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Affective Learning in Online Multimedia and Lecture Versions of an Introductory Computing Course

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This study evaluated students' affective learning in an introductory computing course that was taught in Hong Kong once in a lecture format and twice in a rich interactive multimedia online format to 414 college students in all. A simplified experience sampling method was used to assess affective learning at the midterm and end of each course in terms of intrinsic engagement (positive affect, perceived challenges, perceived skills in course activities), extrinsic engagement (performance expectations, performance goals, performance self-efficacy), and negative affect in course activities. Controlling for students' computing background and pre-enrollment academic ability, multivariate analysis of covariance indicated that, compared to lectures, e-learning modules fostered more intrinsic engagement, comparable extrinsic engagement, and more negative affect. Findings suggest directions for developing online courses that optimise both cognitive learning and affective learning.

An increasing number of universities internationally are experimenting with online learning. Online courses utilise the World Wide Web as a platform to deliver course materials as Web pages that contain text, hyperlinks, graphics, animations, audios, videos, games, and quizzes. Online courses also utilise email and discussion forums to enable student–teacher and student–student communication. Some online courses conform to a full distance-education model, in which classroom communications are replaced entirely with computer-mediated communications, whereas others conform to a hybrid model, in which students attend some lectures, seminars, and/or laboratory sessions in campus where they can interact face-to-face with their teachers and peers.

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Researchers in the field of online education are increasingly interested in evaluating the effectiveness of online courses. The comparisons between online courses and their lecture-based counterparts have so far produced encouraging results: students' performance in the online courses was generally comparable (e.g., Collins, 2000; Dennis, 2003; Johnson, Aragon, Shaik, & Palma-Rivas, 2000; Parker & Gemino, 2001) and superior in some cases (e.g., Allen et al., 2004; Kekkonen-Moneta & Moneta, 2002; Koskela, Kiltti, Vilpola, & Tervonen, 2005). This preliminary evidence suggests that the combination of Web technologies and Internet communications fosters positive learning outcomes and is a valid alternative to lecture-based teaching.

However, researchers in the field of online education have not yet sufficiently investigated an important component of the learning experience: students' emotional processes while learning, or "affective learning" (e.g., Frymier, 1994; Rodriguez, Plax, & Kearney, 1996). LaRose and Whitten (2000) pointed out that the motivational strategies that teachers utilise in the classroom, such as projecting enthusiasm for the subject matter, are difficult to implement in the virtual classroom. Referring to the motivational effects of the learning experience on persistence in academic programs, they argued that if the virtual classroom fails to foster students' engagement, "learner motivation could be the downfall of Web instruction" (p. 320).

Psychological theories of motivation emphasise that high levels of cognitive learning are not an unequivocal marker of successful learning. Self-determination theory (Deci & Ryan, 1985; Ryan & Deci, 2000) states that learners achieve competence either through exploratory behaviours that are experienced as freely chosen and, thus, are intrinsically motivated, or through instrumental behaviours that are experienced as necessary, or even forced, in order to achieve an end and, thus, are extrinsically motivated. Heyman and Dweck (1992) added that the first path corresponds to the pursuit of mastery goals, focused on the development of competence, whereas the second path corresponds to the pursuit of performance goals, focused on the evaluation of competence. These theories state that while both paths can be effective for acquiring competence, only intrinsic-mastery engagement unequivocally fosters resilience to failure, positive overall psychosocial development, and self-motivated lifelong learning. Therefore, it is important to extend our evaluation of the effectiveness of online courses from performance, or cognitive learning, to the emotional processes undertaken by students while learning, or affective learning.

Instructional Immediacy as the Root of Affective Learning

Research into teaching and learning has regarded the dynamic interaction between the person and the activity as the key construct for understanding a person's affective experience while learning. In the educational literature, the dynamic person–activity interaction has been called "immediacy" (Andersen, 1979; Mehrabian, 1981). The term was originally used to refer to teacher immediacy, involving face-to-face

interactions between teacher and student, and student immediacy, involving face-to-face interactions between students. LaRose and Whitten (2000) have extended the construct to other learning contexts and renamed it "instructional immediacy". Instructional immediacy includes teacher and student immediacy, involving interactions via email and discussion forums, and "computer immediacy", involving interactions between computer and student. LaRose and Whitten's taxonomy of instructional immediacy helps to clarify the nature of the comparison between online and lecture courses.

Teacher immediacy in the real classroom includes verbal behaviours, such as answering questions and praising students, and nonverbal behaviours, such as smiling and gesturing, that foster students' liking of and feelings of closeness to the teacher (Andersen, 1979; Mehrabian, 1981). These behaviours are thought to convey informational feedback and incentive for studying. Teacher immediacy can be simulated in the virtual classroom through interactive audio and video, email, and discussion forums. However, LaRose and Whitten (2000) pointed out that email and discussion forums provide delayed and fragmented feedback, and cannot convey nonverbal behaviour; interactive audio and video provide both verbal and nonverbal cues, but the quality of today's live interactive video is so poor that nonverbal behaviour is hardly visible. Therefore, LaRose and Whitten concluded that the teacher immediacy of the virtual classroom is less effective than that of the real classroom.

Student immediacy in the real classroom includes supportive peer interactions, forming relationships, playing games, competing, and simulating problems and exams (Brophy, 1987). These behaviours are thought to promote closeness between students, and to provide status and other social incentives. LaRose and Whitten (2000) argued that the lack of nonverbal cues in the virtual classroom is at the same time an obstacle and an opportunity. For example, the anonymity of the virtual classroom decreases the likelihood of forming new relationships (Hiltz & Wellman, 1997) but helps to overcome the fear of evaluation when expressing one's own ideas (Sproull & Kiesler, 1991). Therefore, LaRose and Whitten concluded that the student immediacy of the virtual classroom could be as effective as that of the real classroom.

Computer immediacy includes the provision of personalised messages, performance feedback, and study and practice material in the form of text, graphics, audio, and video in response to student requests and characteristics. McFarland (1996) argued that the effectiveness of computer immediacy resides in multimedia, according to the principle that "anything words can do, words with sounds and pictures can do better" (Kalmbach, 1994, p. 29), and that multimedia are particularly beneficial in the affective domains. Bork (2001) argued that interactive multimedia is effective because it allows continuous two-way communication with the learner, dynamic assessment of the learner's strengths and weaknesses, and dynamic tailoring of the displayed information and problems to fit the learner's profile and competence. Preliminary support for McFarland and Bork's claims comes from studies showing that the proper use of interactive multimedia in college education enhances problem-solving skills (Frear & Hirschbuhl, 1999) and attitudes toward learning

(Kettanurak, Ramamurthy, & Haseman, 2001), and fosters higher-order learning outcomes (Herrington & Oliver, 1999; Kekkonen-Moneta & Moneta, 2002).

LaRose and Whitten's (2000) taxonomy and evaluation of instructional immediacy indicate that the effectiveness of online courses relative to lecture courses depends on the extent to which the computer immediacy of the virtual classroom compensates for the inferior teacher immediacy of the virtual classroom. However, two problems complicate the evaluation of the relative effectiveness of online and lecture courses. First, Martin and Taylor (1997) pointed out that students embark on a learning curve when adapting to the challenges of new educational technology; even carefully designed computer immediacy may require learner practice to become fully effective. Therefore, comparison studies would benefit from gathering repeated measures of affective learning from beginning to end of a course. Second, affective learning is a multifaceted construct; computer immediacy and teacher immediacy may differentially influence different facets of affective learning. Therefore, comparison studies need to assess all the relevant facets of affective learning.

Facets and Models of Affective Learning

Paralleling research into teaching and learning, psychological theories of motivation have also emphasised the importance of the dynamic person–activity interaction to affective learning. Three psychological models identify key facets of affective learning and explain the processes through which immediacy influences them. Bandura and Cervone's (1983) model of effortful performance represents instructional immediacy as performance feedback. Performance feedback positively influences subsequent effort, particularly if the learner has performance goals. Effort is also positively influenced by the learner's self-efficacy beliefs, particularly when a learner is dissatisfied with his or her prior performance. In turn, self-efficacy increases or decreases over the course of the learning process as a function of the valence of performance feedback. Therefore, this model identifies two markers of the effectiveness of instructional immediacy: high performance goals and self-efficacy.

Carver and Scheier's (1981) model of the self-regulation of behaviour states that people keep trying to achieve a goal only if their expectations of eventual success are sufficiently positive. Furthermore, if people perceive that their progress toward the goal is sufficiently rapid, they will experience positive affect (i.e., they will feel enthusiastic, interested, strong, or active); otherwise, they will experience negative affect (i.e., they will feel anxious, upset, ashamed, or guilty) (Carver & Scheier, 1990). This model represents instructional immediacy as performance feedback, provision of appropriate information for achieving performance goals, and appropriate task complexity. If any of these immediacy components is deficient, students will reduce their expectations, goals, actual progress, and positive affect, and increase their negative affect. Therefore, this model identifies four markers of the effectiveness of instructional immediacy: high performance expectations, performance goals, positive affect, and low negative affect.

Csikszentmihalyi's (1990) flow model states that positive affect is a function of the skills that the person feels he/she has in relation to the activity and the perceived challenges of the activity. When challenges and skills are high and in relative balance with each other, the person tends to experience flow in consciousness, and positive affect is higher than in any other condition. Three characteristics of the activity make flow more likely (Csikszentmihalyi, 1996): clear goals every step of the way, timely performance feedback, and optimal task complexity. Instructional immediacy is represented as the provision of these conditions. Therefore, this model identifies three markers of the effectiveness of instructional immediacy: high perceived challenges, perceived skills, and positive affect.

The facets of affective learning identified by these models can be conceptually grouped into three broad dimensions. Deci and Ryan (1985) depict Csikszentmihalyi's (1990, 1996) flow model as the prototype of intrinsically motivated behaviour to satisfy the basic organismic need of competence. Therefore, perceived challenges, perceived skills, and positive affect can be regarded as contributing to a dimension of intrinsic and mastery-oriented engagement. Bandura and Cervone's (1983) model of effortful performance and Carver and Scheier's (1981, 1990) model of the self-regulation of behaviour emphasise the motivational implications of performance evaluation, which are mainly rooted in incentives external to the task. Therefore, performance expectations, goals, and self-efficacy can be regarded as contributing to a dimension of extrinsic and performance-oriented engagement. Finally, although sensitive to failures in achieving intrinsic or extrinsic goals, negative affect has a connotation that goes far beyond the intrinsic–extrinsic dichotomy. Therefore, negative affect can be regarded as a third independent dimension of affective learning.

Goals of this Study

This study examines an undergraduate introduction to computing course that was taught in Hong Kong first in a large lecture format and then in a richly interactive multimedia online format. These courses were previously compared with respect to cognitive learning and end-of-semester course evaluations (Kekkonen-Moneta & Moneta, 2002). The goal of this study was to evaluate the relative effectiveness of the online and lecture versions of the course in fostering students' affective learning.

In this study, affective learning was conceptualised as a third level of analysis, in addition to the levels of cognitive learning and end-of-semester course ratings. The comparison between course formats was conceptualised as a test of the effectiveness of the immediacy provided by rich interactive multimedia e-learning modules versus the immediacy provided by lectures and, more specifically, as a test of McFarland's (1996) claim that multimedia is particularly beneficial in the affective domains. The comparison was performed on the facets of affective learning representing intrinsic engagement, extrinsic engagement, and negative affect. These facets were assessed in the middle and at the end of each course. A longitudinal study design allowed a comparison between courses over time, and examined whether the students in the

online courses experienced a learning curve in adjusting to the novelty of the course format.

Method

The Course

The data for this study were collected from students attending the undergraduate course COMP101 Computing Fundamentals, taught by the second author of this paper at the Hong Kong University of Science and Technology. The course aimed to enhance students' computer literacy and practical computing skills; it was compulsory to first-year students majoring in biology and chemistry, and elective to others. The course was offered in lecture format in spring 2000, and in online format in fall 2000 and spring 2001. There was only one offering of the course per semester. As such, the students who attended the courses investigated in this study had no choice of instructor or course format.

The lecture version of the course. In the large lecture format, the course ran for 14 weeks and there were two 50-minute lectures and one 1-hour 50-minute laboratory session every week. The lectures presented computer literacy materials and computing skill materials with step-by-step illustrations for using different software. These materials were delivered with the aid of lecture notes prepared in PowerPoint. The lecture notes were edited into full but compact sentence structure format. Students could download the lecture notes from the Web. In the laboratory sessions, students were assigned to groups of about 35 and completed practical computing exercises under the supervision of a graduate teaching assistant. Students could use email to communicate with the lecturer and teaching assistants.

The online version of the course. In the online format, the course ran for 15 weeks and started with two 1-hour 50-minute lectures to orient students to the university's computing environment and to the new self-regulated e-learning mode. Then, the weekly lectures were entirely replaced with Web-based e-learning modules implemented via the LearningSpace platform. All other course elements (laboratory sessions and communication by email) were kept the same as in the lecture format. Face-to-face laboratory sessions were retained in the online courses in order to monitor students' reactions to the novel learning experience. Students could access the e-learning modules via Internet at any time, and were required to study specific areas prior to attending the laboratory sessions. The volume of communication by email turned out to be comparable in the lecture and online courses.

The e-learning modules integrated the lecture notes, examples, and demonstrations that the lecturer had presented in the lecture course. The computer literacy materials were organised into 13 concept modules with two subsection levels, and the computing skill materials were organised into 12 skill modules. The modules

were highly interactive, and contained 46 hyperlinks, 247 "chunks" of materials implemented using Flash, 227 illustrated slides, 171 still and 22 interactive graphics, 9 narrated and 12 non-narrated animations, 43 narrated and 38 non-narrated screen capture recordings (screencams), 13 videos, 7 interactive exercises (games), 125 self-assessment questions, and 12 downloadable zip files containing all software demo files. The modules allowed both sequential and random access navigation.

The Students

The total enrollment across the three courses was 414 students. Of these, 105 attended the lecture course, 180 the first online course, and 129 the second online course; 369 (89%) were first-year students, 19 (5%) were second-year students, and the remaining 26 (6%) were third-year students; 324 (78%) were biology students, 17 (4%) were chemistry students, and the remaining 73 (18%) were students in other disciplines.

Measurement of Affective Learning

Students' affective learning was measured using a simplified experience sampling method (ESM; Csikszentmihalyi & Larson, 1987; Csikszentmihalyi, Larson, & Prescott, 1977). The ESM involves administering a questionnaire at random times during everyday life activities such as attending classes, interacting with friends, or commuting. The questionnaire asks participants to specify the activity they were engaged in and its context, and to rate their current subjective experience on various Likert-type scales. In this study, an ESM questionnaire was administered to the students on two occasions only, one week prior to the midterm and one week prior to the final, during laboratory sessions. The variables and items of the ESM questionnaire employed in this study are shown in the appendix.

The ESM was completed by 360 (87%) students at the midterm administration and 362 (87%) at the final administration; 389 (94%) students completed the ESM at least in one of the two administrations. There was complete information on all the affective learning variables for 348 (84%) students in the first administration and 350 (85%) in the second administration.

Positive and negative affect. Affect was assessed by six of the 20 items of the Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988). Students were asked: "Please read the following adjectives in detail and think if you have those feelings when you are working on COMP101 course materials." We computed positive affect scores by averaging the items "Interested", "Excited", and "Strong", and negative affect scores by averaging the items "Upset", "Ashamed", and "Nervous", all scored on a scale ranging from 1 ("None") to 5 ("Very much"). The alpha reliability coefficients (midterm, final) were (.71, .82) for positive affect and (.79, .81) for negative affect.

Performance expectations and goals. Expectations are typically measured by asking respondents to anticipate rewards or punishments for their own behaviour in specific situations, whereas goals are typically measured by inquiring how respondents direct their own behaviour in specific contexts over extended periods of times (e.g., Bandura, 1986). In this study, performance expectations and goals were assessed by the items "What grade do you expect to get in this course?" and "What grade are you trying to get in this course?" respectively. We converted grades (F, D, C-, C, C+, B-, B, B+, A-, A, A+) to a numerical scale ranging from 0 (F) to 4.33 (A+).

Performance self-efficacy. Self-efficacy beliefs are typically measured by asking respondents to gauge how confident they are that they can do a specific activity or exercise a specific function while coping with a difficult task (e.g., Bandura, 1986). In this study, performance self-efficacy was assessed by the item "How confident are you that you will be able to handle the difficulties in the upcoming midterm/final exam?", scored on a scale ranging from 1 ("Not at all") to 9 ("Very").

Perceived challenges and skills. Challenges and skills were assessed by four items each. Students were asked: "Indicate how you feel about COMP101 activities (studying, attending lectures/navigating through the e-learning modules, & labs)". We computed scores for challenges by averaging the items "Challenges of these activities", "The effort you put in these activities", "The pace of these activities", and "Are these activities important to you?", and scores for skills by averaging the items "Your skills in these activities", "Do you succeed at what you are doing?", "Are you satisfied with how you are doing?", and "How confident do you feel in doing these activities?", all scored on a scale ranging from 1 ("Low") to 9 ("High"). The alpha reliability coefficients (midterm, final) were (.80, .81) for challenges and (.82, .86) for skills.

Construct validity of the scores. All the items used in this study had been previously administered to other college student samples at the Chinese University of Hong Kong in 1997–2001.

All the items designed to measure intrinsic engagement and negative affect were used in a standard ESM study on a sample of 289 students who provided a total of 17,577 random-time snapshots of experience in everyday life contexts (Moneta, 2003, 2004; Moneta & Wong, 2001). The psychometric properties of the ESM item scores were investigated using exploratory factor analysis. Moneta (2003) first fitted a single-factor principal component model to the constituent items of each of the four ESM variables separately (positive affect, challenges, skills, and negative affect). For all four variables a single factor explained more than 50% of the total variance, the factor loadings of the constituent items were all greater than .55, and Cronbach's alpha coefficient was greater than .7. Then, scale scores were computed by averaging the constituent items of each of the four variables, and the four scale scores were

factor analysed using principal components with varimax rotation. There were two eigenvalues greater than 1 and the scree plot indicated a need to extract two factors, which explained 69% of the variance. The three scales (positive affect, challenges, and skills) designed to measure intrinsic engagement loaded on one factor, whereas negative affect constituted the other factor. Therefore, as hypothesised in this study, intrinsic engagement and negative affect appear to be independent dimensions of students' daily experience.

The items designed to measure extrinsic engagement were derived together with other items from a student focus group, and were selected from the item pool in a pilot study as being the most salient to students. However, because the extrinsic engagement items cannot be administered repeatedly in a standard ESM administration, previous studies could not determine whether extrinsic engagement stands up as a third independent dimension of student experience as hypothesised in this study.

Measurement of Performance

We used overall course grade to assess the concurrent/predictive validity of the affective learning variables. The assessment components and their weights, in parentheses, were: midterm exam (30%), final exam (30%), six in-class quizzes (10%), 12 labs (attend and finish; 10%), and three homework assignments (20%). In each course, marks were converted to grades (F to A+) according to a fixed distribution. We converted grades to a numerical scale ranging from 0 (F) to 4.33 (A+).

Measurement of Control Variables

Hong Kong Advanced Level Examination. Shortly before the midterm exam, students were asked to report their attained grades in the Hong Kong Advanced Level Examination (HKALE), the academic ability test that the Joint University Programmes Admission System (JUPAS) uses to assign students to the eight University Grants Committee-funded universities in Hong Kong. The HKALE assesses academic ability in English and various academic subjects such as mathematics and physics. The grades were given the following numerical values: U = 1, F = 2, E = 3, D = 4, C = 5, B = 6, and A = 7. We used as control variables the HKALE English score and the HKALE academic score, computed as the mean of all the tests taken by the student except for the English test.

Computing background. Students' computing experience was assessed at the beginning of the course with a paper-and-pen checklist asking the following 10 yes/no questions: "I have a PC"; "I know how to copy files to a floppy disk using Windows 95/98/2000"; "I know how to log into a PC using a campus computer"; "I know how to read/send email messages"; "I know how to use Netscape or Internet Explorer"; "I have created my own Web page"; "I know how to edit documents

using a word processing program (for example, Microsoft Word)"; "I know how to use spreadsheet/statistical software (for example, Microsoft Excel)"; "I know how to prepare presentations using a presentation graphics program (for example, Microsoft PowerPoint)"; and "I have written computer programs (for example, in Pascal or in C)". "Yes" answers were scored as 1 and "No" answers as 0, and a student's computing background score was obtained by summing up his/her answers.

Data Analysis

Dimensions of affective learning. We first investigated the relationships between students' affective learning variables, employing exploratory factor analysis. We extracted orthogonal factors by the method of principal components and rotated them by the varimax method.

Course differences and time trends of affective learning. We then compared the mean scores of each affective learning variable across courses and times of measurement, employing repeated measures analysis of covariance. The dependent variable was affective learning, the between-subjects factor was course (lecture, first online, second online), the within-subjects factor was time (midterm, final), and the covariates were HKALE English, HKALE academic, and computing background. Separate models were fitted on intrinsic engagement, extrinsic engagement, and negative affect. Intrinsic engagement was analysed using multivariate analysis of covariance (MANCOVA), in which positive affect, challenges, and skills were the three dependent variables. Likewise, extrinsic engagement was analysed using MANCOVA, in which performance expectations, performance goals, and performance self-efficacy were the three dependent variables. Negative affect was analysed using univariate analysis of covariance (ANCOVA).

The MANCOVA and ANCOVA models allowed the testing of mean differences in affective learning between courses. For each of the three models, we tested the main effect of course and four contrasts: the Helmert contrast of both online courses in combination versus lecture course, and the simple contrasts of first online course versus lecture course, second online course versus lecture course, and first online course versus second online course. These analyses tested the relative effectiveness of the compared courses in fostering affective learning averaged through midterm and final measurements.

The models also allowed the testing of mean differences in affective learning within courses. For each of the three models, we tested the main effect of time that, if significant, would imply that affective learning changes from midterm to final in all courses, and the interaction course x time that, if significant, would imply that the change in affective learning from midterm to final differs between courses. These analyses clarified whether the novelty of the online course format required an adjustment period, and whether adjustment problems were solved by the end of the semester.

Results

Data Description

Table 1 shows the correlations between the affective learning variables measured in the lecture and online courses one week before the midterm and one week before the final, and the test–retest correlations of the same variables. The correlations between different variables were similar in the midterm and final, indicating that the relative meaning of the variables is stable over time. The test–retest correlations were all moderately positive, indicating that the variables are relatively stable over time but still responsive enough to changes in the courses to require a longitudinal analysis.

Table 1 also shows the correlations of the affective learning variables with course grade. With the exception of the midterm measure of challenges, all the intrinsic engagement variables had weak positive correlations with course grade. All the extrinsic engagement variables had moderate positive correlations with course grade. Negative affect had a weak negative correlation with course grade. In general, the correlations with course grade were stronger for the final measures than for the midterm measures. These findings are consistent with a two-way relationship between affective learning and academic performance: affective learning fosters performance and, in turn, the performance feedback that students gather throughout the semester influences affective learning.

Table 1 also shows the correlations between the affective learning variables and the control variables. The HKALE English score had a weak positive correlation with performance goals in the final and a weak negative correlation with negative affect in the final. The HKALE academic score had weak negative correlations with performance self-efficacy in the midterm and final. The computing background score had weak positive correlations with all the extrinsic engagement variables and skills at both points in time, and a weak negative correlation with negative affect in the midterm. Moreover, there were differences in the mean scores of the control variables across the three courses (results not shown). Therefore, the control variables are potential confounders of differences in affective learning between courses, and need to be statistically controlled for.

Dimensions of Affective Learning

Because the correlations between different affective learning variables were stable, we performed the factor analysis on the average scores attained by participants in the two administrations. Two eigenvalues were greater than 1, but the scree plot indicated that three factors were needed. The three-factor solution accounted for 78.6% of the variance.

Table 2 shows the loadings of the affective learning variables. Factor I included positive affect, challenges, and skills and, thus, can be labelled intrinsic engagement. Factor II included performance expectations, goals, and self-efficacy and, thus, can be labelled extrinsic engagement. Factor III included only negative affect. The loadings within each factor were strong. However, skills had secondary loadings on

Table 1. Correlations between students' affective learning variables assessed one week before the midterm (lower diagonal elements) and one week before the final exam (upper diagonal elements), test–retest correlations (diagonal elements in parentheses), and correlations between affective variables, course grade, and control variables

	Final measure							One point in time measure			
Variable	1	2	3	4	5	6	7	8	9	10	11
1. Positive affect	(.56**)	.53**	.61**	.11*	.16**	.36**	.01	.13*	−.04	−.03	.07
2. Perceived challenges	.47**	(.57**)	.43**	.00	−.13*	.08	.12*	.06	.07	.04	−.02
3. Perceived skills	.45**	.35**	(.55**)	.26**	.31**	.51**	−.27	.29**	.02	−.06	.37**
4. Performance expectations	.13*	−.05	.41**	(.57**)	.70**	.40**	−.16**	.31*	−.05	−.04	.20**
5. Performance goals	.10	.01	.40**	.66**	(.53**)	.36**	−.17**	.32**	.04	.02	.26**
6. Performance self-efficacy	.19**	.01	.50**	.51**	.41**	(.45**)	−.28**	.30**	−.08	−.11*	.32**
7. Negative affect	.14**	.14**	−.26**	−.26**	−.18*	−.24**	(.54**)	−.12*	−.06	.00	−.13*
8. Course grade	.22**	.13*	.30**	.49**	.54**	.29**	−.20**	1.00	.19**	.10	.30**
9. HKALE English	−.02	.01	.02	.02	.11*	−.01	−.14*	.19**	1.00	.30**	.07
10. HKALE academic	−.03	−.07	−.04	.03	.08	−.13*	.05	.10	.30**	1.00	−.01
11. Computing background	.09	−.05	.18**	.26**	.25**	.29**	−.05	.30**	.07	−.01	1.00

Note. The data from the lecture course and the two online courses were combined. Range of n across correlation coefficients = 304–360.
*$p < .01$; **$p < .01$.

Table 2. Factor loadings of the three-factor solution of students' affective learning variables: Factor I = intrinsic engagement, Factor II = extrinsic engagement, and Factor III = negative affect

	Factor		
Affective learning variable	I	II	III
Positive affect	.87	.10	.02
Perceived challenges	.82	−.07	.20
Perceived skills	.72	.37	−.39
Performance expectations	.02	.92	−.11
Performance goals	.05	.90	−.05
Performance self-efficacy	.32	.61	−.43
Negative affect	.12	−.12	.93

Note. The data from the lecture course and the two online courses were combined; the analysis used the individual average of each variable assessed one week before the midterm and one week before the final; $n = 389$; factors were extracted using the principal components method, and subdued to varimax rotation; the model accounted for 78.6% of the variance.

Factor II (extrinsic engagement) and Factor III (negative affect), whereas performance self-efficacy had secondary loadings on Factor I (intrinsic engagement) and Factor III (negative affect). These findings confirm the expected factor structure but reveal that skills and performance self-efficacy have composite meanings and are somewhat intertwined.

Course Differences and Time Trends in Affective Learning

Table 3 shows the mean scores and standard deviations of the affective learning variables measured in the lecture and online courses one week before the midterm and one week before the final, and the probability levels of various tests of mean differences between and within courses provided by the MANCOVA (intrinsic engagement and extrinsic engagement) and ANCOVA (negative affect) models.

Intrinsic engagement. The pattern of mean values suggests that, compared to the lecture course, the mean score of positive affect in the first online course was comparable in the midterm and lower in the final, whereas in the second online course it was higher in the midterm and final. Moreover, compared to the lecture course, the mean score of challenges in the first online course was higher in the midterm and slightly lower in the final, whereas in the second online course it was markedly higher in the midterm and final. Compared to the lecture course, the mean score of skills was lower in the first online course and higher in the second online course in the midterm and final. Finally, compared to the first online course, the mean scores of all three intrinsic engagement variables in the second online course were higher in the midterm and final.

Table 3. Means and standard deviations (in parentheses) of students' affective learning variables assessed one week before the midterm and one week before the final in the lecture and the online versions of the course, and probability levels of the MANCOVA (intrinsic engagement and extrinsic engagement) and ANCOVA (negative affect) tests of mean differences between and within the courses controlled for students' computing background, HKALE English, and HKALE academic

						Test of mean differences between courses			Test of mean differences within courses		
		Course			Main effect of course	1st + 2nd online vs. lecture	1st online vs. lecture	2nd online vs. lecture	1st online vs. 2nd online	Main effect of time	Interaction of time × course
Affective learning variable	Time	Lecture	1st online course	2nd online course	$p <$	$p <$	$p <$	$p <$	$p <$	$p <$	$p <$
Intrinsic engagement					.001	.019	.239	.001	.001	.015	.380
Positive affect[a]					.001	.086	.356	.001	.001	.530	.270
	Midterm	2.73 (.56)	2.73 (.67)	3.15 (.68)							
	Final	3.02 (.74)	2.85 (.77)	3.40 (.81)							
Perceived challenges[b]					.001	.001	.547	.001	.001	.007	.239
	Midterm	4.93 (1.25)	5.15 (1.24)	6.22 (.96)							
	Final	5.43 (1.27)	5.42 (1.25)	6.33 (1.00)							
Perceived skills[b]					.001	.545	.084	.014	.001	.021	.314
	Midterm	5.27 (1.51)	5.06 (1.23)	5.93 (.96)							
	Final	5.52 (1.30)	5.07 (1.39)	5.99 (.99)							
Extrinsic engagement					.003	.547	.222	.087	.001	.175	.175
Performance expectations[c]					.041	.390	.686	.076	.017	.034	.249
	Midterm	2.93 (.56)	2.99 (.49)	2.87 (.51)							
	Final	2.96 (.61)	2.89 (.63)	2.86 (.54)							
Performance goals[c]					.973	.971	.936	.895	.692	.304	.032
	Midterm	3.14 (.55)	3.20 (.54)	3.29 (.46)							
	Final	3.23 (.52)	3.09 (.53)	3.25 (.48)							

Table 3. *(continued)*

Affective learning variable	Time	Course			Test of mean differences between courses				Test of mean differences within courses		
					Main effect of course	1st + 2nd online vs. lecture	1st online vs. lecture	2nd online vs. lecture	1st online vs. 2nd online	Main effect of time	Interaction of time × course
		Lecture	1st online course	2nd online course	$p <$	$p <$	$p <$	$p <$	$p <$	$p <$	$p <$
Performance self-efficacy[d]					.252	.270	.118	.630	.327	.647	.221
	Midterm	4.73 (1.72)	4.53 (1.59)	4.91 (1.82)							
	Final	5.21 (1.94)	4.48 (1.69)	5.04 (1.71)							
Negative affect[a]					.001	.002	.212	.001	.001	.995	.339
	Midterm	1.72 (.75)	1.94 (.77)	2.37 (.95)							
	Final	2.02 (.72)	2.16 (.91)	2.47 (1.01)							

Note. Range of the scales: (a) 1 ("None") to 5 ("Very much"); (b) 1 ("Low") to 9 ("High"); (c) 0 ("F") to 4.33 ("A+"); and (d) 1 ("Not at all") to 9 ("Very"). After listwise elimination of missing data, the sample sizes were 285 for intrinsic engagement, 277 for extrinsic engagement, and 285 for negative affect.

The multivariate *F* test of the main effect of course was significant, indicating that there are differences in intrinsic engagement between courses. The multivariate contrast between the two online courses in combination and the lecture course was significant, indicating that intrinsic engagement was higher in the online courses. However, the corresponding univariate test was significant for challenges and not significant for positive affect and skills, suggesting that the superiority of the online courses in combination might be confined to the perception of challenges. The multivariate contrast between the first online course and the lecture course was not significant, whereas the contrast between the second online course and the lecture course was significant, suggesting that intrinsic engagement in the second online course was higher than in the lecture course, whereas intrinsic engagement in the first online course might have been the same as in the lecture course. Finally, both the multivariate contrast and all three univariate contrasts between the two online courses were significant, indicating that intrinsic engagement in the second online course was higher than in the first online course.

The pattern of mean values suggests that, in all courses, students had higher mean scores of intrinsic engagement at the final than at the midterm. The multivariate *F* test of the main effect of time was significant. The corresponding univariate test was significant for challenges and skills, and was not significant for positive affect. The multivariate test of the interaction time × course and the corresponding univariate tests were all not significant. These findings indicate that intrinsic engagement grew uniformly across courses, but positive affect might have been uniformly stable across courses.

Extrinsic engagement. Compared to the lecture course, the first online course yielded a higher mean score of performance expectations in the midterm and a lower mean score in the final, whereas the second online course yielded lower mean scores in the midterm and final. Moreover, compared to the lecture course, the first online course yielded lower mean scores of performance self-efficacy in the midterm and final, whereas the second online course yielded a higher mean score in the midterm and a lower mean score in the final. Compared to the lecture course, the first online course yielded lower mean scores of performance self-efficacy in the midterm and final, whereas the second online course yielded a higher mean score in the midterm and a lower mean score in the final. Finally, compared to the first online course, the second online course yielded lower mean scores of performance expectations and higher mean scores of performance goals and performance self-efficacy.

The multivariate *F* test of the main effect of course was significant, indicating that there are differences in extrinsic engagement between courses. However, all the multivariate tests of specific contrasts between the lecture and online courses failed to achieve significance. Therefore, there was no difference in performance expectations between the online courses separately or in combination, on the one hand, and the lecture course on the other hand. However, the multivariate contrast between the two online courses and the univariate contrast of performance expectations were

significant, suggesting that performance expectations in the second online course were lower than in the first online course.

The pattern of mean values suggests that, in all courses, there was no time trend in extrinsic engagement. Neither the multivariate F test of the main effect of time nor the multivariate F test of the interaction time × course was significant, indicating that extrinsic engagement was uniformly stable across courses.

Negative affect. The pattern of mean values suggests that negative affect was higher in the online courses, particularly in the second, than in the lecture course, both in the midterm and in the final.

The univariate F test of the main effect of course was significant, indicating the presence of differences in negative affect between courses. The contrast between the two online courses in combination and the lecture course was significant. The contrast between the first online course and the lecture course was not significant, whereas the contrast between the second online course and the lecture course was significant. Finally, the contrast between the two online courses was significant. In sum, negative affect in the online courses was higher than in the lecture course, and negative affect in the second online course was higher than in the first online course.

The pattern of mean values suggests that, in all courses, students had higher mean scores of negative affect in the final than in the midterm. However, both the main effect of time and the interaction time × course were not significant. Therefore, negative affect was uniformly stable across courses.

Additional Analyses

Three sensitivity analyses were conducted to evaluate the robustness of the findings. First, all the correlation coefficients of the study variables were computed separately for each course and compared across courses. The three correlation matrices were found to be markedly similar (results not shown). Second, we replicated the exploratory factor analysis of the scores of the affective learning variables on the data from each course separately. The differences in factor loadings across courses were so small as to be attributable to the small sample size of each separate analysis (results not shown). Finally, we repeated the MANCOVA and ANCOVA tests excluding the students who took the courses voluntarily. The results were virtually identical to those obtained for all students (results not shown), suggesting that the reason for taking the course was not a relevant factor. In all, these analyses support the robustness of the findings.

Discussion

The present study has three main findings. First, the facets of affective learning have a three-dimensional structure. Second, the lecture and online course formats have different merits in promoting the three facets of students' affective learning. Third,

there were differences in affective learning between the two online courses. These findings shed light on the emotional processes undergone by learners in the traditional and virtual classrooms.

Dimensions of Affective Learning

The scales used to measure the facets of affective learning had satisfactory internal consistency and temporal stability. The facets of affective learning conformed to the expected three-dimensional representation. Positive affect, perceived challenges, and perceived skills contribute to a dimension of intrinsic engagement; performance expectations, performance goals, and performance self-efficacy contribute to a dimension of extrinsic engagement; negative affect stands alone as a dimension of emotional distress in learning.

Perceived skills and performance self-efficacy were also positively associated with each other's dimension and, thus, have a dual intrinsic–extrinsic connotation. Bandura and Cervone (1983) argued that self-efficacy promotes both extrinsic motivation and intrinsic motivation. Therefore, it is likely that both perceived skills and performance self-efficacy tap into the broad construct of self-efficacy: whereas perceived skills capture more the intrinsic side of the construct, performance self-efficacy captures more its extrinsic side. This interpretation is supported by the finding that both perceived skills and performance self-efficacy were negatively associated with negative affect, which is consistent with the basic social cognitive principle that self-efficacy prevents anxiety (e.g., Bandura, 1986).

Differences in Affective Learning between the Online and Lecture Courses

Intrinsic engagement tended to be higher in the online courses than in the lecture course. In terms of Csikszentmihalyi's (1990, 1996) flow model, the computer immediacy of the online courses appears to be more effective than the teacher immediacy of the lecture course in providing students with the basic contextual elements (clear goals every step of the way, timely performance feedback, and optimal task complexity) that foster intrinsic engagement in learning.

There were no differences in extrinsic engagement between the lecture and online courses. In terms of Bandura and Cervone's (1983) model of effortful performance and Carver and Sheier's (1981, 1990) model of self-regulated behaviour, the computer immediacy of the online courses appears to be as effective as the teacher immediacy of the lecture course in providing students with performance feedback, appropriate information for achieving performance goals, and appropriate task complexity.

Negative affect was consistently higher in the online courses than in the lecture course. This finding is open to three complementary interpretations. First, the online students may have had more frustrating incidents with failing technology, such as slow dial-up connections. Second, the online students may have received less emotional support from course-related social interactions. Finally, the online

students may have found it difficult to take more initiative with a self-regulated learning approach; nervousness and shame may have been the consequences of procrastination. In terms of Carver and Sheier's (1981, 1990) model of self-regulated behaviour, all three highlighted factors may have disrupted students' progress toward their learning goals and caused negative affect.

In all, the online and lecture course formats seem to have different merits in influencing students' affective learning. Findings suggest that the immediacy provided by richly interactive multimedia e-learning modules fosters more intrinsic engagement than the immediacy provided by lectures, comparable extrinsic engagement, and more negative affect.

Differences in Affective Learning between the Online Courses

Compared to the first online course, the second online course elicited more intrinsic engagement, lower performance expectations (one of the three facets of extrinsic engagement), and more negative affect. There are two complementary interpretations of these findings.

First, these findings highlight the importance of the matching between instructional type and learner type. Most students in the first online course were first-semester students, whereas most students in the second online course were second-semester students. Therefore, the differences in affective learning between the two online courses might be due to differences in students' maturity.

Second, these findings highlight the importance of the way new instructional technology is justified to students and is perceived by students. The first online course was one of the first large-scale attempts at e-learning with Hong Kong Chinese students; the students might have felt like participants in a tentative experiment. The students of the second online course knew that the online course had already been run successfully, and might have felt like participants in a novel but reliable instructional process. Therefore, the differences in affective learning between the two online courses might be due to differences in students' perception of the reliability of the online instructional format.

In all, it would appear that students' maturity and students' perception of the reliability of the instructional format are individual differences that moderate affective learning when using richly interactive multimedia e-learning modules. Maturity and reliability appear to have both positive (i.e., more intrinsic engagement) and negative (i.e., more negative affect) effects on affective learning. A possible explanation for these conflicting effects is that maturity and reliability foster more effort in studying, which, in turn, results in more stress.

Time Trends of Affective Learning

Intrinsic engagement tended to grow in all courses from midterm to final, whereas extrinsic engagement and negative affect were stable. Moneta and Csikszentmihalyi (1999) argued that the optimal learning process begins by inducing a perception of

low skills and moderate challenges, and evolves toward increasingly higher levels of challenges and skills in relative balance with each other. Therefore, the growth of challenges and skills found in this study suggests that the course was well designed and conducted in both lecture and online formats.

The time trend of intrinsic engagement did not differ across courses. This finding indicates that students in the online courses had no learning curve in adjusting to the new format of instruction; or, if they had adjustment problems, they solved them prior to the midterm. Therefore, carefully designed richly interactive multimedia e-learning modules appear to require limited learner practice to become effective in the affective domains.

Cultural Moderators

Several studies suggest that students in Hong Kong universities are less self-regulated and more other-regulated in learning than students in Western universities (Biggs, 1992; Moneta & Siu, 2002; Salili, 1994; Spinks, Lam, & Van Lingen, 1998). Because online courses capitalise on learner self-regulation, Hong Kong students may be less prepared than Western students to benefit from them. The process of taking more initiative and becoming a self-regulated learner in the online courses studied here probably required a conscious and energy-consuming change in the students' study habits, and this process may have fostered negative affect.

Research into the "paradox of the Asian student" showed that Hong Kong and other Asian students use a combined understanding-memorising approach to learning (Kember, 1996), and tend to reach a comparatively deeper understanding of the subject matter (Biggs, 1996; Kember & Gow, 1990). The cultural tendency both to memorise and to understand implies a systematic, sequential, and small-step approach to the exploration of novel stimuli. The e-learning modules that were used in this study prompted students to explore illustrations, solve problems, or answer questions, and provided immediate and specific feedback. This personalised and step-by-step interaction was hardly possible in the lecture course due to the relatively large class size. Because rich interactive multimedia e-learning modules provide unique opportunities for step-by-step learning, Hong Kong students may be more prepared than Western students to benefit from them. The process of learning in a more sequential and detail-oriented fashion in the online courses probably matched the approach to learning of the Hong Kong Chinese students, and this matching may have fostered intrinsic engagement.

Limitations

This study has two main limitations. First, because there was no random assignment to the two course formats, this study shares all the limitations of non-randomised studies. However, these limitations are offset by the absence of self-selection of course format and by the statistical control enforced on pre-enrollment academic ability and computing background. Second, having the same face-to-face laboratory component

in both lecture and online courses confounded the comparison of the two course formats. Joy and Garcia (2000) pointed out that correlated parts of a treatment are a recurrent confounder in comparisons of the effectiveness of technology-based and conventional delivery. The implication for this study is that if the immediacy provided by laboratory sessions interacted with the immediacy provided by e-learning modules and lectures, then the relative effectiveness of the e-learning modules is inflated. Because the laboratory sessions were the major opportunity for face-to-face interactions in the online courses, the students attending those courses may have invested more energy in the laboratory sessions than the students attending the lecture course. Consequently, the higher intrinsic engagement of the online courses could be in part due to the students making better use of their laboratory sessions.

Conclusions

Previous studies have found that carefully designed e-learning modules are effective in fostering cognitive learning (e.g., Frear & Hirschbuhl, 1999; Herrington & Oliver, 1999). This study adds to the literature by showing that carefully designed e-learning modules are effective in fostering intrinsic engagement but ineffective in preventing negative affect. Therefore, this study supports McFarland's (1996) claim that multimedia is beneficial in the affective domains, but adds that replacing lectures with rich interactive multimedia e-learning modules results in both positive and negative consequences in the affective domains. Finally, this study suggests that students' maturity and students' perception of the reliability of the online instructional format are important moderators of the effects that richly interactive multimedia e-learning modules have on affective learning.

The findings of this preliminary study suggest four directions for future research. First, it is important to identify the specific causes of students' higher negative affect in online courses, and design interventions to counteract them. Second, it is important to determine how the advantage in intrinsic engagement and the disadvantage in negative affect of online courses trade off in terms of influencing students' motivation to keep learning after the course. Third, it is important to identify the key individual differences that predispose students to benefit in the affective domains from a richly interactive multimedia online course format. Finally, it is important to gain a deeper understanding of how affective learning and cognitive learning influence each other dynamically throughout a course. Progress in these research directions should provide indications for developing online courses that optimise both cognitive learning and affective learning, with the primary goal of helping students with different profiles to become self-motivated lifelong learners.

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Appendix: Affective learning variables and items

Factor	Variable	Item	Source of item
Intrinsic engagement	Positive affect	Interested	a
		Excited	a
		Strong	a
	Perceived challenges	Challenges of these activities	b
		The effort you put in these activities	b
		The pace of these activities	b
		Are these activities important to you?	b
	Perceived skills	Your skills in these activities	b
		Do you succeed at what you are doing?	b
		Are you satisfied with how you are doing?	b
		How confident do you feel in doing these activities?	b
Extrinsic engagement	Performance expectations	What grade do you expect to get in this course?	c
	Performance goals	What grade are you trying to get in this course?	c
	Performance self-efficacy	How confident are you that you will be able to handle the difficulties in the upcoming midterm/final exam?	c
Negative affect	Negative affect	Upset	a
		Ashamed	a
		Nervous	a

Note. a = PANAS (Watson et al., 1988); b = experience sampling method (e.g., Moneta, 2004); c = indigenous, derived from a focus group.

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