The Proposal of the System That Recommends e-Learning Courses Matching the Learning Styles of the Learners

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Abstract. In providing e-learning, it is desirable to build an environment that is suitable to the student's learning style. In this study, using the questionnaire to measure the student's preferences for asynchronous learning and the use of ICT in learning that has been developed by authors, the relationship between the learning preferences of a student that have been measured before and after the course and his or her adaptability to the course is explored. The result of multiple regression analyses, excluding the changes in learning preferences that may occur duirng the course, shows that a student's learning adaptability can be estimated to some extent based on his/her learning preference measured before the course starts. Based on this result, we propose a system to recommend e-learning courses that are suitable to a student before the student takes the courses.

Keywords: e-learning, learning preferences, e-learning adaptability, multiple regression analysis, course recommendation

1   Introduction

E-learning has been widely adopted in vocational training, higher education and life-long learning. In Japan, some higher education institutions have signed agreements to transfer credits earned through e-learning in other institutions. The scale of such credit transfer systems has increased and nowadays students can select courses they want to take among many available courses.

The advancement of information and communication technologies (ICT) allows learning management systems (LMS) with diverse functions to be developed and utilized. The research on instructional design and learning technologies with regards to e-learning has flourished, and now e-learning takes various forms ranging from classes based on textual materials and classes utilizing audio-visual materials such as still images and videos to classes mainly focusing on communications between students and instructors or among students.

E-learning allows student-centered learning in which students themselves, instead of instructors, set the time, place and pace for their study. Therefore, in e-learning it is

desirable to establish a learning environment that matches the learning style of the student. The study proposes a system that suggests appropriate e-learning courses that matches the learning style of a student based on the data about the student's learning preference gathered in advance.

2 Flexibility of Learning Styles and Learning Preferences

2.1 Flexibility of Learning Styles

The research on learning styles and learning preferences has been prolific in Europe and North America. According to the Learning Skills Research Center (LSRC) in U.K., the number of journal articles on the learning styles and learning preferences has reached more than 3,800. In those articles, 71 different theories and models for learning styles and preferences have been presented. LSRC has selected 13 most prominent theories and models of learning styles and preferences from the 71 theories and models, and further studied the 13 models [1]. LSRC classified the 13 models of learning styles and preferences into five categories from the most susceptible to the least susceptible to environments based on Curry's onion model [2].

Previously some studies were conducted using the Kolb's learning style [3] in developing computer-based training (CBT) [4] and examining the influence of learning styles on the "flow" experience and learning effectiveness in e-learning [5]. Other studies used GEFT (Group Embedded Figure Text) [6] to see the influence of learning styles and learning patterns on learning performance [7] and the instrument developed by Dunn, Dunn and Price [8] to build a system which provides learning environment suitable to the student's learning style [9].

When investigating learning styles and learning preferences in e-learning, how should we consider the "flexibility of learning styles and preferences?" E-learning has the potential to provide "student-centered learning" and tends to be designed based on the pedagogy of providing learning environments according to the students' needs, abilities, preferences and styles rather than providing uniform education without any consideration of individual needs and differences. Therefore, it is meaningful to provide students and teachers with information about the students' adaptability to e-learning courses by using a questionnaire on learning preferences in e-learning. Here we use the term "learning preferences" instead of "learning styles" as the term, "preferences"connotes more flexibility than "styles."

This study looks at learning preferences of students in e-learning courses and determines if their learning preferences regarding asynchronous learning and the use of ICT of a student changes after taking an e-learning course.

2.2 Asynchronous Learning and the Use of ICT

As e-learning is usually conducted asynchronously, it requires more self-discipline of students in comparison with face-to-face classes. E-learning might be easier for students who want to learn at their own pace to continue and complete a study.

However, it can be challenging for those who do not like studying on their own and prefer studying in face-to-face classes.

The use of learning management systems (LMS) can ease the distribution of course materials and the communication among students or between students and teaching staff. Some measures have been taken to help students understand the content of e-learning materials and also to motivate students in studying materials through e-mails sent by teachers and tutors of e-learning courses [10]. However, the use of ICT in e-learning tends to become complex as its functionality increases and may discourage those students who are not familiar with the ICT use.

The use of ICT and asynchronous learning is a typical characteristic of e-learning. However, as it is stated earlier, those who do not like asynchronous learning or the use of ICT may have the tendency to drop out in the middle of e-learning courses. Therefore, it is desirable that students and their teachers know the students' learning preferences and their adaptability of e-learning courses in advance [11].

To investigate the learning preferences in e-learning, we developed learning preference questionnaire items asking preferences in studying, understanding, questioning, and doing homework [12].

This study investigates the change in learning preferences after taking an e-learning course, using the learning preference questionnaire mentioned above. Furthermore, the study confirms through multiple regression analyses the hypothesis that the adaptability to an e-learning course can be estimated before the student's taking the course based on his/her answers to the learning preference questionnaire and proposes a system that recommends e-learning courses suitable to a student based on his/her learning preferences.

3 Survey on Learning Preferences and e-Learning Course Adaptability

3.1 Survey on Learning Preferences

The survey on learning preferences was administered to those students who enrolled in the eHELP (e-Learning for Higher Education Linkage Project) which is a credit transfer system for e-learning courses offered by multiple member universities in Japan.

In eHELP, students take one to three full online course(s) offered by other institutions in parallel to taking courses offered by their own institution. In taking an e-learning course, a student studies the content which is equivalent to 15 lessons (90-minute per a lesson) face-to-face classes. The majority of e-learning courses offered in eHELP is those in which students study by watching video lectures of instructors while using the downloadable text materials.

This study was conducted from the early December of 2008 to the early January of 2009 when all the e-learning courses were completed. All the items in the questionnaire were asked with the 7-point Likert-type scale; from 1 being "don't agree at all" to 7 "agree strongly," and we obtained valid responses from 53 students. Those responses in which answers to the items were all the same including the reverse coded

items were considered invalid. The questionnaire consists of 40 items asking preferences in studying, understanding, questioning, and doing homework in terms of asynchronous learning and the use of ICT. The questionnaire was made available online and students accessed the questionnaire online.

As the result of the factor analysis [3], we could extract three factors with eigenvalues over .07(see Appendix 1): the factor 1 being "preference for asynchronous learning," the factor 2 "preference for the use of ICTs in learning" and the factor 3 "preference for asynchronous digital communication."

3.2   The survey on e-Learning Course Adaptability

When the learning preference questionnaire was administered, the questionnaire on e-learning course adaptability was also administered to the students who enrolled in eHELP courses. The items in the questionnaire are shown in the Table 1. The questionnaire consists of 10 items asking psychological aspects of learning such as the level of students' understanding and the level of satisfaction.

The questionnaire (see Table 1) was administered online to the students enrolled in each of the eHELP courses upon their completion of the course (i.e., between December 2008 and January 2009) and 69 completed responses were obtained. All the items in the questionnaire were asked with the 7-point Likert-type scale; from 1 being "don't agree at all" to 7 "agree strongly." The scores for the item (g) and (h) were reverse-coded. The mean score was 4.7. The mean score was calculated for the e-learning course adaptability, the factors 1, 2, and 3 respectively for each student, and the values were used in the subsequent analyses. In addition, the reverse-coded items were recoded to adjust to the other items.

Table 1. The question items in the e-learning course adaptability questionnaire and the mean scores

Item	Mean
(a) The content of this e-learning course is more understandable than regular class contents.	4.51
(b) The style of learning of this e-learning course is easier to learn than regular classes.	4.90
(c) The pace of this e-learning course is more suitable than regular classes.	4.91
(d) This e-learning course is more satisfying than regular classes.	4.36
(e) This e-learning course is more effective than regular classes.	4.35
(f) This e-learning course is more interesting than regular classes.	4.91
(g) This e-learning course makes me more tired than regular classes. (recoded)	4.84
(h) This e-learning course makes me more nervous than regular classes. (recoded)	5.59
(i) This e-learning course brings me more endeavor than regular classes.	4.07
(j) This e-learning course brings me more motivation than regular classes.	4.41

3.3 Correlations

Correlations between the scores of the three learning preference factors and the score for the e-learning course adaptability were analyzed among the 69 respondents who completed both of the two questionnaires. The correlation r is shown in Table 2.

A statistically significant ($p < 0.01$) correlation was seen between the learning preference factor 1 (the preference for asynchronous learning) and the e-learning course adaptability and between the factor 2 (the preference for the use of ICT in learning) and the adaptability. The correlation between the learning preference factor 3 (the preference for asynchronous digital communication) and the e-learning course adaptability is not as high; however, the correlation is statistically significant at the level of $p<.05$.

Table 2. Correlations between the e-leaning course adaptability and the leaning preference Factors

	r	p	n
Adaptability - Factor 1	0.53	< 0.01	69
Adaptability - Factor 2	0.60	< 0.01	69
Adaptability - Factor 3	0.29	$<.05$	69

3.4 Multiple Regression Analysis

In order to further investigate the relationships between the e-learning course adaptability and each of the three factors of learning preferences, a multiple regression analysis was conducted. The results are shown in Table 3.

Table 3. The result of a multiple regression analysis

Variable Name	Regression Coefficient	p
Intercept	1.82	$** < 0.001$
Factor 1(preference for asynchronous learning)	0.23	$**0.0054$
Factor 2(preference for the use of ICT in learning)	0.45	$**0.0003$
Factor 3(preference for asynchronous digital communication)	0.01	0.938
Multiple R-square	0.43	$** < 0.001$

**significant at $p=0.01$ *significant at $p=0.05$

As shown in Table 3, the regression coefficients of the factor 1 and the factor 2 are relatively high and the p values are less than 0.01. However, as for the factor 3, the regression coefficient is low and its p value is also not significant enough. It can be suspected that the multicollinearity is high between the factor 2 and the factor 3. Therefore, another multiple regression was conducted excluding the factor 3.

As the result, the regression coefficients for the factor 1, the factor 2, and the intercept resulted in 0.23, 0.45, and 1.84 respectively.   Therefore, the multiple regression equation was derived as follows,

Adaptability to e-learning courses＝1.84＋0.23×factor 1＋0.45×factor 2   **(1)**

It is possible to predict the e-learning course adaptability for students in eHELP based on this formula.

4 Estimation of e-Learning Course Adaptability

4.1   Changes in Learning Preferences

In order to further investigate the flexibility of learning preferences in e-learning discussed in the section 2, the changes in learning preferences of students before and after taking an e-learning course in the Spring semester (from the early April, 2009, to the early July, 2009) were investigated, using the learning preference questionnaire mentioned previously.

The Figure 1 indicates the changes in learning preferences of 18 students who responded to the questionnaire both at the beginning of the course and at the end of the course.   It shows the scores of responses at the beginning of the course deducted from the scores at the end of the course in bar charts. Hence, the vertical axis in the Figure 1 indicates the sum of the differences in scores before and after the course. The white bars on the left side in the Figure 1 (from q1 to q17) shows the changes in the factor 1 (preference for asynchronous learning) and the black bars on the right side indicates the changes in the factor 2 (preference for the use of ICT). As a whole, the factor 1 got positive scores and the factor got negative scores.
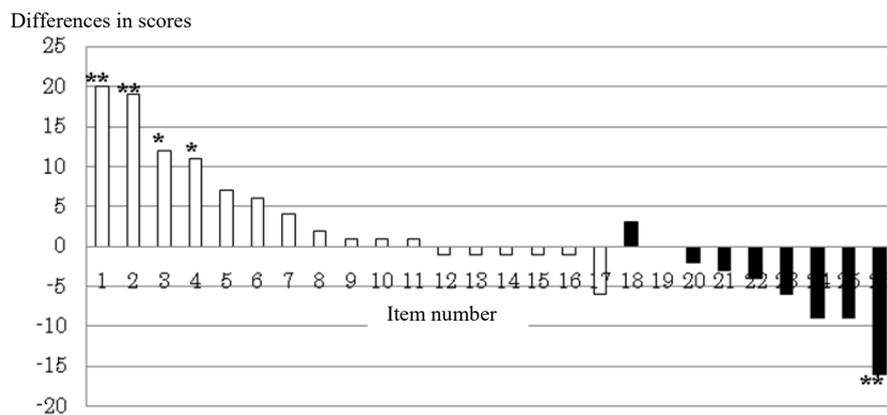

Figure 1: The changes in learning preferences regarding asynchronous learning and the use of ICT after taking an e-learning course

The paired sample t-test was conducted to the changes in scores shown in the Figure 1. As a result, q1, q2, and q26 showed significant differences ($p<0.05$) as indicated ** in the figure. In addition, the paired sample t-test of scores on q3 and q4 showed significant differences at $p<0.10$ as indicated * in the figure. Hence, it has been found that the learning preferences change after taking e-learning courses with regards to the five items indicated above.

By taking e-learning courses, students' preference for asynchronous learning tends to change positively, while their preference for the use of ICT tends to change negatively. Therefore, it has been found that the learning preferences for asynchronous learning and the use of ICT can change in e-learning environments.

4.2 Estimation of e-Learning Course Adaptability through Multiple Regression Analyses

Applying the scores obtained at the beginning of the course to the multiple regression formula, we attempted to predict the e-learning course adaptability at the end of the course. The Figure 2 shows the correlation between the e-learning course adaptability scores calculated by applying the item scores for the factors 1 and 2 obtained at the beginning of the Spring course and the actual scores obtained at the end of the course (n=18). In this case, the correlation coefficient is 0.01, which indicates that the e-learning course adaptability cannot be predicted.

The Figure 3 shows the correlation between the actual scores and the scores calculated using the multiple regression formula without the scores of the five items (from q1 to q4 and q26) that tend to change after experiencing e-learning as discussed in the section 4.1. As the correlation coefficient is 0.65, it can be concluded that there is a significant correlation between the calculated scores and the actual scores.

It shows the possibility of predicting the e-learning course adaptability at the end of the course by using the formula (**1**) discussed in the section 3.4 with the scores excluding those of the learning preference items that may change after taking an e-learning course.
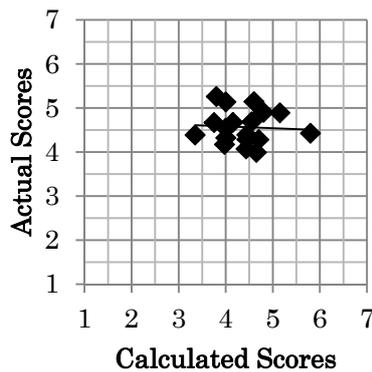

Figure 2:   The correlation between the actual scores and the calculated scores of e-learning adaptability using all the items of the factor 1 and 2 (the spring semester)
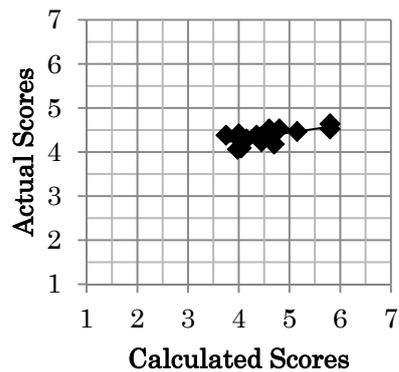
Figure 3:   The correlation between the actual scores and the calculated scores of e-learning adaptability excluding the items that are changeable after taking an e-learning course (the spring semester)

4.3 Development of a System to Recommend e-Learning Courses Suitable to a Student

The section 4.2 has shown that a student's e-learning course adaptability can be estimated before the course starts based on his/her responses to the learning preference questionnaire items on asynchronous learning and the use of ICT in learning. Thus, as shown in the Figure 4, based on the past data, the study considers the development of a system that recommends e-learning courses suitable to a student according to the result of the learning preference questionnaire of the student before the course starts.
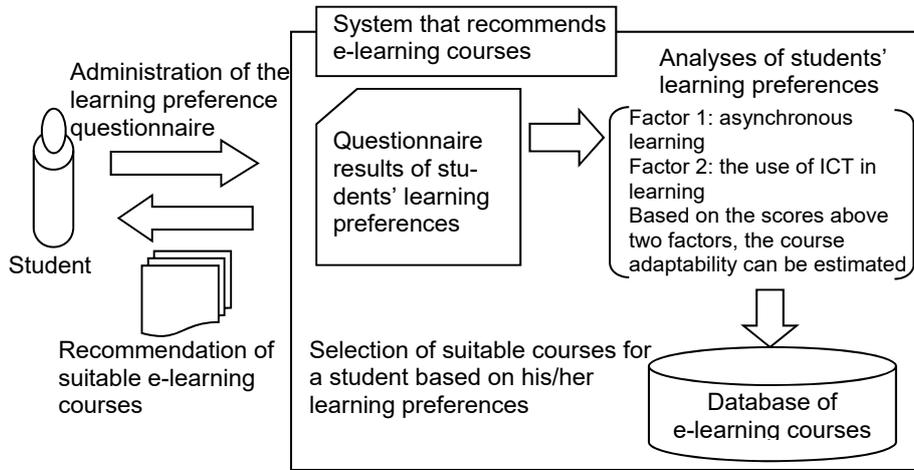

Figure 4. The system of recommending e-learning courses suitable to a student in consideration of the student's learning preferences

The course (i)'s adaptability scores (Z_i) of past students gathered after the courses were over are classified into three (high, middle and low) levels. Then the average of learning preference scores for asynchronous learning ($\bar{x}_{i,h}$, $\bar{x}_{i,m}$, $\bar{x}_{i,l}$) and for the use of ICT in learning ($\bar{y}_{i,h}$, $\bar{y}_{i,m}$, $\bar{y}_{i,l}$) are calculated for each group (i.e., high, middle and low level in course adaptability scores).

In the results of the learning preference questionnaire of the student (a) administered before the start of the course, when the average score of the preferences for asynchronous learning being x_a and the average score for the use of ICT in learning being y_a, the deviations from each of the means of course adaptabilities at three different levels can be calculated as:

$$D_{a,h} = \sqrt{(x_a - \bar{x}_{i,h})^2 - (y_a - \bar{y}_{i,h})^2}$$
$$D_{a,m} = \sqrt{(x_a - \bar{x}_{i,m})^2 - (y_a - \bar{y}_{i,m})^2}$$
$$D_{a,l} = \sqrt{(x_a - \bar{x}_{i,l})^2 - (y_a - \bar{y}_{i,l})^2}$$

For the eHELP course (k), the scores of adaptability to the course are grouped into three levels as $Z_h >= 4.5$, $4.5 > Z_m > 4.0$, and $Z_l <= 4.0$. Table 4 shows the means of learn-

ing preference scores for asynchronous learning (x) and for the use of ICT in learning (y) at each of the three levels.

Table 4. Means of learning preference scores for each of the three levels of the adaptability to the course (k) (N=13)

Course adaptability \ Learning preference	Learning preference of students in the course (k) (means)	
	Asynchronous learning ($\overline{x}_k$)	The use of ICT in learning ($\overline{y}_k$)
$Z_h>=4.5$	1.20	0.800
$4.5>Z_m>4.0$	0.368	0.306
$Z_l<=4.0$	-0.236	0.037

Figure 5 plots the learning preferences at each level of course adaptability shown in Table 4 in each axis. ● indicates the mean of the Z_h group; ▲ indicates the mean of the Z_m group; and × indicates the mean of the Z_l group. For example, if the student(a)'s preferences for asynchronous learning and the use of ICT in learning are indicated as in Figure 5, the adaptability to the course can be expected as being Z_h. In a similar vein, the student(a)'s course adaptability can be calculated for other courses. In this way, it becomes possible to build a system which assists a student's selection of e-learning courses by recommending the courses that are considered suitable for the student.
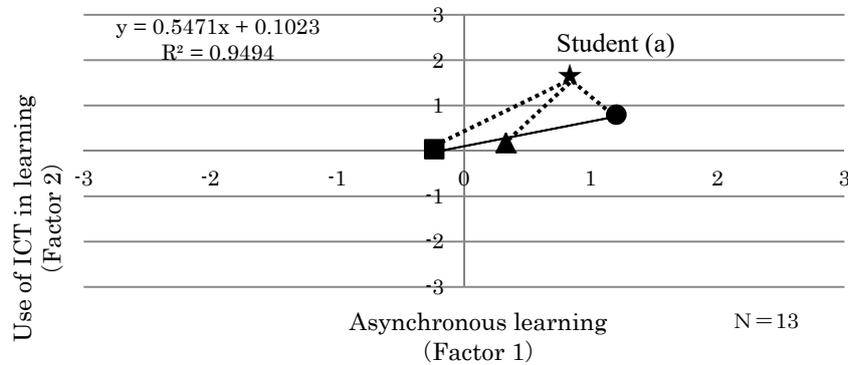

Figure 5. The distances from the course adaptability score of the student (a) in the course (k) and the means in the three different levels

5   Conclusion

This study investigated the relationship between learning preferences and e-learning course adaptability by administering questionnaires to students who were enrolled in e-learning courses at higher education institutions. The results of the study

show that the learning preferences regarding asynchronous learning and the use of ICT may change after taking e-learning courses. It has been also found that there is a significant correlation between the actual e-learning course adaptability scores and the scores calculated using the multiple regression formula with the response scores of the items that do not tend to change. Based on those results, it is concluded that the e-learning course adaptability of an individual student at the end of the course can be predicted by administering the questionnaire at the beginning of the course.

Based on these results, a system recommending e-learning courses suitable to a particular student based on the student's score on the learning preference questionnaire administered before the beginning of the course is proposed.

In the future, the system to recommend suitable courses to a student is planned to be built and to be used in the operation of e-learning courses at eHELP.

In addition, we would like to continue the research on the factors influencing e-learning so that students can choose learning methods and environment that suit their learning preferences.

References

1. Coffield, F., Moseley, D., Hall, E. and Ecclestone, K.: Learning Styles and Pedagogy in Post-16 Learning. In: A Systematic and Critical Review, Learning and Skills Research Center, London (2004)
2. Curry, L.: An Organization of Learning Styles Theory and Constructs. In: ERIC Document 235185 (1983)
3. Kolb, D.A.: LSI Learning-Style Inventory. McBer & Company. Training Resources Group, Boston, MA (1985)
4. Henke, H.: Learning Theory: Applying Kolb's Learning Style Inventory with Computer Based Training. In: A Project paper for A Course on Learning Theory (1996)
5. Rong, W.J. and Min, Y.S.: The effects of learning style and flow experience on   the effectiveness of e-learning. Fifth IEEE International Conference on Advanced Learning Technologies. pp.802-805 (1996)
6. Witkin, H., Oltman, P., Raskin, E. and Karp, S.: A Manual for The Group Embedded Figures Test. Palo Alto; California (1971)
7. Lu, J., Yu, C.S. and Liu, C.: Learning style, learning patterns, and learning performance in a WebCT-based MIS course. Information & Management, pp. 497-507 (2003)
8. Dunn, R., Dunn, K. and Price, G.E.: The Learning Style Inventory. Lawrence, KS: Price Systems, 1989.
9. Wolf, C. and Weaver, I.: Towards 'learning style'-based e-learning in computer science education. Australasian Computing Education Conference (ACE2003). vol. 20, (2003)
10. Fuwa, Y., Ushiro, M., Kunimune, H., Niimura, M.: Efforts toward the Establishment of Quality Assurances for Adults Students of Distance Learning on e-Learning System -Practice and Evaluations of Support and Advice Activities-.Journal of Multimedia Aided Education Research, vol.3, no.2, pp.13--23 (2007)
11. Nishino, K., Ohno, T., Mizuno, S., Aoki, K., Fukumura, Y.: A Study on learning Styles of Japanese e-learning learners. In: 11th International Conference on Humans and Computers, pp.299--302 (2008)
12. Nishino, K., Toya, H., Mizuno, S., Aoki, K. and Fukumura, Y.: The relationship between the learning styles of the students and their e-learning course adaptability, KES2009, pp.539—546 (2009)

Appendix 1: The Learning Preference Questionnaire

Factor 1   preference for asynchronous learning

q1	When I study through computers, I tend not to care how others study.
q2	I tend to learn more actively when I study alone than studying with others at one place.
q3	I can familiarize myself better when I study independently at my convenience than studying with others at one place.
q4	I study at my own pace and do not care how others study.
q5	I would rather study alone at the place and time convenient to me than learn in class with other people.
q6	I can concentrate better when I study independently at my convenience than studying with others at one place.
q7	I can learn better when I study at the time I decide than when I study at the time decided by others.
q8	I would rather do group learning through computers than face-to-face.
q9	I would rather follow the computer instruction rather than study reading textbooks.
q10	I understand better when I study at my convenient time rather than learning in class with other people.
q11	I feel more motivated when I study using computers than learning from teachers in person.
q12	It is easier for me to take test individually than to take one in a place with others.
q13	I feel less tired looking at a computer screen than looking at a blackboard or a large screen in a classroom.
q14	I want to study at my own pace.
q15	I can be more creative when I study alone than studying with others at one place.
q16	I feel more motivated when I study at my convenience than learning in class with other people.
q17	I feel less tired when I study independently at my convenience than studying with others at one place.

Factor 2   preference for the use of ICT in learning

q18	I understand better when I learn through computers than when I learn by reading books.
q19	I tend to learn more actively using computers than studying in class.
q20	I prefer learning through computers to learning by reading books.
q21	I am familiar with computers.
q22	It is easier for me to take test on a computer than on paper.
q23	I would rather submit my report in an electronic format than in a paper and pencil format.
q24	I prefer taking notes using a computer than writing on paper.
q25	I can concentrate better looking at a computer screen than looking at a blackboard or a large screen in a classroom.
q26	It is easier for me to memorize what is on a computer rather than to review printed materials.

Factor 3   preference for asynchronous digital communication

q27	I would rather receive answers later from teachers via mail than asking questions in person or through chat.
q28	I prefer communicating via email to communicating through telephones.
q29	I would rather ask questions using email or bulletin boards than asking teachers in person.
q30	It is easier for me to communicate through computers or cell phones than to communicate face-to-face.
q31	I can be more creative when I think on paper than using computers.