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Assessing emotions related to learning new software: The computer emotion scale

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Abstract

To date, little research has been done on the role of emotions with respect to computer related behaviours. The purpose of this study was to develop a reliable, valid scale to assess emotions while learning with computers. Four emotions (anger, anxiety, happiness, and sadness), selected after a detailed review of the research, were evaluated. Internally reliability estimates were acceptable. Construct validity was confirmed by an exploratory factor analysis. Convergent validity was supported by strong correlations among emotions and affective attitude, but not cognitive and behavioural attitudes. Finally, predictive validity was corroborated by consistent and significant correlations among emotion, computer knowledge, and use.

Keywords: Computer; Emotions; Anger; Anxiety; Scale; Measure; Computer use; Computer ability; Computer knowledge

1. Overview

The study of emotions has shifted from the musings of philosophers to a multidisciplinary subject addressed by scientists, psychologists, and educators. Modern researchers have identified emotions as fundamental to human development and communication (see Oatley & Jenkins, 1992 for review). Scientific studies have also demonstrated the clinical effects of emotions resulting in chemical and hormonal changes in both the brain and the body

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(Goleman, 1995). Most recently, the study of emotions has expanded to the subject of learning, where researchers are studying the positive and negative effects of emotions on cognitive processing.

To date, little research has been done on the role of emotions with respect to computer related behaviours. Tangential research has focused extensively on computer anxiety, but other emotions such as anger, happiness, and sadness have been largely overlooked. The purpose of this study was to develop a reliable and valid scale to assess emotions while learning with computers.

2. Literature review

2.1. Linking emotions to cognition – models of emotion

The increase in the study of both emotions and learning has created considerable debate. Traditional views identify emotion and cognition as clearly separated constructs (Goleman, 1995; Lazarus, 1991a, 1991b). Others, while acknowledging that the processes are separate, argue that emotions and cognition coexist. LeDoux (1989) claims that emotion and cognition are mediated by separate but integrated systems of the brain. Gray (1990) points out that the brain systems mediating emotion and cognition overlap. Taking the relationship between emotion and cognition further, there is "growing awareness that, far from being polar opposites, [emotion and cognition] are in fact inextricably connected" (O'Regan, 2003, p. 80). Frijda (1986) and Simon (1967) also support the perspective that emotion and cognition are intertwined.

2.2. Emotions and everyday cognition

Current research has acknowledged the role of emotion in everyday cognitive activity. Emotion is considered critical in the process of adapting to unpredictable environments or juggling multiple goals (Case, Hayward, Lewis, & Hurst, 1988; Neisser, 1963; Oatley & Johnson-Laird, 1987; Simon, 1967). Similar studies have identified that an emotional reaction is likely when one is in danger of harm, being threatened, challenged, or, conversely, if one is in a situation of benefit or readiness (Lazarus, 1991b). Emotion could be activated by a number of factors, including motivation, communication, or survival (Rolls, 2000). These studies suggest that emotional reactions are used to adapt to unpredictable and changing environments.

Goleman (1995) argues that human experiences leave an emotional "blueprint" in the brain, thus permitting us to expect or anticipate subsequent emotional reactions. Mayer, Caruso, and Salovey (1999) posit that a full concept of "intelligence" must include the notion of emotional intelligence, for the perception, understanding, and management of emotions is essential to social interaction. The concept of emotional intelligence for everyday life, then, has become more mainstream and is receiving scholarly attention, despite difficulties in determining how to measure it (Daus & Ashkanasy, 2003).

2.3. Emotion and formal learning

While research on emotion and informal or everyday cognition has flourished (e.g., Frijda, 1986), the role of emotion in formal learning has been largely ignored (Gardner, 1983;

Oatley, 1987; Simon, 1967). However, there has been some interest in how emotions affect the formal learning process. Isen (1990) examined the impact that feelings had on cognition and social behaviour, and found that positive feelings facilitate the recovery of positive material. Izard, Kagan, and Zajonc (1984) argue that when studying cognitive processes, one must consider biological preparedness, emotional threshold, and temperament as moderating influences. In other words, one's emotional state before learning may affect one's cognitive results. Emotions, though, often develop throughout the learning process. The learning process almost certainly has an end goal (the attainment of information, the retention of information) and an emotion most often occurs when this end-goal is interrupted (Mandler, 1984). This interruption could be a positive or negative experience, resulting in emotions such as frustration, happiness, or relief. Throughout the learning process, then, emotions tend to shift a person's prior goals to something new (Fischer, Shaver, & Carnochan, 1990).

2.4. Emotions and learning with computers

With the ever growing presence of computers in society, it is not uncommon for users to express emotional reactions such as anger, desperation, anxiety, or relief. The frustration of not being able to escape from a seemingly straightforward error or the relief of finally gaining some control over a software package has probably been experienced by most computer users at one time or another. It is conceivable, then, that emotions play some role in the learning process.

One emotion, anxiety, has been study extensively with respect to computers, however precise and consistent definitions have been lacking. Constructs have included *confidence* (Heinssen, Glass, & Knight, 1987; Loyd & Gressard, 1984), *positive or negative feelings* (Beckers & Schmidt, 2001; Ceyhan, 2006; Loyd & Gressard, 1984; Nickell & Pinto, 1986), *intimidation* (Nickell & Pinto, 1986; Heinssen et al., 1987), *fear* (Bronsan & Lee, 1998; Heinssen et al., 1987), *damaging anxiety* (Ceyhan, 2006; Russell & Bradley, 1997), *equipment anxiety* (Marcoulides & Wang, 1990), *learning or task performance anxiety* (Ceyhan, 2006; Rosen & Weil, 1995; Russell & Bradley, 1997), *observation anxiety* (Bronsan & Lee, 1998; Dyck, Gee, & Smither, 1998), *anticipatory anxiety* (Bronsan & Lee, 1998), *state-anxiety* (Gaudron & Vignoli, 2002; Wilfong, 2006), *fear of social embarrassment* (Russell & Bradley, 1997), *general or non-specific anxiety* (Hong & Koh, 2002; Todman & Day, 2006; Yaghi & Abu-Saba, 1998), *self-efficacy* (Beckers & Schmidt, 2001), and *cognitive beliefs* (Beckers & Schmidt, 2001). This range of anxiety constructs makes it difficult to build theory and a coherent knowledge base. The relationship between computer anxiety and computer ability or experience, for example, is tenuous at best (Beckers, Rickers, & Schmict, 2006; Honeyman & White, 1987; Koohang, 1987; Mackowiak, 1988; Smith & Caputi, 2001).

Only one empirical study could be found looking at the role of another emotion, anger, with respect to computer related behaviour. Wilfong (2006) reported that computer anger was strongly related to self-efficacy, but not computer use or experience. Emotions such as sadness or happiness have yet to be formally evaluated in the context of learning new computer skills.

2.5. Purpose of the study

While it is evident that emotions play a role in learning, little research has been done examining the full range of emotions that could influence how people learn and perform with computers. While extensive work has been done looking at computer anxiety, the impact of other emotion constructs such as anger, sadness, and happiness have not been examined. The purpose of this study was to develop a reliable and valid scale to assess key emotions associated with learning computer related tasks.

3. Method

3.1. Sample

The sample consisted of 184, Intermediate–Senior (grade 7–12), preservice teachers (123 females, 61 males) from a variety of cultural backgrounds (20% reported that their first language was not English), ranging in age from 23 to 58 years ($M = 33.4$; $SD = 8.7$). Eighty-one percent of the subjects reported having 10 or more years experience using computers. It is important to note that years of computer experience in this study was not necessarily equivalent to computer knowledge. Preservice teachers' pre-laptop scores on the computer ability survey were relatively low for all 12 computer ability subscales with the exception of the word processing and spreadsheets constructs.

3.2. Description of the program

The Bachelor of Education degree at this university is an 8-month consecutive program, focussing on Computer Science, Math, and Science (Physics, Chemistry, Biology, and General Science) at the intermediate-secondary school level (grades 7–12). All students were required to have a B.A. with five full university courses in their first teachable area and three full university courses in their second teachable area.

Every student in the preservice teacher education program was given an IBM R51 ThinkPad at the beginning of the year, loaded with a wide range of educational and application-based programs. All classrooms were wired with high-speed Internet access through cable and a wireless network. In addition, students had access to a wireless network throughout the university campus.

3.3. Model of technology use – integration

An integrated model was used to incorporate technology into the preservice education. In other words, students used their laptop computers in all courses offered, but did not take a stand-alone course in technology use. All students attended a 4-h introductory workshop at the beginning of the year to introduce them to the basic operations of laptop computers and connecting to the Internet. All students were offered voluntary 2-h workshops throughout the year that focussed on specific software skills in Word, PowerPoint, searching the Web, Web Page Design, and Dreamweaver. Finally, there was one support person available 4 h per day, five days a week, to assist students with individual problems.

3.4. Data sources

Survey. The Computer Emotion Scale (CES) survey consisted of 12 items (see Appendix A). Three other scales were used to assess the predictive validity of the CES and include the Compute Knowledge Scale – CKS (77 items), the Teacher Computer Attitude Scale

– TCAS (25 items), and the Teacher Computer Use Scale – TCUS (47 items). Descriptive details for all scales are presented in Table 1.

Computer emotions. While considerable debate reigns on what constitutes a basic emotion, it is generally agreed upon that there are at least four basic emotions: happiness, sadness, anxiety (fear), and anger (Arnold, 1960; Ekman, Friesen, & Ellsworth, 1972; Izard, 1969; James, 1884; Oatley & Johnson-Laird, 1987; Plutchik, 1980; Tomkins, 1962). Therefore, in this study, four theoretically distinct constructs (anger, anxiety, happiness, and sadness) were used to assess emotions of preservice teachers "while learning a software package".Oatley and Johnson-Laird's (1987) four basic emotion categories were used in conjunction with a subset of their 590 emotional words to create appropriate emotional scale items (Appendix A). Two researchers achieved 100% agreement on the assignment of emotional words to the four basic emotion categories. A detailed analysis of the scale characteristics will be presented in the results section.

Computer attitude. Four theoretically distinct constructs (cognitive, affective, behavioural, and self-efficacy), based on over 45 years of general attitude scale development

Table 1
Description of survey instruments used

Scale	No. items	Range	Internal reliability
Emotions			
Anger	3	0–3	$r = 0.69$
Anxiety	4	0–3	$r = 0.73$
Happiness	3	0–3	$r = 0.70$
Sadness	2	0–3	$r = 0.65$
Computer knowledge			
Operating system	10	0–6	$r = 0.95$
Communication	10	0–6	$r = 0.94$
WWW skills	9	0–6	$r = 0.92$
Word processing	10	0–6	$r = 0.95$
Spreadsheet	6	0–6	$r = 0.97$
Database	10	0–6	$r = 0.95$
Graphics	6	0–6	$r = 0.95$
Presentation	6	0–6	$r = 0.95$
Create web page	10	0–6	$r = 0.98$
Attitude			
Affective – negative	4	0–6	$r = 0.88$
Affective – positive	4	0–6	$r = 0.80$
Cognitive – teach	4	0–6	$r = 0.83$
Cognitive – student	4	0–6	$r = 0.76$
Self efficacy	6	0–6	$r = 0.89$
Behavioural	3	0–6	$r = 0.87$
University Use			
Basic software	3	0–4	$r = 0.69$
Advanced software	10	0–4	$r = 0.91$
Collaboration	5	0–4	$r = 0.80$
Social	4	0–4	$r = 0.82$
Field use			
Student	18	0–3	NA
Teacher	7	0–3	NA

(Kay, 1993), were used to assess attitudes of preservice teacher toward computers. A principal components analysis revealed six distinct factors consistent with the four construct model proposed in attitude theory literature. These include cognitions or beliefs about teacher and student interactions with computers (teacher and student cognitive attitudes), negative and positive feelings toward computers (negative and positive affective attitudes), stated intentions to interact with and use computers in the future (behavioural attitudes), and confidence with respect to computers (self-efficacy). Internal reliability estimates were moderate to high ranging from 0.76 to 0.89 (Table 1).

Computer ability. Several researchers (e.g., Fulton, 1997; Kay, 1989b, 1992a, 1992b) have noted that computer proficiency is an evolving concept based, to a certain extent, on who is learning and what technology is available. Perhaps the best one can do is to examine what skills are important in a given context. Recall that the context of this study includes the following key elements: preservice teachers (grades 7–12), ubiquitous access to a computer and the Internet, and a model that focuses on integration. It is reasonable, then, to develop a comprehensive assessment of computer ability based on the kind of tools that would be used in an educational setting. Therefore, a composite measure of nine computer skills was developed from a content analysis of instruments designed to assess computer ability of beginning teachers (Albee, 2003; Bartlett, 2002; Bucci, 2003; Collier, Weinburgh, & Rivera, 2004; Fulton, 1997; Gunter, 2001; Seels, Campbell, & Talsma, 2003; Thompson, Schmidt, & Davis, 2003; Wepner, Ziomek, & Tao, 2003; Wilkerson, 2003). The specific skills identified in previous research included operating systems, communication, World Wide Web, word processing, spreadsheet, database, graphics, presentations, and web page creation. A new measure of computer ability was created because the majority of previous instruments did not report reliability or validity statistics (Albee, 2003; Bartlett, 2002; Bucci, 2003; Fulton, 1997; Gunter, 2001; Seels et al., 2003; Thompson et al., 2003; Wepner et al., 2003). The reliability estimates for the computer ability skills assessed in this study were high ranging from 0.92 to 0.98 (Table 1).

Computer use. A composite measure of computer use was developed based on a comprehensive review of research designed to assess computer use in preservice teachers (Baylor & Ritchie, 2002; Compton & Harwood, 2003; Garland, 1999; Halpin, 1999; Maeers, Browne, & Cooper, 2000; Milbrath & Kinzie, 2000; Pope, Hare, & Howard, 2002; Russell, Bebell, O'Dwyer, & O'Connor, 2003; Thompson et al., 2003; Vannatta & Beyerbach, 2000; Wang & Holthaus, 1999). A decision was made to develop a new measure because previous measures were either limited in focus (Halpin, 1999; Maeers et al., 2000; Milbrath & Kinzie, 2000) or not statistically reliable (Baylor & Ritchie, 2002; Pope et al., 2002; Russell et al., 2003; Thompson et al., 2003; Wang & Holthaus, 1999). Use was looked at in two environments – at the university where preservice candidates took their classes and in the field placement where preservice teachers practiced their teaching.

In the university environment, four categories of computer use were assessed: basic software ($r = 0.69$), advanced software ($r = 0.91$), collaboration ($r = 0.80$), and social ($r = 0.82$). A principal component factor analysis supported the validity of this structure. In the classroom room environment where preservice teachers did their practice teaching (field placement), two categories of computer use were examined – teacher-based and student-based. The items from this scale were not intended to form coherent, reliable structures. The scale was designed to be a comprehensive checklist of technology tools that preservice candidates could use. Given the wide range of tools examined and the limited time in the field placement (6 weeks), consistent and frequent patterns of use would be difficult to attain. Therefore a factor analysis and internal reliability estimates were not calculated.

3.5. Procedure

Subjects were told the purpose of the study and then asked to give written consent if they wished to participate. All four scales were administered online at the beginning (September) and end of the year (April). The complete set of scales took an average of 20–25 min to complete.

3.6. Data analysis

A series of analyses were run to assess the reliability and validity of the CES. These included:

(1) internal reliability estimates of emotion constructs (reliability);
(2) a principal component factor analysis (construct validity);
(3) correlations among emotion constructs (construct validity);
(4) correlation among emotion constructs and computer attitude constructs (convergent validity);
(5) correlation among change in emotion and change in computer attitudes (convergent validity);
(6) change in emotions (predictive validity);
(7) correlation among emotion constructs and computer knowledge constructs (predictive validity);
(8) correlations among change in emotion and change in computer knowledge (predictive validity);
(9) correlation among emotion constructs and computer use constructs (predictive validity); and
(10) correlations among change in emotion and change in university use (predictive validity).

4. Results

4.1. Internal reliability

The internal reliability estimates for all four emotion constructs were moderate, but acceptable for measures in the social sciences (Kline, 1999; Nunnally, 1978), ranging from 0.65 to 0.73 (Table 1). Scales with fewer items produced lower reliability estimates.

4.2. Construct validity

Principal component analysis. A principal components analysis was done to explore whether the four emotions formed four distinct factors. Since all communalities were above 0.4 (Stevens, 1992), the principal component analysis was deemed an appropriate exploratory method (Guadagnoli & Velicer, 1988). Both orthogonal (varimax) and oblique (direct oblimin) rotations were used, given that the correlation among potential strategy combinations was unknown. These rotational methods produced identical factor combinations, so the results from the varimax rotation (using Kaiser normalization) are presented because they simplify the interpretation of the data (Field, 2005). The Kaiser-Meyer-Olkin measure of sampling adequacy (0.827) and Bartlett's test of sphericity ($p < 0.001$) indicated that the sample size was acceptable.

The principal components analysis was set to extract the four factors (Table 2). The resulting rotation corresponded relatively well with the proposed emotion constructs with three exceptions. First, "helpless" was expected to load on the sadness construct, but it was grouped with the anxiety descriptors. Second, "frustration" loaded on both anxiety and anger constructs. Third, "dispirited" loaded with anger and sadness constructs. Overall, the structure was consistent with the proposed grouping of scale items listed in Appendix A.

Correlations among emotion constructs. Correlations among the four emotion constructs supported by the factor analysis were significant, but small enough to support the assumption that each emotion measured was distinct (Table 3). This result also supports the notion that users experience more than one emotion while learning.

Table 2
Varimax rotated factor loadings on strategies used to incorporate technology

Emotion items	Factor 1	Factor 2	Factor 3	Factor 4
Insecure	0.79			
Nervous	0.74			
Helpless	0.70			
Anxious	0.59			
Excited		0.85		
Curious		0.72		
Satisfied		0.60		
Frustrated	0.50		0.47	
Angry			0.86	
Irritable			0.69	
Disheartened				0.87
Dispirited			0.47	0.55

Factor	Eigenvalue	PCT of VAR	CUM PCT
1	4.37	36.4	36.4
2	1.64	13.6	50.0
3	1.01	8.4	58.4
4	0.90	7.5	65.9

Table 3
Correlations among emotion constructs

	Angry	Anxious	Happiness	Sadness
Angry	1.00	0.52**	−0.37**	0.55**
Anxious		1.00	−0.23*	0.46**
Happiness			1.00	−0.39**
Sadness				1.00

* $p < 0.005$ (2-tailed).
** $p < 0.001$ (2-tailed).

5. Convergent validity

Correlation among emotion constructs and computer attitude constructs. All four emotion constructs were strongly correlated with affective attitudes (negative and positive) and self-efficacy. Negative emotions (anger, anxiety, and sadness) showed a positive correlation with negative affective attitudes and a negative correlation with positive affective attitudes and self-efficacy. The reverse pattern was seen for happiness which was negatively correlated with negative affective attitudes and positively correlated with positive affective attitudes and self-efficacy. A weaker, but significant correlation was observed among three of the four emotion constructs and cognitive attitudes. Anxiety was not significantly correlated with cognitive attitudes. Only anxiety and happiness constructs were correlated with behavioural attitudes (Table 4).

Correlation among change in emotion constructs and change in computer attitudes. Changes in all four emotions constructs were significantly correlated with affective attitudes (negative and positive) with one exception. Change in anxiety was not correlated with a change in positive emotion. Correlations among change in emotions and the remaining four computer attitude constructs (cognitive-teacher, cognitive-student, self-efficacy, behavioural) were largely insignificant (Table 5).

Table 4
Correlations among pre-laptop emotion constructs and pre-laptop computer attitudes

	Angry	Anxious	Happiness	Sadness
Affective (negative)	0.49***	0.60***	−0.39***	0.43***
Affective (positive)	−0.36***	−0.32***	0.62***	−0.35***
Cognitive (teacher)	−0.18*	−0.11	0.28***	−0.20*
Cognitive (student)	−0.19*	−0.00	0.44***	−0.10
Self-efficacy	−0.32***	−0.59***	0.37***	−0.35***
Behavioural	−0.13	−0.23**	0.18*	−0.12

* $p < 0.05$ (2-tailed).
** $p < 0.005$ (2-tailed).
*** $p < 0.001$ (2-tailed).

Table 5
Correlation among change in emotion constructs and change in computer attitudes

	Angry	Anxious	Happiness	Sadness
Affective (negative)	0.20*	0.27***	−0.31***	0.24**
Affective (positive)	−0.17*	−0.08	0.44***	−0.23**
Cognitive (teacher)	−0.01	−0.20*	0.14	−0.10
Cognitive (student)	−0.02	−0.02	0.38***	−0.05
Self-efficacy	−0.16	−0.19*	0.11	−0.07
Behavioural	−0.08	−0.01	0.06	−0.10

* $p < 0.05$ (2-tailed).
** $p < 0.005$ (2-tailed).
*** $p < 0.001$ (2-tailed).

6. Predictive validity

Change in emotions. After the 8-month, integrated laptop program, preservice teachers reported significantly less anxiety and anger while they were learning software (Table 6). Happiness increased and sadness decreased, but not significantly. Happiness may not have increased because of a ceiling effect.

Correlation among emotion constructs and computer knowledge constructs. There was a strong significant relation among emotions reported while learning, and computer skill (Table 7). Happiness and anxiety showed the highest correlations with all nine computer skill measures. Negative emotions (anxiety, anger, and sadness) were negatively correlated with ability, whereas the one positive emotion, happiness, showed a positive correlation.

Correlation among change in emotion and change computer knowledge. There are two notable findings with respect to how change in emotions related to change in computer knowledge acquired over the 8-month, integrated laptop program. First, positive increases in happiness expressed while learning were significantly correlated with increases in eight of the nine computer skills assessed (web page design was the one exception). Second, a decrease in anxiety, was significantly correlated with increases in seven of the nine computer skills assessed (presentation and web page design skills were the exceptions). Overall,

Table 6
Emotion construct scores before and after integrated laptop program

Emotion construct	Before program		After program		df	t
	M	(SD)	M	(SD)		
Anger	2.05	(1.34)	1.72	(1.23)	149	3.41*
Anxious	2.48	(1.93)	1.81	(1.64)	149	5.26**
Happiness	5.47	(1.58)	5.69	(1.63)	149	−1.42
Sadness	1.09	(0.92)	0.99	(0.87)	149	3.41

* $p < 0.005$.
** $p < 0.001$.

Table 7
Correlations among emotion constructs and computer knowledge

	Angry	Anxious	Happiness	Sadness
Operating system	−0.31**	−0.54**	0.44**	−0.33**
Communication	−0.30**	−0.46**	0.36**	−0.37**
World wide web	−0.27**	−0.43**	0.36**	−0.36**
Word processing	−0.28**	−0.44**	0.41**	−0.36**
Spreadsheets	−0.30**	−0.48**	0.32**	−0.36**
Database	−0.28**	−0.44**	0.46**	−0.34**
Graphics	−0.31**	−0.44**	0.38**	−0.31**
Presentations	−0.31**	−0.43**	0.41**	−0.35**
Web page design	−0.33**	−0.36**	0.28**	−0.22*

* $p < 0.005$ (2-tailed).
** $p < 0.001$ (2-tailed).

changes in anger and sadness were not significantly related to changes in computer skills (Table 8).

Correlation among emotion constructs and computer use constructs. There was a strong significant relationship among all emotion constructs and computer use prior to the start of the program (Table 6). Happiness, anxiety, and anger showed the highest correlations with all four use constructs. Negative emotions (anxiety, anger, and sadness) were negatively correlated with use, whereas the one positive emotion, happiness, showed a positive correlation (see Table 9).

Higher levels of positive or happy emotions ($r = 0.23$; $p < 0.005$) and lower levels of angry emotions ($r = -0.17$; $p < 0.005$) were significantly correlated with teacher based use of computers by preservice candidates during their field placements. Higher levels of happiness ($r = 0.22$; $p < 0.05$) and lower levels of anger ($r = -0.25$; $p < 0.01$), sadness ($r = -0.24$; $p < 0.05$), and anxiety ($r = -0.18$; $p < 0.05$) were significantly correlated with the use of student-based computer activities by preservice teachers during their field placements.

Table 8
Correlation among change in emotion constructs and change in computer knowledge

	Angry	Anxious	Happiness	Sadness
Operating system	−0.17*	−0.29***	0.26**	−0.07
Communication	−0.16	−0.27**	0.30***	−0.12
World wide web	−0.21*	−0.26**	0.30***	−0.11
Word processing	−0.12	−0.24*	0.26**	−0.07
Spreadsheets	−0.07	−0.18*	0.17*	−0.01
Database	−0.03	−0.24**	0.21*	−0.07
Graphics	−0.13	−0.18*	0.18*	−0.06
Presentations	−0.08	−0.04	0.27**	−0.01
Web page design	−0.09	−0.08	0.10	0.03
Total ability diff.	−0.14	−0.26**	0.28***	−0.07*

* $p < 0.05$ (2-tailed).
** $p < 0.005$ (2-tailed).
*** $p < 0.001$ (2-tailed).

Table 9
Correlations among emotion constructs and use of computers

	Angry	Anxious	Happiness	Sadness
Basic use	−0.18*	−0.32***	0.33***	−0.30***
Advanced use	−0.29**	−0.38***	0.42***	−0.31***
Collaborative use	−0.15**	−0.26***	0.33***	−0.29***
Social use	−0.07	−0.25***	0.21**	−0.19*
Total use	−0.24***	−0.38***	0.42***	−0.34*

* $p < 0.05$ (2-tailed).
** $p < 0.005$ (2-tailed).
*** $p < 0.001$ (2-tailed).

Table 10
Correlation among change in emotion constructs and change in university use of computers

	Angry	Anxious	Happiness	Sadness
Basic use	−0.03	−0.12	0.27**	−0.08
Advanced use	−0.06	−0.16	0.28**	−0.05
Collaborative use	−0.12	−0.18*	0.07	−0.04
Social use	−0.07	−0.06	0.08	−0.23**
Total use	−0.10	−0.18*	0.23**	−0.12

* $p < 0.05$ (2-tailed).
** $p < 0.01$ (2-tailed).

Correlation among change in emotion and change computer use. Increases in basic and advanced skills were significantly correlated with happiness expressed while learning (Table 10).

7. Discussion

7.1. Reliability

The reliability of the emotion subscales in the CES was acceptable (Kline, 1999; Nunnally, 1978), hovering around 0.70. That said, it would be advisable to refine and possibly add items, particularly for the sadness scale, which had the lowest reliability estimate. There was overlap among several of the emotion descriptors (e.g., frustrated and dispirited) in the principle component analysis, so the addition of clearer and more items might improve reliability. Previous researchers have had considerable difficulty defining emotions (e.g., Arnold, 1960; Ekman et al., 1972; Izard, 1969; James, 1884; Oatley & Johnson-Laird, 1987; Plutchik, 1980; Tomkins, 1962), so the variability and slight inconsistencies observed in this study should come as no surprise.

7.2. Face validity

The design of the scale developed in this study was based on an extensive review of the literature focussing on the definition of emotions (Arnold, 1960; Ekman et al., 1972; Izard, 1969; James, 1884; Oatley & Johnson-Laird, 1987; Plutchik, 1980; Tomkins, 1962) as well was the selection of a subset of 590 emotional words categorized by Oatley and Johnson-Laird (1987). The selection of appropriate emotional words for the appropriate emotional categories was done by two raters where 100% agreement was achieved. With the exception of two items (frustration and dispirited), the descriptors appeared to fall within the categories anticipated by the raters and revealed in the principal component analysis. However, moderate reliability estimates and slight deviations in the factor analysis indicate that there is room to improve the face validity of the scale.

It is important to note that the 590 emotional words offered by Oatley and Johnson-Laird (1987) cover a broad range of expression, whereas the typical emotions experienced while learning new software may be narrower. For example, it might be unusual to feel extreme emotions such as rage, terror, love, or elation while learning with computers. "Learning emotions" may be less intense, however one does not want to preclude the existence of more passionate affect. In this study, for example, the use of the word "dispirited" may have been confusing or too intense.

One suggestion might be to do qualitative interviews with subjects to determine if the descriptors suggested by Oatley and Johnson-Laird (1987) actually represented the intended constructs. Another check for face validity might be to observe subjects learning software to: (a) see the range of emotions experienced while learning and (b) see if self-reported emotions are consistent with actual behaviour.

7.3. Construct validity

The principal components analysis revealed four distinct emotions that were consistent with the theoretical framework proposed by previous researchers (Arnold, 1960; Ekman et al., 1972; Izard, 1969; James, 1884; Oatley & Johnson-Laird, 1987; Plutchik, 1980; Tomkins, 1962). In addition, correlations among emotions were consistently significant, but not too high, indicating that the four emotions are related but distinct. Two emotional words loaded on two factors: frustrated and dispirited. The suggestions for improving face validity by using a pilot study are equally relevant to construct validity. Making sure that there are adequate and clear descriptors is the next step in refining the CES. Overall, the construct validity is acceptable given that this is a first attempt to look at more than one emotion with respect to computer related behaviour.

7.4. Convergent validity

Six components of computer attitude were measured along with four emotions. Three of the components, positive affective attitude, negative affective attitude, and self-efficacy, would be expected to correlate significantly and highly with emotions. These expectations were confirmed by the results of this study. Positive emotion (happiness) correlated positively with positive affective and self-efficacy (confidence) and negatively with negative affect. Negative emotions (anger, anxiety, sadness), showed the reverse pattern. On the other hand, correlations among emotions and the other attitude components (cognitive and behavioural attitudes) were weak or not significant. It appears that emotion constructs as measured by the CES converged on the anticipated affective attitude constructs.

7.5. Predictive validity

Several predictions could be made about the relationship among emotions, computer knowledge, and use in this study. First, one would expect that positive emotions would increase and negative emotions would decrease as a result of the 8-month integrated, computer laptop program. As students used laptops more, it is reasonable to assume they would become more comfortable learning new software. Indeed, anxiety and anger levels decreased significantly, however happiness and sadness did not change. This prediction, then, was partially supported.

A second predication was that emotions should be related to computer knowledge. Students who feel happy about learning software probably learn more whereas students who feel anxiety, anger, or sadness may experience more challenges and barriers to learning. This prediction was confirmed – all four emotions were significantly correlated with all nine computer knowledge constructs at the beginning of the program.

A third predication was that increases in happiness and decreases in negative emotions would be significantly correlated with gains in computer knowledge. In other words, subjects who become more comfortable learning new software probably gained more knowledge in the 8-month program. This prediction was supported by the results where changes in two of the four emotions (anxiety and happiness) correlated significantly with changes in computer knowledge.

A fourth prediction was that emotions would be significantly related to use of computers. Subjects who are emotionally comfortable learning new software would be expected to use computers more. This prediction was supported by significant correlations among all four emotions and all four university use constructs with few exceptions.

A fifth prediction was that emotions would be correlated with use of computers in the field as a teacher support tool and as a student tool. This prediction was supported by significant correlations among: (a) happiness and anger with teacher-based use of computers and (b) happiness, anger, anxiety and sadness with student-based use of computers.

Finally, it was predicted that changes in emotions would be correlated with changes in use of computers. Increased happiness and decreased negative emotions should translate into more frequent use of computers. Some support for this prediction was observed, however, overall, changes in emotions did not translate into changes in university use of computers. One explanation for this inconsistency might be the limited control students had over computer use. At the university, students have little choice over whether they used software – software use was integrated into most courses.

7.6. Implications for education

Since this a formative study, it would not be prudent to make any strident conclusions about the role of emotions in learning with computers. Several comments, though, however tentative, are worth noting.

First, exposing preservice teachers to an integrated laptop program, helped to significantly reduce reported anxiety and anger levels in just 8 months. These changes corresponded with increases in computer skills and use at the university and in the field. While there are no comparison groups, ubiquitous access to computing appears to play a significant role in improving the emotional environment required to learn with computers.

Second, it is worth considering the full range emotions a new user feels while learning a new software package, not just anxiety levels. New users may experience emotions in private or may not show them externally, but clearly anger, happiness, and sadness are also present and important. Developing strategies to reduce excessively negative emotions or to promote curiosity and excitement may be important with respect to promoting use of computers at the university and in the field placements.

Third, emotions toward computers can be changed – they are not necessarily fixed, innate, pre-ordained, or inevitable. With a steady infusion of integrated computer use, more positive emotional responses can lead to increased use of computers.

7.7. Caveats

While the results of this study suggest that the Computer Emotion Scale has moderate reliability and good validity, they should be treated with caution for the following reasons. First, self-report measures were used, therefore the survey responses need to be validated, perhaps by checking actual emotions expressed while learning a new software package. Second, subjects were asked, "In general, when I am learning how to use a new software package, I feel". While this prompt was intended to gather an overall impression of emotions experienced, it is reasonable to speculate that emotions expressed while learning may be largely dependent on the software being learned. Easy to use software might bring about a narrow range and limited expression of emotions, while more challenging software might elicit more intense emotions. Finally, the sample consisted of relatively advanced users, at least in terms of years of computer experience. A more diverse population with a wider range of computer experience is needed to be more confident in the generalizability of the scale.

7.8. Future research

It is clear from the results in this study that broadening the range of emotions examined with respect to educational technology is useful and meaningful. Predictive validity analysis revealed that all four emotions constructs were significantly related to computer knowledge and use. However, there are several suggestions for future research that would help build on the results obtained in this paper, including:

1. expanding the number of emotional descriptors in Appendix A, through qualitative interviews;
2. validating descriptors through an interview process;
3. observing users while they are learning a new software package and interviewing them about the emotions they felt; and
4. exploring strategies that might help to promote positive emotion and reduce negative emotions

7.9. Summary

The purpose of this study was to develop a scale to measure emotions related to learning new computer software. Four emotions (anger, anxiety, happiness, and sadness) were evaluated based on a detailed review of the research. Internal reliability estimates were acceptable but on the low side. Construct validity was confirmed by an exploratory factor analysis. Convergent validity was supported by strong correlations among emotions and affective attitude, but not cognitive and behavioural attitudes. Finally, predictive validity was corroborated by consistent and significant correlations among emotion, computer knowledge and use.

Appendix A

In general, when I am learning how to use a new software package, I feel

	None of the time	Some of the time	Most of the time	All of the time
1. Satisfied[a]	0	1	2	3
2. Disheartened[b]	0	1	2	3
3. Anxious[c]	0	1	2	3
4. Irritable[d]	0	1	2	3
5. Excited[a]	0	1	2	3
6. Dispirited[b]	0	1	2	3
7. Insecure[c]	0	1	2	3
8. Frustrated[d]	0	1	2	3
9. Curious[a]	0	1	2	3
10. Helpless[c]	0	1	2	3
11. Nervous[c]	0	1	2	3
12. Angry[d]	0	1	2	3

[a] Happiness construct.
[b] Sadness construct.
[c] Anxiety construct.
[d] Anger construct.

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