

**A confirmatory factor analysis of the Bath County computer attitude scale
within an Egyptian context: Testing competing models**

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Developed by Bear, Richards, and Lancaster (1987), the Bath County Computer Attitude Scale (BCCAS) was designed to assess attitudes towards computers within areas of computer use, computer-aided instruction, programming and technical issues, social issues surrounding computer use, and computer history. One specific advantage of the BCCAS is that it appears to be suitable for international comparisons, having been used in research in South Africa, India, United Kingdom, New Zealand, and Israel. The present study reported on the development of an Arabic version of the BCCAS among a sample of 340 undergraduates in Egypt. An exploratory factor analysis technique retained two factors: satisfaction and practicality. Satisfaction represents the values and enjoyment associated with using computers. Practicality represents learning with and about computers. Satisfaction and practicality factors each incorporated 10 items and had a correlation of 0.40. A confirmatory factor analysis technique revealed that a two-factor model fitted the data more appropriately than a one-factor model. The BCCAS had an invariant factorial structure across Egyptian males and females. The BCCAS had a positive relationship with other measures of attitudes towards computers, previous experience with computers, and future plans to work with computers. Relevance of these findings to teaching computers skills, learning with computers as well as learners' attitudes towards computers is discussed.

Introduction

Computers have an increasingly important effect on undergraduate courses, in terms of pedagogical methods, curriculum content and student study practices. For example, computer technology gives access to library resources, interrogates information databases, and provides a teaching medium that can result in more effective learning as well as a major tool for assignment work. As a consequence of these technological developments, institutions of higher education are continuing to expand their computer oriented facilities in terms of hardware, software, taught courses, and provisions of self-directed individual learning. Such technological developments, however, are not without psychological implications. A developing body of psychological research has drawn attention to the crucial influence that attitudes towards computers may have on children and adults utilize opportunities to use computer technology (see, Steele, Plaensky, Lynch, Lacy, & Duffy, 2002). Therefore, it is possible to suggest that to gain maximum benefit of computer technology, institutions should be aware of, explore, and monitor students' attitudes towards computers.

Bear, Richards, and Lancaster (1987) developed a computer attitude scale which they named Bath County Computer Attitude Scale (BCCAS). The initial version of the BCCAS consisted of 38 items designed to assess five areas associated with computers: (a) general computer use, (b) computer-assisted instruction, (c) programming and technical concepts, (d) social issues surrounding computer use, and

(e) computer history. Data for developing the early version of the BCCAS were obtained from a sample of 398 students in grades four through twelve. Some items of the BCCAS were worded positively (e.g., *I enjoy using a computer*); others were worded negatively (e.g., *Reading and talking about how computers might be used in the future is boring*). Students could choose among “I Agree” (scored as 2 points for positively worded and 0 for negatively worded items), “I Don’t Know” (Scored as 1 point), and “I Disagree” (scored as 2 points for positively worded and 0 for negatively worded items).

Bear et al. reported that an exploratory factor analysis retained five factors which cohered to produce an empirically unidimensional scale. For the purpose of reducing the length of the BCCAS without sacrificing its internal consistency reliability, the 26 items with the highest corrected item-to-total correlations coefficients were selected. The internal consistency reliability (Cronbach $\alpha = .94$) for the revised 26 items of the BCCAS was equal to that estimated for the original 38 items.

Bear et al. validated the 26-item scale among a second sample of 551 students in grades four through seven. They used two instruments to explore the concurrent validity of the BCCAS. The first instrument consisted of a six-item survey covering topics such as computer usage and experience, educational and career plans that involve using computers, and favourite school subjects. The second instrument was the Elementary Form of the Estes Attitude Scale (Estes, Estes, Richards, & Roetteger, 1981) that measures attitudes towards school subjects (i.e., reading, mathematics, and science).

Bear et al. found a positive, but low-level, relationship between attitudes towards computers and self-reported computer experience and usage. In addition, those respondents who planned to learn more about computers and enter a computer-related career held more positive attitudes than those who did not. In addition, Bear et al. reported a significant correlation of 0.5 between the BCCAS and the Elementary Form of the Estes Attitude Scale. Bear et al. concluded that the BCCAS is a unidimensional scale, internally consistent and valid. However, they recommended replication studies with alternative criteria and samples drawn from other populations.

Pike, Hofer, and Erlank (1993) used the BCCAS in a study of 462 students in Western Cape of South Africa. The results of the study showed that school leavers who intended to enter the computer profession had more positive attitudes towards computers than other school leavers. The authors did not, however, provide any information on the reliability of the BCCAS.

Miller and Varma (1994) used the BCCAS in a study of 279 six and seven graders in Dehru Dun, India. The results of the study showed that computer experience, usage, future plans related to computers, trait anxiety, and mathematics anxiety were significant predictors of attitudes towards computers. The BCCAS had a Cronbach alpha of 0.81.

Furthermore, Francis and Evan (1995) explored the reliability and validity of the BCCAS among a sample of 387 undergraduates in the United Kingdom. An exploratory factor analysis retained one factor. The BCCAS had a Cronbach alpha of 0.95 and it correlated highly with eight other measures of attitudes towards computers.

Similarly, Katz, Evans, and Francis (1995) developed a Hebrew version of the BCCAS among a sample of 339 undergraduates in Israel. An exploratory factor analysis retained one factor. The BCCAS had a Cronbach alpha of 0.90 and it

correlated highly with items measuring computer experience and future plans to work with computers.

However, a different picture emerged from a study with New Zealand students. McKinnon, Nolan, and Sinclair (2000) reported that a confirmatory factor analysis revealed that a one-factor model representing the BCCAS fitted the data inadequately: ($\chi^2 = 438.4$, $df = 350$, $p = .00$), Goodness of Fit Index (GFI) = .79, Adjusted Goodness of Fit Index (AGFI) = .75, Root Mean Square Residual (RMSR) = .07. However, a two-factor model (i.e., expressiveness and instrumental) fitted the data more appropriately: ($\chi^2 = 359.13$, $df = 349$, $p = .34$), Goodness of Fit Index (GFI) = .93, Adjusted Goodness of Fit Index (AGFI) = .91, Root Mean of Square Residual (RMSR) = .05. The expressive and instrumental factors had a Cronbach alpha of 0.90 and 0.86 respectively. The authors, however, did not provide any information regarding the number or the loadings of items on the expressiveness and instrumental factors.

Aims and Context of the Study

Since the mid 1980s, the Egyptian government has initiated a nationwide computerization process of its public sector and governmental offices. In 1985, the government established the Information and Decision Support Center (IDSC) that provide technical assistance to the governmental offices. Recent statistics show that there are 1200 IDSCs in Egypt. For the purpose of further integrating computers in the Egyptian society, the government has recently initiated a national project to support purchasing a computer for every home (Ministry of Communications and Information Technology, personal communication, 13 April, 2006). Hence, identifying factors implicated in developing positive attitudes towards computers constitutes a major interest for Egyptian educators.

The present study is reported on the use of an Arabic version of the BCCAS among a sample of Egyptian undergraduates. One goal of the present study is to validate the research findings on the factorial structure of the BCCAS by testing a one-factor model (i.e., unidimensionality) versus a two-factor model. A second goal is to test for the invariance of the BCCAS factorial structure across Egyptian males and females. A third goal is to explore the reliability of the BCCAS using both tau-equivalent and congeneric models (Fleishman & Benson, 1987). A final goal is to examine the concurrent validity of the BCCAS using measures of attitudes towards computers, previous experience with computers, and future plans to work with computers.

Methods

Participants

Subjects of the present study included 340 (190 males and 150 females) undergraduates enrolled in a public university in El-Minia, Egypt. The median age of the sample was 21 years with a range from 19 to 23 years-olds. Students were recruited to participate during their normal classes at their university. Participation was voluntary and 14 students from the approached sample declined to participate in data collection.

Measurements

The first author translated the 26 items of the BCCAS from English to Arabic. Applying a blind-back-translation strategy, two qualified translators, working without referencing to the English version of the BCCAS, independently translated the Arabic version back to English. All the translators were accredited with the British-Egyptian Centre in El-Minia, Egypt. Other three qualified translators then independently compared the original English version of the BCCAS to the new English version that was translated back from Arabic, and rated the match between the two versions on a scale from 1 to 10. A score of 1 represented poor match, whereas a score of 10 represented perfect match. The average percentage of match between the two versions of the BCCAS was 92 per cent which could be considered acceptable (see, Brislin et al., 1973). Respondents were asked to rate their agreement or disagreement with each item of the BCCAS on a 4 point-Likert-type scale that ranged from 1 (Strongly Disagree) to 4 (Strongly Agree).

Procedures

The Arabic version of the BCCAS was administered to the sample of the study during the tenth week of the 2006 school year. Participants were asked to respond to two Arabic versions of the Attitudes towards Computers Measure (Cronbach $\alpha = .85$), and Computer Liking Scale (Cronbach $\alpha = .83$) (Hasan, 1994). In addition, participants were asked to respond to two questions concerning their previous experience with computers and future plans to work with computers. The question concerned participants' previous experience with computers (Abd-El-Fattah, 2005) was rated on a five-point scale that ranged from 1 (Slightly experienced) to 5 (Very experienced). The question concerned participants' future plans to work with computers was rated on a five-point scale that ranged from 1 (Not likely at all) to 5 (Very much likely).

Results

Exploratory Factor Analysis

An exploratory factor analysis with oblique rotation, presented in Table 1, retained two factors each consisting of 10 items. The satisfaction factor (Cronbach $\alpha = .76$) explained 30 per cent of the total variance extracted and it represented the values and enjoyment associated with using computers. The practicality factor (Cronbach $\alpha = .78$) explained 23 per cent of the total variance extracted and it represented learning with and about computers. There was a significant relationship ($r = .40, p < .01$) between the satisfaction and practicality factors.

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Table 1
Exploratory factor analysis with oblique rotation of the BCCAS ($N = 340$)

Item	Statements	Loadings on Satisfaction	Loadings on Practicality
Satisfaction			
9	Computers are boring.	.77	.16
5	It is easy to get tired of using a computer.	.74	.20
4	Learning about computers is interesting.	.70	.18
1	Working math problems on a computer is fun, like solving puzzles.	.65	.19
7	I enjoy using a computer.	.62	.11
10	Working on a computer is a good way to spend spare time.	.55	.05
15	Using a computer becomes boring after about half an hour.	.46	.23
16	Computers are not exciting.	.43	.15
20	Computers help people to think.	.41	.24
24	School would be better place without computers.	.40	.08
Practicality			
3	People who use computers in their jobs are the only people who need to study about computers.	.19	.72
6	It is fun to figure out how computers work.	.09	.68
12	Classroom discussions about the use of computers in society are a waste of time.	.21	.65
14	Studying about the history of computers is boring.	.13	.63
8	Learning about the different uses of computers is interesting.	.17	.57
21	Reading and talking about how computers might be used in the future is boring.	.22	.52
17	Learning about the development of computers is interesting.	.08	.48
26	Learning about computer hardware and software is fun.	.14	.45
22	I enjoy learning how computers are used in our daily lives.	.23	.43
18	Studying about the uses and misuses of computers will help me be a more responsible citizen.	.12	.40
Eigenvalue		3.83	3.58

Confirmatory Factor Analysis

Results from a confirmatory factor analysis using the LISREL 8.5 program (Joreskog & Sorbom, 2001) are presented in Table 2. The analysis showed that the overall fit ($\chi^2(170, N=340) = 232.8, p = .00$) of the one factor model was not satisfactory. The modification indices produced by the LISREL 8.5 program for the one factor model were theoretically unjustifiable and therefore were not considered. The analysis, however, showed that the overall fit ($\chi^2(168, N = 340) = 190.8, p = .12$) of the two factor model, presented in Figure 1, was satisfactory.

Table 2

Chi-square (χ^2), degrees of freedom (df), and fit indices⁽¹⁾ for one-factor and two-factor models of BCCAS ($N=340$)

Statistic/ Model	One-Factor	Two-Factor	Baseline	Constrained
χ^2	232.2	190.8	366.7	392.7
df	170	168	336	358
<i>p</i>	.00	.01	.12	.1
RMSEA	.08	.03	.04	.04
SRMR	.07	.05	.05	.06
AGFI	.83	.97	.96	.97
PGFI	.62	.37	.38	.41
CFI	.85	.98	.97	.99

Note: ⁽¹⁾ All values of the reported modification indices fall within the recently suggested guidelines (see, Hu & Bentler, 1999)

It is noted from Figure 2 that there is a correlation between the error terms ($r = .22, p < .01$) associated with two observable variables (i.e., T9 and T5). Generally, the specification of correlated error terms for the purpose of achieving a better fitting model is not an acceptable practice; as with other parameters, such specifications must be supported by a substantive or empirical rationale (see, Jorskog & Sorbom, 1985). Specifically, the correlated error terms often indicate some type of redundancy between the measured variables (Abd-El-Fattah, in press). Put bluntly, the measured variables with correlated error terms may express similar meaning. On this basis, the correlated error terms between the two specified items are considered to be justifiable.

Once the model achieves an overall satisfactory fit, one should examine the statistical significance of each of the hypothesized path coefficients. The test statistic is the critical ratio (CR), which represents the parameter estimate divided by its standard error. As such, it operates as a *z*-statistic in testing whether the estimate is statistically different from zero. Based on a significance level of .05, the test statistic needs to be $>\pm 1.96$ before the hypothesis that the estimate equals 0.0 can be rejected (Byrne, 2001). All the hypothesized path coefficients of the two-factor model of the BCCAS, presented in Table 3, were statistically significant.

Table 3

Standardized path coefficients, critical ratio, error variance and R^2 of the second-order-two-factor model of the BCCAS ($N = 340$)

Paths	Path coefficient	Standard error	Critical ratio	R^2
Satisfaction				
T9	.75	.23	3.3	.56
T5	.71	.17	4.2	.50
T4	.77	.20	3.9	.59
T1	.76	.18	4.2	.58
T7	.69	.13	5.3	.48
T10	.77	.16	4.8	.59
T15	.70	.11	6.4	.49
T16	.72	.13	5.5	.52
T20	.81	.25	3.2	.66
T24	.74	.14	5.3	.55
Practicality				
T3	.70	.12	5.8	.49
T6	.78	.15	5.2	.61
T12	.69	.12	5.7	.48
T14	.80	.19	4.2	.64
T8	.78	.16	4.9	.61
T21	.79	.14	5.6	.62
T17	.82	.13	6.3	.67
T26	.73	.17	4.3	.53
T22	.75	.18	4.2	.56
T18	.71	.13	5.5	.50

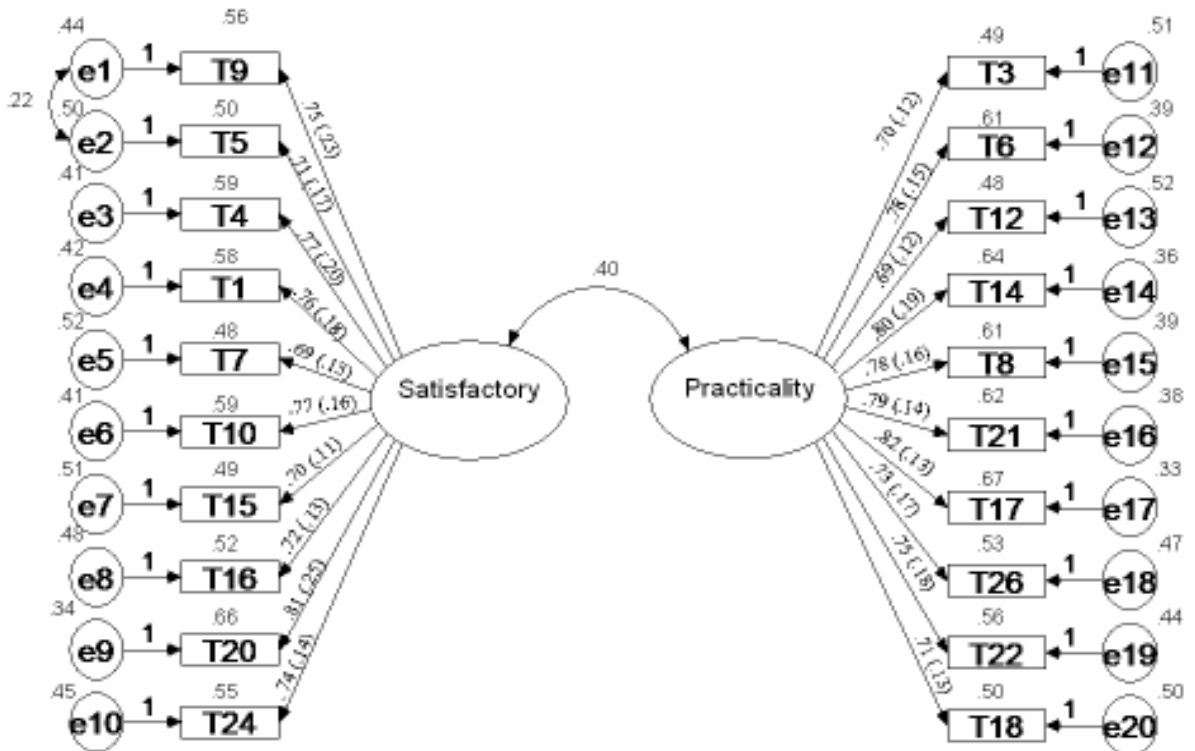


Figure 1. Two-factor model of the BCCAS

Joreskog (1971a) and Bollen (1989) argued that tests of invariance work on the null hypothesis (H_0) that $\sum_1 = \sum_2 = \dots = \sum_G$, where \sum represents the population variance covariance matrix and G is the number of groups. Failing to reject H_0 implies that the groups are equivalent and thus tests for invariance are unjustified. Put bluntly, data should be pooled and all subsequent analyses should be based on a single group. Rejection of H_0 , however, argues for the nonequivalence of the groups and thus for the subsequent testing of increasingly restrictive hypotheses in order to identify the source of noninvariance.

For the purpose of testing for the invariant factorial structure of the BCCAS across Egyptian males and females, the AMOS 6.0 program (Arbuckle, 2005) was used to test a baseline model (Joreskog & Sorbom, 1996; Yung & Bentler, 1996) of the BCCAS. Results, presented in Table 2, showed that the baseline model fitted the data satisfactory (χ^2 (336, N =340) = 366.7, $p = .12$).

Another baseline model was constructed with equality constraints specified for factor loadings, variances, and covariances across gender. While it is possible to test for equality of error variances and covariances across groups, “the testing of equality constraints bearing on error variances and covariances is now considered to be excessively stringent...” (Byrne, 2001, p. 186). In the present study, however, the testing for error covariance could be justified on the basis of the substantial values ($r = .22$, $p < .01$) of these covariances. Results, presented in Table 2, showed that the overall fit of the constrained baseline model was satisfactory (χ^2 (358, N =340) = 392.7, $p = .1$). The chi-square difference ($\Delta\chi^2$) between the baseline model and the constrained model was statistically nonsignificant ($\Delta\chi^2 = 26$, $\Delta df = 22$, $p = .25$) which indicated that the factorial structure of the BCCAS was invariant across Egyptian males and females.

Reliability of the BCCAS

Cronbach alpha assumes that the items of a scale are tau-equivalent (Cohen & Swerdlik, 2001; Hopkins, Stanley, 1981). The tau-equivalent measures have the same true scores, but may have unequal error variances (Novick & Lewis, 1967). This means that each item is measuring the same construct to the same degree; a restrictive assumption that is unlikely to be met in practice. If the items of a scale are not tau-equivalent, Cronbach alpha will be a conservative estimate of reliability (Novick & Lewis, 1967).

Joreskog (1971b) argued that the congeneric model is the least restrictive model based on the classical testing theory. The assumption underlying the congeneric model is that different items do not reflect the same true score.

$$X_j = T_j + E_j \tag{1}$$

Each observed test score consists of the true score for that test plus error. The congeneric model further assumes that the true scores for different items correlate perfectly with each other. This assumption led to a respecification of

$$X_j = M_j + \beta_j T + E_j \tag{2}$$

where β_j refers to the loading of an item on a generic true score and M_j represents the mean. Put bluntly, each observed score reflects the same generic true score (Alwin & Jackson, 1980) but to different degrees, as reflected in different β_j for different items.

If the congeneric model applies, the degree to which each item reflects the generic true score (as shown in the β_j coefficients) must be considered. If items are summed to form a scale, the formula (Fleishman & Benson, 1987) to estimate reliability is,

$$p_{xx} = \frac{(\sum B_j)^2}{(\sum B_j)^2 + \sum \theta_j^2} \quad (3)$$

where θ^2 represents error variance for each item.

Applying the congeneric model approach, the reliability estimates of the satisfaction and practicality factors were .87 and .88 respectively. It is noted, however, that the reliability values for the satisfaction and practicality factors using the congeneric model were higher than the estimates obtained when applying the tau-equivalent model (i.e., Cronbach α). These findings seem to be consistent with the suggestion that Cronbach alpha works as a lower bound estimate of reliability when the assumption of the tau-equivalence model is not met (Lord & Novick, 1968; Novick & Lewis, 1967; Shevlin, Miles, Davies, & Walker, 2000).

Validation of the BCCAS

The BCCAS had a significant correlation of .49, .47, .43, and .45 with the Attitudes towards Computers Measure, Computer Liking Scale, experience with computers, and future plans to work with computers respectively.

Discussion

The main goal of the present study was to examine the factorial structure and the psychometric properties of an Arabic version of the Bath County Computer Attitude Scale (BCCAS) among a sample of Egyptian undergraduates. Specifically, the present study tested a one-factor model versus a two-factor model of the BCCAS.

A confirmatory factor analysis showed that the two-factor model (i.e., satisfaction and practicality) fitted the data more appropriately than the one-factor model. The satisfaction factor represents the values and enjoyment associated with using computers. The practicality factor represents learning with and about computers. In addition, a multi-group confirmatory factor analysis showed that the BCCAS had an invariant factorial structure across Egyptian males and females.

Similarly, McKinnon et al. (2000) found that a two-factor model (i.e., expressiveness and instrumental) fitted the data collected from New Zealand students more appropriately than a one-factor model. The authors, however, did not provide any information regarding the number or the loadings of items on the expressiveness and instrumental factors.

In contrast, several researchers have used an exploratory factor analysis and argued for the unidimensionality of the BCCAS (Bear et al., 1987; Francis & Evan, 1995; Pike et al., 1993). However, it is conceivable that most of these studies suffered lack of information and robustness. For example, with the exception of the McKinnon's et al. study, probably no published study has utilized a confirmatory factor analysis to explore the factorial structure of the BCCAS. In addition, Francis

and Evan (1995) failed to rotate their principal component analysis, thus providing ambiguous information regarding the unidimensionality of the BCCAS.

Furthermore, the present study used a congeneric model approach to estimate the reliability of the BCCAS. Shevlin et al. (2000) emphasized that the congeneric model seemed to be more rigorous to estimate reliability than computing composite factors based on factor scores or additive indices of items which ignore the relative contribution of each item to the composite factor (i.e., tau-equivalent model). Shevlin et al. argued that the congeneric model minimizes measurement errors in the items contributing to each factor and thus increase the reliability of the composite factors. In the present study, the satisfaction and practicality factors showed substantial improvement in their reliability estimates when applying the congeneric model.

In contrast, probably, all published studies have depended on a tau-equivalent model (i.e., Cronbach alpha) to estimate the reliability of the BCCAS. However, several researchers (Groth-Marnat, 2003; Lord & Novick, 1968; Shevlin et al., 2000) have argued that Cronbach alpha works as a lower bound estimate of reliability when the assumption of the tau-equivalence model is not met. The tau-equivalence model assumes that each item is measuring the same underlying construct to the same degree; a restrictive assumption that is unlikely to be met in practice

The present study evidenced the concurrent validity of the BCCAS through exploring its relationship with Attitudes towards Computers Measure, Computer Liking Scale, computer experience, and future plans to work with computers.

In summary, the BCCAS seems to represent a promising measure of students' attitudes towards computers. The BCCAS showed satisfactory psychometric properties and probably best represented by a two-factor model. Teachers and educators should be aware of, explore, and monitor their students' attitudes towards computers. Since it articulates two meaningful indices (i.e., satisfaction and practicality), the BCCAS could be recommended for its usefulness and value in this direction.

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