

Adaptive learning for ESL based on computation

Ya-huei Wang and Hung-Chang Liao

Ya-huei Wang is an Associate Professor at Chung-Shan Medical University, Taiwan. She got her Master degree in English language and literature from University of Rochester, U.S.A. and her Ph.D. in education from National Changhua University of Education, Taiwan. Her current research interests include gender education, female image, speaking anxiety, learners' motivation, and language learning strategies. Hung-Chang Liao is a Professor at Chung-Shan Medical University, Taiwan. He got his Ph.D. from National Chiao-Tung University, Taiwan. His current research interests include social science education, research method for social science, experimental design, and statistic analysis. Address for correspondence: Dr Hung-Chang Liao, No. 110, Sec. 1, Jian-Koa N. Road, Taichung 402, Taiwan. Tel: 886-4-24730022 ext. 17171; email: huncliao@ms43.hinet.net, hccliao@csmu.edu.tw

Abstract

In the conventional English as a Second Language (ESL) class-based learning environment, teachers use a fixed learning sequence and content for all students without considering the diverse needs of each individual. There is a great deal of diversity within and between classes. Hence, if students' learning outcomes are to be maximised, it is important to know how to provide learning content using students' preferences, learning characteristics and knowledge background as a basis. A five-step algorithm was proposed that was based on the four factors (gender, learning motivation, cognitive style and learning style) as the different learner characteristics. The percentage increase between the pretest and posttest scores was used to determine optimal adaptive learning sequences to accommodate a variety of individual differences. The algorithm included the following five steps—to obtain the learning performance, to distinguish the learning performance of the lowest and highest groups, to use the different learning sequences as a basis for categorisation, to test the four factors between the lowest and highest performance, and to reduce the number of handouts. Finally, an empirical study for validating the adaptive learning sequence was conducted. By analysing the students' characteristics and the optimal learning sequences, an attempt was made to develop an adaptive learning sequence system to facilitate students' learning and to maximise their learning outcome, thus addressing the problem of fixed learning sequences in conventional ESL instruction.

Introduction

Adaptive learning is a system that was developed to accommodate a variety of individual differences. Recently, in order to improve students' interaction and learning

outcome, ways of developing adaptive learning for use in different courses have been researched (Arlow & Neustadt, 2001; Constantine, 2001; Gibbons, Nelson & Richards, 2001; Larman, 2001). While constructing the adaptive learning system, it is important to identify the factors that influence students' learning outcome to further understand students' differences.

Current research does not only focus on using adaptive content and teaching strategies to facilitate teaching-learning process; attempts are also being made to use learning technologies to develop knowledge and skills. When using an adaptive learning system, teachers would have to adapt their instruction to individual learning styles and preferences. Adaptive learning systems that are implemented in the context of computer-mediated instruction are called intelligent tutoring systems (ITSs). ITSs dynamically adapt the e-learning content, the pedagogical model and human-computer interaction to the objectives, needs and preferences of individual users for effective learning and teaching (Canfield, 2001; Kaklauskas, Ditkevicius & Gargasaite, 2006; Woo *et al.*, 2006). By collecting students' learning styles, preferences and performances by tracking their knowledge, work and feedback, the system can make inferences from students' learning strengths and weaknesses in order to suggest additional work (Kaklauskas *et al.*; Woo *et al.*). However, ITS have always been used in e-learning and long-distance learning, not in classroom instruction. Future English as a Second Language (ESL) studies may incorporate e-learning, ITS or algorithm techniques to classroom settings or remedial courses to see whether the incorporation can bring positive effects on students' learning outcome.

The key to success in acquiring foreign languages is determined not only by linguistics factors, but also by social and personal factors, such as culture, gender, motivation and personality (Shaughnessy, 1998; Spennemann, 1996; Witkin & Goodenough, 1981). The most extensively used basis for analysing learners' differences in how they learn is the construct of 'style', which encompasses both cognitive styles and learning styles (Riding, 1997).

Researchers have used the results of research on learning profiles that took into account personality and cognitive styles to determine the correlation between learning profile and ability, academic performance or the atmosphere of teaching and learning in the classroom (Ehrman, 2001; Ehrman & Oxford, 1995; Reiff, 1992). Triantafillou, Pomportsis and Demetriadis (2003) proposed a design and formative evaluation of an adaptive educational system, in which cognitive styles constitute an important factor to be considered with respect to adaptive learning. Witkin, Moore, Goodenough and Cox's (1977) field-dependent and field-independent cognitive styles are the most extensively used dimensions. They are the individual stable patterns in the distinct way people encode, think, perceive and process information. Many experimental studies have shown the effect of field-dependence/independence on the facilitation of the learning process and learning outcome (Abraham, 1983; Brumby, 1982; Jamieson & Chapelle, 1987; Summerville, 1999).

Moreover, the interaction between the field-dependence/field-independence dimension and methods of instruction has been noted in second language instruction (Hite, 2004). Jonassen and Grabowski (1993) proposed that individual differences that are based on the field-dependence/field-independence dimension should be considered while designing the instructional framework and instructional environment. The Group Embedded Figure Test (GEFT) (Witkin, Ottman, Raskin & Karp, 1971) has always been used to derive scores for field-independence by requiring subjects to demonstrate their ability to disembed simple shapes from more complex geometrical backgrounds. Field-independent learners tend to be more socially detached; they are more able to analyse the elements of environments to separate parts from a background field. Nonetheless, field-dependent learners tend to be more people oriented; they are more dependent on the external environment, experiencing the environment as a whole (Witkin *et al.* 1977).

Along with cognitive styles, research has shown that motivation also plays an important role in the three processual stages of learning English: input, central processing and output. Motivation can function as a critical predictor of students' learning outcome. Manolopoulou-Sergi (2004) pointed out that learning motivation plays a significant role in the learning of foreign languages. Robinson (2003) and Skehan (1998) aimed at highlighting the role of motivation in stimulating the information-processing model of foreign language learning. As their motivation is enhanced, students can increasingly become active participants in their own learning process.

In addition, Dunn (1990) highlighted the importance of identifying students' learning styles, in order to tailor instruction to trigger students' concentration, which in turn would promote storage in long-term memory. Learning styles can be identified using an inventory of learning styles, such as the Kolb (1984) learning style questionnaire. People differ in how they perceive information and how they process it. In the learning process, people tend to perceive information in either a concrete or an abstract manner. When processing information, people tend to be either active or reflective (Correll & Gregoire, 1998). The effective learner relies on the following four different learning modes: concrete experience, reflective observation, abstract conceptualisation and active experimentation (Kolb, 1984). Concrete experience learners are able to involve themselves openly and fully to new experience without bias. Unlike concrete experience learners, abstract conceptualisation learners are oriented more towards authority and less towards their peers. Reflective observation learners prefer using an impartial and reflective approach. Active experimentation learners are able to use theories to make decisions and judgement.

In the research on individual differences, there is a fierce debate concerning learning profiles. It is crucial to link teaching strategies and learning profiles if students' learning outcomes are to be maximised. Combinations of teaching strategies and learning profiles have been demonstrated and carried out in a variety of educational contexts (Evans, 2003). Researchers and practitioners have studied learning styles, as well as personality and cognitive types, to determine learners' characteristics that are relevant

to their learning performance, to predict their performance and to improve the performance of both teachers and students (Ehrman, 2001; Ehrman & Oxford, 1995; Reiff, 1992). Even though there are still some problems regarding self-report learning styles, cognitive styles and motivation inventories, the results of the self-report can offer teachers information to match their instruction with students' learning profiles (Sparks, 2006).

In this paper, four factors (gender, learning motivation, cognitive type and learning style) were selected as the different learners' characteristics. The purpose of the study reported herein was to propose an algorithm to determine optimal adaptive learning sequences for ESL instruction that accommodate a variety of individual differences. Using a survey of the literature as a basis, four factors were derived and selected as the variables to be used for the learners' characteristics in the experiment: gender, learning motivation, cognitive style and learning style.

Experimental method

A total of 295 freshmen at a university in central Taiwan were selected as the experimental sample. Before the experiment, we obtained a learning profile for each student by requiring them to complete a questionnaire that gathered information about gender, learning motivation (values low, medium and high), cognitive style (values field-dependent and field-independent) and learning style (values thinking and feeling.) Each value for each factor was assigned a numerical value (a code). The values and codes for these four factors are shown in Table 1.

Herein, the learning profile questionnaire is introduced as follows.

The learning profile questionnaire developed for this study contained four parts: learning style, cognitive style, motivation to learn English and demographic information. The questionnaire was originally developed in English. After being translated into Chinese, it was reviewed by two bilingual English teachers. Participants were given 60 minutes to complete the questionnaire.

The students' learning style questionnaire was adapted from Kolb's Learning Style Inventory (Kolb, 1985), which was designed to measure students' strengths and weaknesses as learners. In the adapted questionnaire, the two components reflective observation and active experimentation that appeared in the second part of the original

Table 1: The factors and the values the students take

Factors	Value 1 (code)	Value 2 (code)	Value 3 (code)
Gender	Male (1)	Female (2)	
Learning motivation	Low (1)	Medium (2)	High (3)
Cognitive style	Field dependent (1)	Field independent (2)	
Learning style	Thinking (1)	Feeling (2)	

questionnaire were excluded from the study, because students in Taiwan are accustomed to learning by rote memorisation. Students are used to being passive learners (Witkins & Biggs, 1999). They are used to perceiving but not processing information, and are used to not having time to either reflect on experiences from different perspectives or rely on experimentation to make judgements themselves. When answering the questionnaire, students had to choose 'a' or 'b' from two possible answers to indicate which they use more frequently. If students get higher scores on concrete experience, it means that they are feeling-oriented learners. If they get higher scores on abstract conceptualisation, it means that they are thinking-oriented learners. The reliability coefficient of the questionnaire was 0.915 in the pilot study when 80 students were tested.

The motivation for learning English questionnaire was adapted from Gardner's (1985) Attitude/Motivation Test Battery (AMTB). The motivation scale consisted of 24 items, based on a 5-point Likert scale, ranging from 5 (*strongly agree*) to 1 (*strongly disagree*) to measure the students' level of motivation for learning English. The scores of the AMTB ranged from 24 to 120, inclusive. Some items on the questionnaire were negative statements, and hence scored in reverse. Using Ganschow and Sparks' grouping model (Ganschow & Sparks, 1996) as a basis, the students were grouped into high, moderate and low motivation groups according to the scores obtained from the motivation questionnaire. From the questionnaire scores of the 80 students, the mean was 79.17, and standard deviation was 9.55. The students who scored one or more standard deviations above the overall mean were identified as high motivation learners (scores ranging from 89 to 120). The students who scored one or more standard deviations below the overall mean were identified as low motivation learners (scores from 24 to 69). The students who scored from 70 to 88 were categorised as moderate motivation learners. After the pilot study, the reliability coefficient of the motivation for learning English questionnaire was 0.962 when 80 students were tested.

The students' cognitive style was derived from the scores from the GEFT, developed by Witkin and his colleagues as a measure of field orientation (Oltman, Ruskin & Witkin, 1971). Learners were categorised as either field-dependent or field-independent by using their score on the GEFT (Witkin *et al.*, 1971). Witkin's GEFT test, which consists of 18 complex figure shapes, was used to derive scores for field-independence and field-dependence by requiring subjects to demonstrate their ability to disembed simple shapes from more complex geometrical backgrounds. Scores ranged from a strongly field-dependent orientation (0) to a strongly field-independent orientation (18). The students scoring from 0 to 9 were classified as field-dependent, while the students scoring from 10 to 18 were classified as field-independent (Triantafillou *et al.*, 2003). In the pilot study, the GEFT had a reliability coefficient of 0.827. In the final section, demographic information, such as sex, was requested.

Generally speaking, a reliability coefficient of 0.700 is a minimally acceptable level of reliability, but 0.800 or greater is preferable (Hair, Babin, Money & Samouel, 2003). In the pilot study, the learning style questionnaire had a reliability of 0.915; the motivation for learning English questionnaire had a reliability of 0.962; and the GEFT had a

reliability of 0.827. So far, the questionnaires have passed the examination for validity and reliability; therefore, they can be used formally.

In addition, to understand the performance of adaptive learning, a pretest and posttest were necessary. The pretests and posttests of reading comprehension were based on the database of the General English Proficiency Test (GEPT), the questions in which have a multiple-choice format. In 1999, the Ministry of Education of Taiwan supported the Language Training and Testing Centre (2008) in the development of the GEPT, which is divided into five levels, each of which contains sections on listening, reading, writing and speaking. English professionals and scholars were invited to form a testing research committee and a testing advisory research committee. The aim of the GEPT is to provide a valid and reliable instrument for testing each level of English proficiency. After completing the questionnaire, the students took a pretest to ascertain their general level of English reading comprehension. The results of the pretest were recorded. In addition, to avoid the Hawthorn effect or the John Henry effect (Cohen & Manion, 1994), the students were not informed of the purpose of the study in advance, fearing that they might make extra efforts to help the researchers achieve the goal of this study.

After the pretest, students were given different learning handouts, each containing one learning sequence that consisted of main idea and details, vocabulary, inference and critical reading. These handouts served as learning material. There were 10 handouts in all. Each student was given one of the 10 handouts at random. Given that each learning sequence contained four items and no item could appear twice in the same sequence, there were 24 ($4! = 24$) possible learning sequences. Five experts (three English language teachers, one instructional design expert and one educational technologist) participated in the panel discussion. These 24 sequences were reduced to 10 through a series of expert panel discussions in which the optimal coherence of teaching and learning were considered. For instance, all panel experts agreed that the learning sequences in which the inference section was presented before the main idea section (inference → critical reading → vocabulary → main idea and details; inference → vocabulary → main idea and details → critical reading; inference → main idea and details → critical reading → vocabulary; inference → critical reading → main idea and details → vocabulary; inference → vocabulary → critical reading → main idea and details; inference → main idea and details → vocabulary → critical reading; critical reading → inference → vocabulary → main idea and details; critical reading → vocabulary → inference → main idea and details; critical reading → inference → main idea and details → vocabulary; vocabulary → inference → critical reading → main idea and details; vocabulary → inference → main idea and details → critical reading) were not suitable or feasible learning sequences. In order to make an inference in the reading, readers should think about the details and how these details relate to one another. Without first having familiarised themselves with the main idea and details section, students cannot identify the main idea in the reading and put the details together to make an inference. Therefore, in consideration of logical coherence of teaching and learning, all the sequences in which the inference section was presented before the main idea and details section were excluded.

Table 2: The handouts and their learning sequences

<i>Handout</i>	<i>Learning sequence</i>
C_1	Main idea and details, vocabulary, inference, critical reading
C_2	Main idea and details, inference, critical reading, vocabulary
C_3	Main idea and details, critical reading, vocabulary, inference
C_4	Main idea and details, inference, vocabulary, critical reading
C_5	Critical reading, vocabulary, main idea and details, inference
C_6	Critical reading, main idea and details, inference, vocabulary
C_7	Critical reading, main idea and details, vocabulary, inference
C_8	Vocabulary, main idea and details, inference, critical reading
C_9	Vocabulary, critical reading, main idea and details, inference
C_{10}	Vocabulary, main idea and details, critical reading, inference

The handout covered 10 pages and the following content: main idea and details, inference, critical reading and vocabulary. In the main idea and details section, students needed to read passages containing details, such as names, dates, locations and times. Sometimes, a passage did not include a statement of the main idea. Hence, students had to put together the details in the passage to find the main idea. In the inference section, students had to make an inference in the reading in which the meaning was not stated clearly. They had to understand the way in which the details were related to each other in order to make inferences. In the critical reading section, students had to realise what opinions were given in the reading, and how they were supported, in order to see the purpose of the article. In the vocabulary section, students had to be able to understand synonyms and antonyms, so that they would be able to understand the reading materials. They also had to learn to use context clues to make a logical guess about the meaning of a new word in the reading. Table 2 shows the 10 learning sequences that were used and the code that was assigned to each. The Appendix shows the content of Handout C_1 , cited from *Project Achievement Reading* (George & Spache, 1999).

After 3 weeks of class instruction and group instruction using the handouts as learning material, the students were given a posttest. The grades of the posttest were recorded. Using the results of the pretest, the posttest and the students' learning profile questionnaire, the students' profiles were developed. Then, an algorithm was applied to each student's profile in order to extract the optimal learning sequences for that student.

The algorithm

After identifying the characteristics of the sample students, we used an algorithm to find optimal adaptive learning sequences. The algorithm contained five steps.

Step 1. To obtain the difference in learning performance between the pretest and posttest grades

In order to determine the learning performance, the increase between the pretest grade and the posttest grade is computed as a percentage. This STEP uses Equation 1 to compute the increase between the pretest grade and the posttest grade as a percentage.

$$\text{Percentage increase} = \frac{\text{the grade of posttest} - \text{the grade of pretest}}{\text{the grade of posttest}} \quad (1)$$

Step 2. To distinguish the learning performance of the lowest and highest groups

The lowest performance group and the highest performance group are determined, using the percentage increase in the grade as a basis. The percentage increases of the students' grades were sorted from the lowest to the highest as $(g_1, g_2, g_3, \dots, g_{i-2}, g_{i-1}, g_i)$. Then, the authors selected two α cuts to determine the highest performance group and the lowest performance group. This was done because we wanted to obtain the adaptive learning sequences based on the students' learning profiles. The highest performance group had significantly improved performance, while the lowest performance group had no significant improvement. Accordingly, both the highest and the lowest performance groups are worth exploring.

Seventy-five students had an increase in their grades of 1–5%, 161 students had an increase of 8–22% and 104 students had an increase of 25–43%. In expert panel discussions conducted by three English language teachers, it was decided that percentage increases from 8% to 22% could be regarded as normal learning performance. The lowest performance group was determined by making the first α cut to separate those students whose scores increased by less than 5%. This cut yielded a group of 75 students. The highest performance group was determined by making the second α cut to separate those students whose scores increased by 25% or more. This cut yielded a group of 104 students.

Step 3. To use the different learning sequences as a basis for categorisation

After subgroups of the lowest and highest performance groups formed, eight learning sequences were obtained from the lowest and highest performance group: $C_1, C_2, C_3, C_4, C_6, C_8, C_9$ and C_{10} . Learning sequences C_5 and C_7 were not selected from the original 10 because they did not result in any significant increase in performance.

Step 4. To test the four factors between the lowest and highest performance

The differences between the lowest and highest performance groups were tested according to the four factors (gender, learning motivation, cognitive type and learning style.) In order to identify which factors are important for the adaptive learning system, we conducted a proportion test to determine whether there was any difference between the lowest and highest performance groups with respect to factor. Equation 2 gives the method that was used in the proportion test.

$$\begin{aligned} H_0: P_i &= P_j \\ H_a: P_i &\neq P_j \end{aligned} \quad (2)$$

where P_i is the average percentage increase in grade in the lowest performance group's value and P_j is the average percentage increase in grade in the highest performance group's value. The result shows 'reject H_0 ' when the numerical code for the test factor under consideration differs for the lowest and highest performance groups. When this is

Table 3: The result of proportion test

<i>Handout</i>	<i>C</i> ₁	<i>C</i> ₂	<i>C</i> ₃	<i>C</i> ₄	<i>C</i> ₆	<i>C</i> ₈	<i>C</i> ₉	<i>C</i> ₁₀
Gender				1*	1*			
Learning motivation	3*			3*	1*	2*		2**
Cognitive style	2*		1**	2*	2*		2*	
Learning style	1**	2*	2*	1*	2*	2**	2*	

*Less than 0.05 significant level.

**Less than 0.01 significant level.

the case, the value of the test factor that is represented by the numerical code is important with respect to increasing learning performance. Table 3 shows the results of the proportion test, with numerical codes representing the values for each factor.

Step 5. To reduce the number of handouts

The purpose of reducing the number of the handouts is to reduce the teaching cost. We decided which handouts to discard by examining the effect that each learning sequence had on the learning performance of students with different characteristics. This was done by examining the results of the proportion test that are shown in Table 3.

The learning outcome of students who have a feeling learning style who used handout *C*₂ improved significantly, but the use of this handout had no significant effect according to gender, learning motivation and cognitive style. The learning outcome of students with medium-strength motivation to learn who used handout *C*₁₀ improved significantly, but the use of this handout had no significant effect according to gender, cognitive style and learning style. The learning outcome of students with medium-strength motivation to learn and a feeling learning style who used handout *C*₈ improved significantly, but the use of this handout had no significant effect according to gender and cognitive style. Given these results, handout *C*₈ can be used instead of handouts *C*₂ and *C*₁₀.

The learning outcome of students with a field-independent cognitive style and a feeling learning style who used handout *C*₉ improved significantly, but the use of this handout had no significant effect according to gender and learning motivation. The learning outcome of students with low motivation to learn, a field-independent cognitive style and a feeling learning style who used handout *C*₆ improved significantly, but the use of this handout had no significant effect according to gender. Given these results, students who benefited from using handout *C*₉ would also benefit from using handout *C*₆, so handout *C*₆ can be used instead of handout *C*₉.

The learning outcome of students with high motivation to learn, a field-independent cognitive style and a thinking learning style who used handout *C*₁ improved significantly, but the use of this handout had no significant effect according to gender. The learning outcome of male students with high motivation to learn, a field-independent

Table 4: The result of adaptive learning handouts

Factor	Adaptive learning for handouts			
Learning style	Thinking	Thinking	Feeling	Feeling
Cognitive style	Field independent	Field independent	Field dependent	Field independent/ field dependent
Learning motivation	Low	High	Low/medium/high	Medium
Gender	Male	Male	Male/female	Male/female
Handout	C_6	C_4	C_3	C_8

cognitive style and a thinking learning style who used handout C_4 improved significantly. Given these results, students who benefited from using handout C_1 would also benefit from using handout C_4 , so handout C_4 can be used instead of handout C_1 .

Finally, the learning outcome of students with a field-dependent cognitive style and a feeling learning style who used handout C_3 improved significantly, but the use of this handout had no significant effect according to gender or learning motivation. The above findings enabled the authors to reduce the number of handouts to four.

Table 4 provides a representation of the characteristics of students who would benefit from using the final learning sequences.

An empirical study of the adaptive learning sequence

In order to evaluate the performance of the adaptive learning sequence, two homogenous and normally distributed classes were chosen as the experimental group and the control group. Each group consisted of 40 students. The experimental group (class B1) and the control group (class B2) were determined by the toss of a coin. The students were business college students who had studied English for at least 6 years since junior high school. Before the treatment, the experimental group was required to complete the learning profile questionnaire. The results showed that the experimental group contained 23 students who would benefit from using the final learning sequences, which are shown in Table 4. Then, the study programmes C_6 , C_4 , C_3 and C_8 were assigned to them as their optimal adaptive learning sequences, while the students in the control group received a standard fixed learning sequence. Both groups were given an English reading comprehension pretest and posttest within an interval of 4 weeks (3 weeks of instruction and 1 week of independent study). The pretest results for the English reading proficiency test, shown in Table 5, showed that both groups were at about the same reading proficiency level ($t = -1.09$, p -value > 0.05).

The posttest was used to compare the learning outcomes of the two groups after taking the course. Table 6 lists the t -test values of the posttest results. Notably, the mean score of the experimental group ($M = 73.58$) is significantly higher than the mean score of

Table 5: Independent t-test results for the English reading comprehension pretest

<i>Group</i>	<i>Mean</i>	<i>SD</i>	<i>t</i>	<i>p-value</i>
Experiment	45.53	5.32	-1.09	0.27
Control	46.85	5.81		

Table 6: Independent t-test results for the English reading comprehension posttest

<i>Group</i>	<i>Mean</i>	<i>SD</i>	<i>t</i>	<i>p-value</i>
Experiment	73.58	8.21	5.71	0.00*
Control	64.23	6.32		

**p*-value <0.01.

the control group ($M = 64.23$). Hence, it may be concluded that the experimental group outperformed the control group after implementing the adaptive learning sequences ($t = 5.71$, *p*-value < 0.01).

Discussion

An adaptive learning sequence system for enhancing students' English learning outcome was proposed and developed to accommodate a variety of individual differences. Learning profiles can be defined as a preference for certain ways of learning. A learning profile is 'a combination of one's motivation, engagement and cognitive processing habits' (Curry, 1991, p. 252) that shows distinctive and habitual ways in which people proceed, concentrate on and interact with instructional content presented in a learning environment (Shaughnessy, 1998). Research has shown that the use of adaptive learning content can help students to learn material differently and profit differently (Dwyer & Moore, 1991; Jonassen & Grabowski, 1993; Moore & Dwyer, 2001). Given the complex nature of English language learning process, it is critical to use content material with different learning sequences to accommodate different learning profiles. It is also critical to ensure that the content is matched to the learning profile, because mismatching in learning profiles has been regarded as a critical factor in impeding the learning process (Ehrman, 1996). To develop the individual learning profile, an algorithm was used to determine optimal adaptive learning sequences. The results show that handouts C_4 and C_6 (C_4 : main idea and details → inference → vocabulary → critical reading; C_6 : critical reading → main idea and details → inference → vocabulary) are suitable for use by male students with a field-dependent cognitive type. The only difference in sequence between handouts C_4 and C_6 is in the position of the critical reading task. The researchers found that the differences in learners' characteristics between the students who received handout C_6 and those who received handout C_4 were learning motivation and learning style. Zangyuan (2003) found that male students performed better in an adaptive environment, especially, in the science field in Taiwan. Atkinson (2006) found that there was a significant difference in learning

achievement between male and female students, and among students who used different learning styles. Taking into account the findings in the literature and the results yielded by the algorithm in our study, it may be that the learning sequence of main idea and details → inference is suitable for male students whose cognitive style is field-independent and for the instruction of science education. Further, the analysis of results of applying the adaptive learning sequence system shows that male students tend to adopt a field-independent cognitive style in an adaptive learning environment. Handout C₃ (C₃: main idea and details → critical reading → vocabulary → inference} is suitable for students who have a field-dependent cognitive style and feeling learning style. Handout C₈ (C₈: vocabulary → main idea and details → inference → critical reading) is suitable for students who have a medium-strength motivation to learn and who prefer a feeling learning style.

Our study shows that it is important to take the learners' characteristics into account when developing an adaptive learning sequence system and when identifying optimal learning sequences to accommodate students' individual differences. Manolopoulou-Sergi (2004) believed that learning motivation played a significant role in the teaching and learning of foreign languages. He held that learning motivation, as well as learning style and cognitive style, could emerge as an important factor of individual diversity to the learning process and may thus function as an important predictor of the learning outcome of foreign languages. Witkin *et al* (1977) found that students who have a field-independent cognitive style tend to be more autonomous with regard to the development of cognitive restructuring skills and less autonomous with regard to the development of interpersonal skills. By contrast, he found that those who have a field-dependent cognitive style tend to be more autonomous with regard to the development of high interpersonal skills and less autonomous with regard to the development of cognitive restructuring skills. Students who have a field-dependent cognitive style tend to approach task in a global way, while those who have a field-independent cognitive style tend to approach things in an analytical way. Hence, information should be provided to students in a sequence that moves from general to specific for field-dependent students and from specific to general for students with a field-independent cognitive style (Triantafillou *et al*, 2003). As for feedback, students who have a field-dependent cognitive style tend to require extensive, very informative feedback, while students who have a field-independent cognitive style prefer to know what has occurred (Jonassen & Grabowski, 1993).

In order to create an optimal ESL learning environment, teachers should initially identify students' individual differences and preferences by analysing their characteristics and background knowledge and then use this information to identify a learning sequence that will be optimal for maximising each student's learning outcome. This is in contrast to what happens in the conventional class-based ESL learning environment, in which students' potential and learning outcome are hindered because teachers use a fixed learning sequence and give the same content to all students without taking into consideration the diverse needs of each individual (Sarasin, 1998). However, by considering students' prior knowledge and characteristics, it is possible to modify learning

sequences dynamically to match each student's needs and capacity, thus improving learning outcomes.

Conclusion

The authors developed an adaptive learning sequence system for ESL teaching. Ten handouts, all different, were used as learning material. A five-step algorithm was applied to determine optimal learning sequences that were based on students' characteristics. By analysing the results of the algorithm, four handouts, each with a different learning sequence, were identified that could be used in ESL teaching. By analysing the students' characteristics and the optimal learning sequences, the study reported herein addressed the problem of the fixed learning sequence in traditional English instruction and attempted to develop an adaptive learning sequence system to maximise the students' learning outcome. Before delivering course content and strategies to students, teachers should analyse students' preferences and characteristics, because students have many individual differences that are relevant to their learning performance. A fixed learning sequence is not suitable for every student. In Taiwan, it is impossible to design a personalised learning environment to accommodate each student's learning needs. However, it might be possible for teachers to access students' characteristics in advance and to extract their optimal learning sequences on the basis of these characteristics.

Limitations and future research

The study has some limitations. First, the learning profile questionnaire was based on self-report assessment. Hence, its accuracy depended on whether the students understood how they learned. It also depended on whether the students answered the assessment honestly or had the self-awareness to answer it correctly. Future research might apply the adaptive learning sequence system to a non-ESL reading class, to remediate disadvantaged readers, or to the teaching of other educational levels, such as junior high schools, senior high school or continuing education.

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Appendix

Handout C₁

Reading

1-ADBC

Main Idea and Details

- **Reading passages contain details, too. Names, dates, locations, times, colours, and sizes are types of details. The main idea expresses what the passage is about. The passage does not always include a statement of the main idea. Sometimes, you must put together the details in the passage to find the main idea.**
- Find details and the main idea in the passage below.

Two kinds of spiders weave thick white bands of silk across the centres of their webs. The purpose of the bands is to prevent birds and large insects from damaging the webs. The extra bands make the webs many times more visible.

Scientists discovered the purpose of the extra bands while observing the spiders in Florida. The scientist noticed that songbirds would change their flight directions suddenly just before flying into clearly marked webs. The white bands seemed to serve as

markers to warn off birds that might tear the webs. The birds themselves benefited from noticing the webs. Flying into the webs left their feathers covered with sticky threads.

The scientists believed that the clearly seen webs of the spiders also kept butterflies and other large insects from flying into the webs. The butterflies changed direction in front of the marked webs and flew over them.

1. The scientists discovered the purpose of the white bands on the webs by ____.
 - A. catching spiders and studying them
 - B. observing birds flying near the webs
 - C. comparing several kinds of spiders
 - D. making their own webs
2. According to the passage, the marked webs keep away ____.
 - A. all birds and insects
 - B. spiders and butterflies
 - C. birds and large insects
 - D. large and small insects
3. Which title is the best statement of the main idea?
 - A. 'Songbirds and Spiders'
 - B. 'How Spider Spin Webs'
 - C. 'Spider Webs Say, 'Keep Off' '
 - D. 'The Dangers of Spider Webs'
4. According to the passage, birds avoid the marked webs to ____.
 - A. keep their feathers clean
 - B. protect the spiders
 - C. assist the scientists
 - D. change their flight direction

*Check your answers. The correct matches are: **B** for 1, **C** for 2, **C** for 3, and **A** for 4.*

Vocabulary

Synonyms and Antonyms

- **Synonyms and Meanings**

Two words that have almost the same meaning are called 'synonyms'. The simplest way to explain the meaning of a new word is to use its synonym as a definition. For example, **despondent** and **depressed** are synonyms. One way to define **despondent** is to say it means "depressed."

- **Pick the answer that means the same as the word in dark type.**

1. **devised** an idea

A. concocted	B. answered	C. defended	D. dropped
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2. **respond** to a knock

A. listen	B. forget	C. refill	D. answer
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3. **prosper** and grow

A. prospect	B. succeed	C. fail	D. enlarge
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4. **rectify** the problem
 A. solve B. recoil C. correct D. actual
5. **exorbitant** prices
 A. extreme B. soft C. extra D. valuable
6. **blurry** photos
 A. sharp B. blue C. history D. fuzzy

Check your answers. The correct matches are: A for 1, D for 2, B for 3, C for 4, A for 5, and D for 6.

- **Antonyms and Meanings**

Some words mean just the opposite of each other. Two words that have opposite meanings are called antonyms. You can often use an antonym to help you understand and define an unfamiliar word. You can say that the new word means the opposite of its antonym.

For example, the words **indigent** and **wealthy** are antonyms. You know what **wealthy** means. You can figure out that **indigent** must mean “poor.”

- **Choose the answer that means the opposite of the word in dark type. Make sure you choose an antonym and not a synonym.**

1. **inexpensive** shoes
 A. expensive B. low-cost C. beautiful D. comfortable
2. **appears** at dawn
 A. arrives B. disappears C. waits D. sleeps
3. act of **fraud**
 A. kindness B. deceit C. truth D. greed
4. **resembles** the photo
 A. looks like B. wants C. looks unlike D. repairs

Check your answers. The correct matches are: A for 1, B for 2, C for 3 and C for 4.

Context Clues

- **Suppose you come across an unfamiliar word in your reading. You can make a good guess about the word's meaning, even without looking in a dictionary. You can look for meaning clues in the words and sentences that come before and after the new word. The meaning clues you can locate near a new word are called context clues.**

Clue 1: Definition Clue

Sometimes you will find the meaning of a new word given right before or after the word. The definition will be in the same sentence. Look for a definition clue below to help know what “**versatile**” means.

- Many people think that Mildred ‘Babe’ Didrikson Zaharias was America’s greatest female athlete. She was a **versatile**, or many-talented, performer. She won more than

50 major golf tournaments and was also one of the finest track stars in the world. In the 1932 Olympics, she won two gold medals and a silver medal.

*Check your answer. The words or **many-talented** come right after **versatile**. They tell you that **versatile** means “many-talented.”*

Clue 2: Series Clue

Sometimes a new word will be part of a group of words that go together. You can figure out the meaning of the new word by studying the other words in the series. Use a series clue to help you know what “**revered**” means in the following sentence.

- King Sobhuza’s people loved, honored, and **revered** him so highly that they didn’t oppose his actions.

*Check your answer. The other words in the series with **revered** help you to know that **revered** means respected.*

Clue 3: Synonym Clue

Sometimes you can spot a synonym of an unfamiliar word in a sentence near the one in which the new word appears. Look for a synonym below to help you define the word “**enlightened**.”

- King Sobhuza was a very **enlightened** ruler. Because he was so wise, he recognized the need to keep both traditional and modern ways in Swaziland.

*Check your answer. The synonym (wise) for **enlightened** used in the second sentence helps you know that **enlightened** means wise.*

Clue 4: Antonym Clue

Sometimes you can spot an antonym of a new word in a sentence near the sentence in which the new word appears. The antonym can help you define the unfamiliar word. Look for an antonym below to help you guess what “**incapable**” means.

- When Sobhuza II became King of Swaziland in Africa, he wasn’t able to read or write. He was even **incapable** of walking or talking.

*Check your answer. The antonym (able) for **incapable** used in the first sentence helps you know that **incapable** means unable.*

Clue 5: Experience Clue

Sometime you can guess the meaning of an unfamiliar word because the meaning makes sense to you. The meaning fits with things you know to be true about a subject. Use your experience to guess the meaning of “**shunned**” below.

- Because King Sobhuza was a polite, and humble man, he **shunned** his 12 million dollar palace and lived instead in a plain house across the street.

*Check your answer: Since the king didn't live in his palace, based on your experience you can guess that **shunned** means avoided.*

The First Mother's Day

Mother's Day is celebrated every year on the second Sunday in May. The **origin** of this holiday dates back to May 10, 1908. On that day, Anna May Jarvis held church services to honour her own mother, who had died two years earlier.

From this beginning, Anna started a national movement. She wrote to members of the United States Congress, stage governors, and other officials. She made the suggestion that one day be set aside each year for people to honour their mothers, living or **deceased**.

Anna's **proposal** caught on. In 1910, the governors of three states **proclaimed** an official Mother's Day holiday. The next year, every other state also declared the same holiday. In 1914, President Wilson asked people to fly the U.S. flag on Mother's Day to show love, respect, and reverence for their mothers.

At first, Anna May Jarvis was pleased to see how her idea had grown. But later, her happy feelings turned to **displeasure**. She had meant Mother's Day to be a religious holiday, but businesses were turning it into a **commercial**, or money-making, event. They began selling Mother's Day candy, flowers, greeting cards, and other **merchandise**. Anna spent the last 30 years of her life fighting to have Mother's Day celebrated in the spirit that she had originally intended.

- Since the story is about the first Mother's Day, you can guess that **origin** means ____.
A. conclusion B. holiday C. beginning D. last
- An antonym in the sentence helps you know **deceased** means ____.
A. dead B. friendly C. unhappy D. joyful
- Find **proposal** in the story. What synonym for proposal is used in the sentence before?
A. honor B. suggestion C. people D. demand
- Find **proclaimed** in the story, what synonym for proclaimed is used in the next sentence?
A. asked B. declared C. suggested D. shouted
- The other words in the series with reverence help you know **reverence** means ____.
A. holiday B. honor C. beauty D. disdain
- An antonym in the same sentence helps you know **displeasure** means ____.
A. unhappiness B. happiness C. love D. anger
- The words right after **commercial** help you know **commercial** means ____.
A. event B. religious C. money-making D. charitable
- The other words in the series with **merchandise** help you know merchandise means ____.
A. hands B. foods C. products D. toys

Check your answers. The correct matches are: C for 1, A for 2, B for 3, B for 4, B for 5, A for 6, C for 7, and C for 8.

Words with Several Meanings

- **A single word can have several meanings. You can find all the meanings listed in a dictionary entry for the word. You need to look carefully at how the word is used in a sentence or paragraph to determine which meaning fits in the reading.**
- Look at the four sentences below. The word **charged** appears in each one. In each sentence, **charged** has a different meaning.
 1. The landlord **charged** \$250 a month to rent the apartment.
 2. The club **charged** Anne with the responsibility of heading the committee.
 3. The officer **charged** that the man was driving without a license.
 4. The lion **charged** at the deer and captured it.

Here are four different definitions of **charged**. Each meaning fits the way the word was used in one of the sentences you just read. Decide which meaning fits in each sentence.

- A. rushed toward in an attack
- B. blamed or accused
- C. asked a price
- D. entrusted or gave a duty to

Check your answers. Notice the way ‘charged’ was used in each sentence. The correct matches are: C for 1, D for 2, B for 3, and A for 4.

Inference

- **The actions and details you see can help you make an inference about what you don’t see. When you make an inference in your reading, you find the meaning when it is not stated. Reading materials contain many details. You may not need to remember all the details, but you will need to understand the way they relate to each other. This will help you make inferences.**
 - Practise making inferences about the following. Read the test tips before you practise making inferences.
- Tip:** On a test, try reading the questions before you read. Then you will know which details to concentrate on.

Feeling sad is bad, right? Not always, says Randolph Neese, professor of psychiatry at the University of Michigan. Neese studies the connection between mood and goals.

He thinks emotional pain can be beneficial. For example, anxiety helps people avoid dangerous situations.

So how can sadness be helpful? Sadness may prevent people from making changes too impulsively, Neese theorizes. Changes involve risks. At times, it may be better to keep

things as they are. People who are sad often retreat to reflect on their problems. Reflective choices may be better than impulsive ones.

Some people treat emotional pain like a character defect. Neese suggests that may not be true.

The next time sadness colours your mood, stop and think. You may be getting a signal to take your time making important choices.

1. Neese disagrees with some other people about whether ____.
 - A. sadness is a true emotion
 - B. deep depression should be treated
 - C. sadness is a character defect
 - D. sadness leads to emotional pain
2. Neese would probably think that jealousy may be ____.
 - A. beneficial
 - B. a character defect
 - C. a true emotion
 - D. negative
3. If Neese's theory is correct, ____.
 - A. it's always a good idea to push away negative emotions
 - B. anxiety is useful in all situations
 - C. depressed people are impulsive
 - D. negative emotions may sometimes serve useful purposes
4. Details in the passage suggest that Neese's theory is
 - A. quackery
 - B. new
 - C. dangerous
 - D. proven

Check your answers. The correct matches are: C for 1, A for 2, D for 3, and B for 4.

Critical Reading

- **Reading an article is different from reading an X-ray, but the same kinds of questions are important. What is the purpose of the article? What opinions are given, and how are they supported? Thinking about such questions as you read is called critical reading.**
- Practise your critical-reading skills in the following. Read the test tip before practising your critical-reading skills.
Tip: An incorrect answer choice on a test is often partly true, but not entirely true. Be sure to choose the best answer of the four.

When you think of potato chips, do you think about the mouth-watering flavour? Or do you think about the fat? Maybe you think about both. For years, researchers searched for a fat replacer. They finally found one in olestra.

What exactly is olestra? It's a nonfat cooking oil, one that adds no fat or calories. Olestra begins as a vegetable oil, such as soybean or cottonseed. Sugar is added, but maintains the flavour and texture of a fatty substance. When you eat olestra, your system doesn't absorb fat or sugar.

At first, people worried about huge problems digesting olestra. But studies showed that these huge problems did not exist. The Food and Drug Administration (FDA) examined more than 150 studies and 150,000 pages filled with information regarding olestra. In 1996, the FDA approved olestra for use in salted snacks.

1. Olestra is a ____.
 - A. fat
 - B. sugar
 - C. fat replacer
 - D. calorie
2. The FDA examined ____.
 - A. fewer than 100 studies regarding olestra
 - B. more than one-quarter million pages of information regarding olestra
 - C. more than 150 studies and 150,000 pages of information regarding olestra
 - D. more than 100,000 studies regarding olestra
3. The main purpose of the article is to ____.
 - A. give details about olestra as a fat replacer
 - B. encourage people to lose weight
 - C. encourage people to eat more chips
 - D. describe the FDA
4. Based on the article, you can assume that ____.
 - A. olestra is not a good product
 - B. the FDA looks at many documents before approving a new product
 - C. olestra is unhealthy
 - D. olestra has exactly the same effects as fat

Check your answers. The correct matches are: C for 1, C for 2, A for 3, and B for 4.

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