniques used in the present study provide strong support for the validity and reliability of the Computer Anxiety and Learning Measure (CALM) of the multifaceted nature of computer anxiety, and for the invariance of its multidimensional structure across different groups. This measure, therefore, appears to have wide applicability for the assessment of specific facets of anxiety and negative cognitions of adult learners undertaking computer training courses. As such, the CALM has the potential to inform strategies for instruction and remediation on the basis of diagnosis of individual differences in these constructs.

The strongest goodness-of-fit indices from the confirmatory factor analyses reported in the present study support a multifaceted model of computer anxiety for beginning adult users which consists of ten factors plus one negative item factor. Such a model provides excellent explanatory power in that the use of individual facets of a construct can sometimes predict dependent variables more accurately than the more general construct (Carver, 1989). A more parsimonious model still, consisting of only five factors plus a measurement-method effect, was identified using CFA analyses of the data. In particular, the results supported the existence of one second (higher) order factor for each of the Gaining Initial Computing Skills and State Anxiety in Computing Situations scales. This was not surprising, as all items defining the first-order factors in these scales related logically to the general construct for each section, as discussed previously.

Although the results for the Gaining Initial Computing Skills and the State Anxiety in Computing Situations scales, based on their respective four factor models, support the multidimensional nature of these computer anxiety constructs, it is implied by the more parsimonious higher-order models in each case that it may be valid to subsume the different dimensions under a broader construct of General Anxiety in Gaining Initial Computing Skills. Thus, for administration of the CALM instrument in settings where the greater explanatory power of the four factor models of these scales is not deemed significant, the use of a single score for these single higher-order constructs may be justified (cf. Shek, 1993), while acknowledging the considerable oversimplification that this represents, as discussed earlier (because it is comparable to adopting a one factor model whose fit was considerably poorer). On the other hand, given that the overall fits for both first- and second-order models in these scales are almost identical (as shown in Table 2), the decision to adopt one or the other is dependent on one's research purpose.

Conclusion

While the Computer Anxiety and Learning Measure appears statistically and substantively "robust", the generalisability of the model of computer anxiety presented in this study has yet to be demonstrated. While the original sample was representative of the composition of the population of interest, namely, adults undertaking initial computer literacy skills training courses, the model needs to be replicated with a more diverse sample and with a non-student population. It is important to note, however, that the tests of factorial invariance across different faculties reported earlier give considerable support for the stability and generalisabilty of the findings. Future research would need to examine whether the CALM model is invariant across different groups in similar learning /training environments (cf. Marcoulides, Mayes & Wiseman, 1995).

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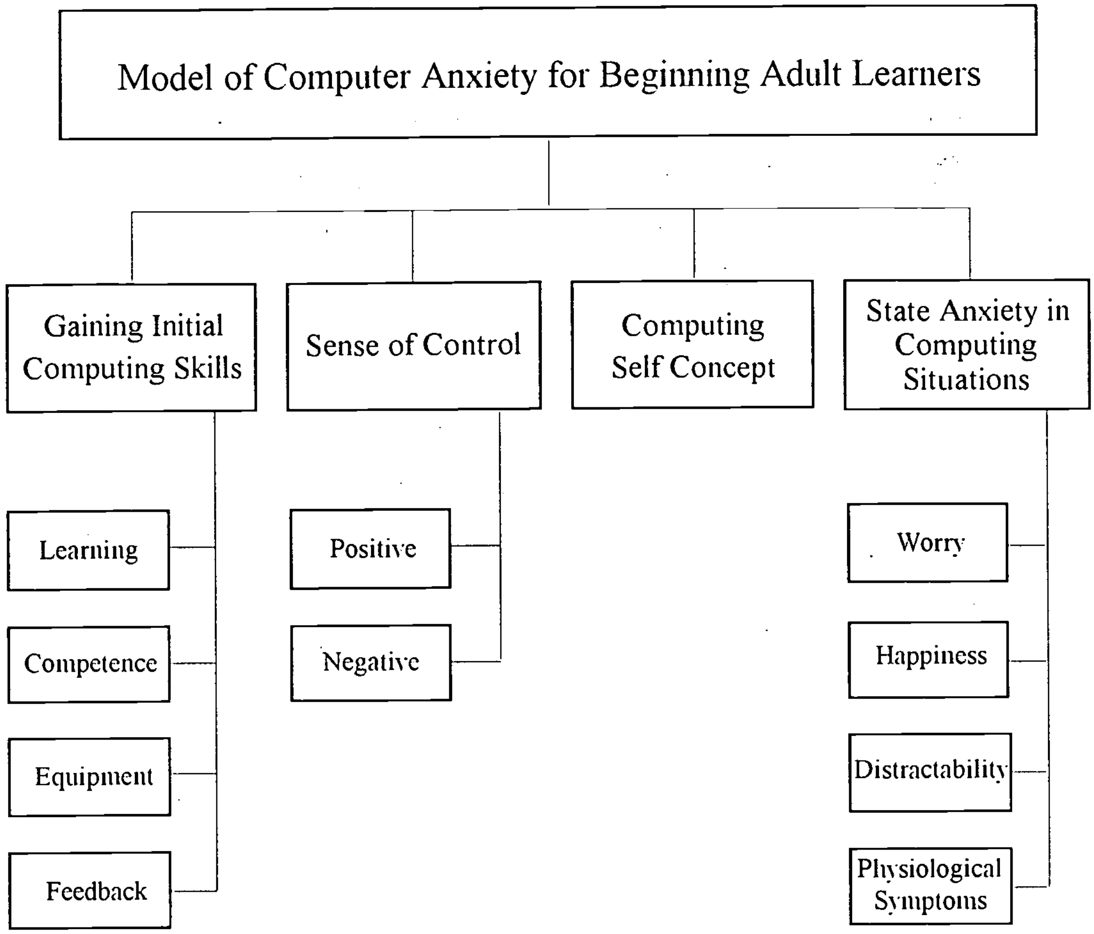

<u>Final Model of the Computer Anxiety and Learning Measure (CALM) Derived from Exploratory and Confirmatory Factor Analyses</u>

Appendix 1

Table 1a

Summary of Goodness-of-fit Indices for "Best" Models of Scales in the Computer Anxiety And Learning Measure: Total Group Analyses

Model	X^2	*df*	X^2/df	RNI	TLI
Gaining Initial Computing Skills					
null	13332.17	231	57.715	.000	.000
1storder	569.44	203	2.805	.976	.968
hiorder	587.60	205	2.866	.971	.967
Sense of Control					
null	7743.47	66	117.325	.000	.000
methodeff	459.16	48	9.566	.985	.980
2factor	204.73	53	3.862	.980	.975
Computing Self-Concept					
null	7346.55	55	133.574	.000	.000
methodeff	114.91	39	2.946	.990	.985
2factor	165.53	43	3.849	.983	.979
State Anxiety in Computing Situations					
null	16374.98	190	86.184	.000	.000
1storder	345.30	164	2.10	.988	.988
hiorder	372.55	166	2.244	.987	.987

Note.
null = null models for the total group; 1storder = first-order models for the total group; hiorder = higher-order models for the total group; methodeff = method effect models for the total group; 2factor = two-factor models for the total group; TLI = Tucker-Lewis Index; RNI = relative noncentrality index.

Table 1b
Three-Group Analyses of Invariance for Faculty of Education/ Health; Faculty of Arts and Social Sciences; and Faculty of Business and Technology

Model	X^2	*df*	X^2/df	RNI	TLI
Gaining Initial Computing Skills (Higher order model)					
3gp (no inv)	1570.34	615	2.553	.934	.975
3gp (fl inv)	1593.93	651	2.448	.935	.977
3gp (tot inv)	1681.29	711	2.365	.933	.978
Sense of Control (Two factor model)					
3gp (no inv)	372.01	144	2.583	.971	.987
3gp (fl inv)	402.05	180	2.234	.971	.990
3gp (tot inv)	423.40	204	2.075	.972	.991
Computing Self-Concept (Method effect model)					
3gp (no inv)	283.62	117	2.424	.979	.990
3gp (fl inv)	324.02	149	2.175	.977	.992
3gp (tot inv)	353.18	171	2.065	.977	.992
State Anxiety in Computing Situations (Higher order model)					
3gp (no inv)	956.09	498	1.920	.973	.990
3gp (fl inv)	993.03	530	1.874	.974	.990
3gp (tot inv)	1091.44	586	1.863	.971	.990

Note.
3gp (no inv) = no invariance constraints across the three groups; 3gp (fl inv) = refers to factor loadings invariant across the three groups; 3gp (tot inv) = refers to all parameters constrained to be invariant across the three groups; TLI = Tucker-Lewis Index; RNI = relative noncentrality index.

Appendix 2

Table 7

Standardised Estimates for the 65 item Computer Learning and Anxiety Measure

Item loading	factor	SMC
GAINING INITIAL COMPUTING SKILLS		
SCALE 1: COMPETENCE ANXIETY		
3. Taking a test on my computer competence	.79	.62
4. Working in a job that requires some computer experience	.73	.53
6. Getting "error" messages from the computer	.66	.40
21. Teaching someone else about computers	.74	.55
26. Dealing with computer malfunctions	.81	.66
29. Being evaluated on my computer competence	.84	.71
33. Learning about computers without structured guidance	.72	.52
SCALE 2: EQUIPMENT ANXIETY		
14. Using computerised equipment	.80	.65
28. Printing off documents	.79	.63
30. Using a "mouse"	.62	.40
35. Presenting work completed on a computer	.75	.56
SCALE 3: FEEDBACK ON COMPUTING SKILLS		
37. Being taught how to use a computer by a peer	.75	.56
38. Getting feedback from my teacher on my computer skills	.93	.89
39. Getting feedback from my peers on my computer skills	.88	.77
40. Collaborating with a friend while learning to use a computer	.79	.63
41. Getting feedback on my computer skills	.93	.87
SCALE 4: LEARNING ABOUT BASIC COMPUTER FUNCTIONS		
1. Taking a course in a computer language	.72	.52
11. Learning computer terminology	.81	.66
12. Reading a computer manual.	.68	.46
15. Learning how a computer works	.83	.69
24. Learning the operating system of a computer	.89	.79
25. Learning a new computer application	.90	.82
STATE ANXIETY IN COMPUTING SITUATIONS		
SCALE 1: WORRY		
4. Feelings of unease	.86	.75
10. Worried about possible problems	.70	.49
18. Threatened	.85	.72
20. Insecure	.89	.78
21. Helpless	.81	.66
27. Worried	.85	.73
28. Rattled	.75	.57

Item	factor loading	SMC
SCALE 2: HAPPINESS		
14. Happy	.81	.65
15. Comfortable	.90	.81
19. Secure	.89	.80
26. Relaxed	.92	.84
29. At ease	.91	.83
30. Content	.87	.76
SCALE 3: PHYSIOLOGICAL SYMPTOMS		
1. Nervous stomach," butterflies"	.91	.83
2. Hot and sweaty	.89	.80
3. Heart palpitations	.91	.83
12. Dry mouth	.80	.63
13. Sweaty palms	.80	.64
SCALE 4: DISTRACTABILITY		
5. Lack of concentration	.99	.97
6. Distractable	.80	.64

SENSE OF CONTROL (Two-factor model)

Item	factor loading	SMC
SCALE 1: POSITIVE SENSE OF CONTROL		
1. I can master the computer	.66	.43
7. I know I can do it	.73	.53
16. I will be able to get the computer to do what I want	.75	.56
18. I will understand what to do	.81	.66
19. I feel in control of what I do	.93	.86
20. I feel confident about my ability with computers	.88	.76
3. Everyone else but me knows what they are doing	.77	.60
SCALE 2: FEAR		
5. People will notice if I make a mistake	.80	.63
9. I'm afraid I'll wreck the program	.72	.53
12. What if I hit the wrong key?	.74	.55
13. I'm too embarrassed to ask for help	.68	.46
17. I might break the machine	.75	.56

SENSE OF CONTROL (One factor plus negative item method effect)

Item	factor loading	SMC
1. I can master the computer	.66	.43
7. I know I can do it	.73	.53
16. I will be able to get the computer to do what I want	.75	.56
18. I will understand what to do	.81	.66
19. I feel in control of what I do	.93	.86
20. I feel confident about my ability with computers	.88	.76

Item	factor loading	**	SMC
3. Everyone else but me knows what they are doing	.48	**.56**	.55
5. People will notice if I make a mistake	.41	**.69**	.64
9. I'm afraid I'll wreck the program	.34	**.67**	.56
12. What if I hit the wrong key?	.37	**.65**	.56
13. I'm too embarrassed to ask for help	.31	**.63**	.49
17. I might break the machine	.37	**.66**	.57

COMPUTING SELF-CONCEPT (Two-factor model)

SCALE 1: POSITIVE COMPUTING SELF-CONCEPT

Item	factor loading	**	SMC
6. I am very confident when it comes to working with computers	.89		.79
7. I can get good grades in computer courses	.78		.62
15. I am confident storing important information on a computer	.78		.60
16. I am sure I could solve any problems I had while using a computer	.79		.63
17. I can help others solve computer problems	.86		.74
19. I am sure that I can help others learn to use the computer	.87		.75

SCALE 2: NEGATIVE COMPUTING SELF-CONCEPT

Item	factor loading	**	SMC
1. I am no good with computers	.87		.76
4. I am not the type to do well with computers	.85		.72
5. I think using a computer would be very hard for me	.81		.66
9. I don't think I could handle a computer course	.69		.48
11. I avoid using computers as much as possible	.79		.62

COMPUTING SELF-CONCEPT (One factor plus negative item method effect) **

Item	factor loading	**	SMC
6. I am very confident when it comes to working with computers	.89		.79
7. I can get good grades in computer courses	.78		.61
15. I am confident storing important information on a computer	.78		.60
16. I am sure I could solve any problems I had while using a computer	.79		.63
17. I can help others solve computer problems	.86		.74
19. I am sure that I can help others learn to use the computer	.87		.75
1. I am no good with computers	.78	**.29**	.69
4. I am not the type to do well with computers	.70	**.51**	.76
5. I think using a computer would be very hard for me	.66	**.55**	.73
9. I don't think I could handle a computer course	.57	**.44**	.51
11. I avoid using computers as much as possible	.69	**.35**	.60

Note 1. factor loadings = factor loadings derived from confirmatory factor analysis (LISREL 7)
SMC = squared multiple correlations (a measure of item reliability).

Note 2. The items in the Sense of Control and Computing Self-Concept scales were presented originally in random order. They are separated here into positively and negatively worded items.

Note 3. ** = For the negatively worded items in the Sense of Control and Computing Self-Concept scales the factor loadings on a separate negative-item method factor are shown in **bold** next to the item loadings on the factor as a whole.

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