Explore Behavior Pattern in an Associated AR English Learning System Consider Different Human Factors

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Abstract

In this study, an associated AR English learning system (AES) was developed for elementary children. Different from a general AR English learning system, when learners scan the AR target object, AES will provide associated virtual learning materials with the target object, including vocabulary, phrase and example sentences. At the same time, all the operational processes of the learner will be recorded in database within coding scheme by the system. The aim of this research is exploring learners' behavior differences through analyzed their behavior log considering the human factors with gender and prior knowledge. One thing worth noting is, according to the result of the analysis, we found that learners can get a better performance in class when they are learning with an associated AR English learning system than a general AR English learning system. In addition, through observe the behavior pattern associated graphs, we found that female learners lost the scan directions of AR learning target more often than male learners. However, the female learners learning with an AR target more carefully and detailed than male learners. According to the results of this study, it is shown that when learning English through AR technology, the gender difference is an important impact factor. Therefore, when teachers and AR developers want to use AR to assist English learning in the future, they must pay special attention to this.

Keywords: Learning behavior, Augmented reality, English learning, Human factors

1 Introduction

Language is the most essential medium of interpersonal communication. In the global era, English has become the common language of international communication [1]. Taiwan is an EFL (English as Foreign Language) English learning environment. However, in the general English teaching environments, teachers usually just explain the contents of textbooks orally [2], which is a kind of passive learning [3]. For the learning, especially language learning, this kind of learning method does not enable learners to effectively apply what they have learned to life. In other words, if the teacher only teaches through lectures, it will not be able to effectively attract the learners' attention and concentration, which will affect the memory of the learning content [4]. According to above, some studies have pointed out that it is very important to change teaching methods and strategies to increase learners' motivation and interest when students learning English [5]. Additionally, the most important thing is that let learners can make different types of knowledge meaningful in the process of learning, and establish relevance in real life [6]. In this way, learners can truly experience how to apply what they have learned [7].

Augmented Reality (AR) is a technology that combines virtual information with real images [8]. This technique allows the learning process to better meet the principles proposed by Mayer [9]. The other literature has also indicated that AR-based learning is merging by two theories, experiential learning and contiguity principle of multimedia learning [10]. At the same time, many studies have pointed out that the effective application of AR in education can definitely improve students' interest in learning, attention and learning efficiency [11-12]. As AR features visualization and interactivity, it has great potentiality for enhancing EFL learning [13]. As a matter fact, there were various English learning AR applications have been developed and used in English learning courses, but most of the research in this field has focused on English vocabulary learning. Then, students who study only English vocabulary may not be able to establish the relationship between words, phrases and sentences [14]. That is to say, the problem raised by Knobelsdorf [6] still exists, and learners can't make different types of knowledge into meaningful content in real life during the learning process.

Furthermore, in the past studies, language learning using augmented reality mostly explored the differences in learning motivation and learning effectiveness of learners under the influence of different teaching design methods. The impact of human factors (such as gender and prior knowledge) in this kind of AR teaching environment is rarely discussed. That is to say, the related AR researches of explore these influencing factors as same as "sleeping beauties" that they did not receive proper attention at the time of publication unfortunately [15]. However, the impact of these important factors has the opportunity to be verified in other ways, and may arouse the general attention of educators. For instance, previous researches on gender differences and prior knowledge may only focus on learners' learning motivation or learning achievements, but in addition to the quantitative results of the questionnaire, if the other learning data of learners in the learning process can be analyzed together, the teacher can better understand the learning status of each learner [16].

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There are few studies have explored the behavioral process of learners in the procedure of using AR to learn English. If the learner's behavior can be analyzed in more detail, the teacher can further adjust the appropriate teaching methods or content for the learner, and can also further improve the system of applying AR in language learning to obtain better teaching results.

Considering all the factors mentioned above, this study developed an Associated AR English Learning System (AES). Students can learn words, phrases and sentences by scanning the images of teaching material in the textbook or some real objects in classroom. Different from the General AR English Learning System (GES), in addition to the virtual text teaching materials in the AES system, virtual objects related to the scanned target and extended teaching materials will be additionally displayed. Learners can also adjust the difficulty of learning contents according to their own preferences. In the same time, all the operations will be recorded in the database and numbered for the behavioral analysis later. Then, several research questions were proposed in this study as follows:

(1) Which kind of AR system can make learners have better learning performance, between AES and GES?

(2) Whether the human factors of gender will affect behaviors when students learning English with an AR learning system or not?

(3) Whether the human factors of prior knowledge will affect behaviors when students learning English with an AR learning system or not?

2 Literature Review

2.1 The Applications of AR Technology on Education

AR technology can superimpose images, objects and scenes generated by computers into real environment. In the other words, the virtual objects can be added to the real environment, and user can interact with them. This technology must have 3 characteristics: "combine the virtual and the real world", "be able to interact immediately", "be necessary in 3D space" [8]. Milgram, Takemura [17] regarded real and virtual environments as a closed set as shown in Figure 1. The left side is a purely real environment and the other side is a purely virtual environment.

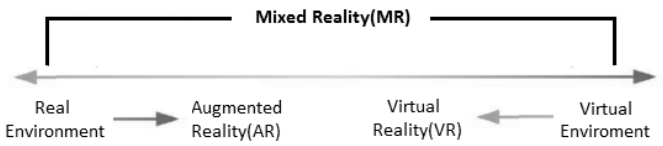

Figure 1. The definition diagram of real and virtual performance [17]

In the previous researches, there have been many studies show that AR applications in education have various advantages. For example, learning based on AR technology can make learners' learning experience more interactive [18]. Moreover, learning with AR applications can increase learners' learning motivation and result in higher learning achievement [19-21]. Because of these advantages, AR is also used in a variety of fields, such as medicine [22], and mathematics [23-24]. At the same time, there are also many studies that apply AR to English learning [25-26].

However, according to the results of a systematic review [27], we found that most of the AR studies apply in Language learning use the interesting provided by AR, to reduce learners' cognitive load and improve learners' learning motivation and learning effectiveness. Or, combine AR with different learning strategies to improve students' learning performance. However, in these studies, there is no more detailed analysis of learners' learning behavior when they learning through AR technology. Besides, the individual differences between learners are also ignored but these factors may affect learners' learning achievement.

Therefore, this study will develop an AR English learning system, in addition to the vocabulary learning materials, it also contains related content of phrases and example sentences, so that learners can have wider associations and applications when learning vocabulary. Further, this system will record all learners' behavior in database during the learning procedure. In this way, we can analyze the differences through behavior data between different individual learners.

2.2 The Influence of Human Factors in Learning

Previous study have pointed out that the important human factors include: gender differences, prior knowledge [28]. Chen, Wang [29] have indicated that gender difference may occurred under specific learning conditions when they are learning English. For example, if there are tips for subtitles, female learners usually perform better than male learners. Same times, in the part of motivation, female learners will also be much higher than that of male learners. Such results are consistent with previous studies, if the environment with too much information, male learners lead to worse learning efficiency [30].

In other hands, Lin, Hwang [2] indicated that when using contextual game-based learning approach in English grammar learning, the high- and low-achieving students had different learning preferences and behavior. The high-achieving students preferred to collect information systematically to help them complete the learning tasks, but the low-achieving students could not seek help strategically, lead to frequent failure to complete learning tasks. These results show that different genders and the level of prior knowledge may affect learners' behavior or learning achievement when learning English [13]. Therefore, if we can analyze the behavioral data between different genders and prior knowledge students and find out the difference, then teacher can adopt more appropriate teaching strategies for learners with different characteristics.

2.3 Learners' Behavioral Patterns

Behavioral patterns refer to the sequential relationships between each type of coded discussion content and can be determined by calculating the statistical significance of a behavioral sequence of one certain behavior followed immediately by another. Lag sequential analysis (LSA) helps researchers to examine the statistical significance of a certain behavior being followed by another and a visualized diagram of behavioral patterns can be inferred by using this method. Behavior transforms patterns refer to the sequential

relationships between each type of coded topics. It can be determined by calculating the statistical significance of a behavioral sequence of a certain behavior followed instantly by another [31].

Interestingly, in the past, most of researches on English learning have used different learning strategies as impact factors to observe the behavioral patterns of learners. However, if educators only analyze their behaviors with some learning strategies but did not consider students' personal differences, it may not achieve the best teaching improvement. So, this study explored learners' behavioral patterns with a particular focus on difference of learners' gender and prior knowledge.

3 Associated AR English Learning System

In this study, a GES was developed at first. Learners can use this system to scan pictures in textbooks, or real objects in the classroom to learn English vocabulary. And then, an ARS was developed based on GES. The biggest difference from the GES system is that when learners scan the textbooks or real objects in the classroom, the system will superimpose a virtual object related to the real object on the screen. In addition, in the AES system, additional related sample phrases and example sentence materials have also been added. All of these teaching materials are provided by an English teacher with more than ten years of teaching experience.

The operation of the system, students only need to install the AR English learning system to a smart phone or a tablet PC, and login the system with their account and password. When login system successfully, students can check the system explanations through click the explain function button on the bottom right of the screen first. Then, students can according to their preferences to set up some settings in the system, such as the degree of the learning difficulty, and pronunciation voice. The user interface of the system settings and system explanation content as shown in Figure 2.

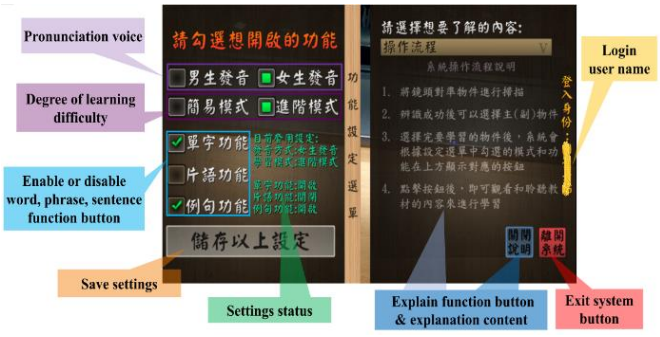

Figure 2. The user interface of the system

To start learning English, students need to scan the learning target which is a real object in the class or a picture in the English books content. When the identification is completed, the interactive learning in the real object and the virtual teaching material will be conducted. The operating procedures of the AR English learning system is shown in Figure 3.

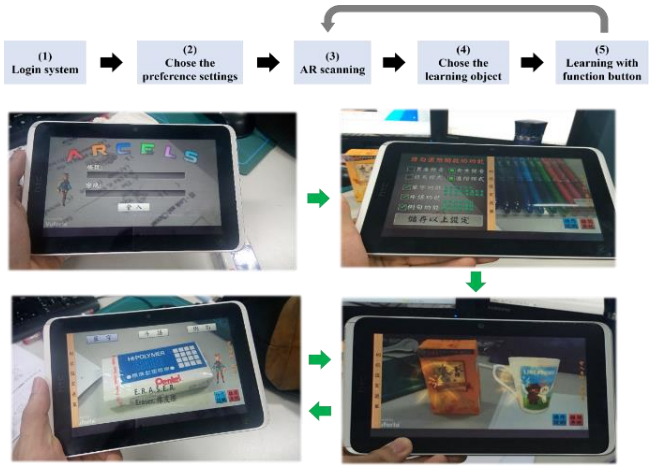

Figure 3. The operating procedures of the AR English learning system

As stated above, after students scanning the AR learning target with a successfully identify, the system will show the main learning object material (a real object in the class) and related learning object material (a virtual object which is combining through AR) on the screen with shining effects. Then, students can click the object they want to learn, and the function button will appear on the top center of the screen, the process of operation as shown in Figure 4.

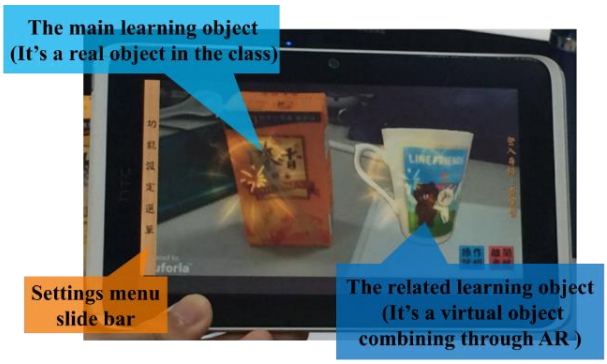

Figure 4. The procedure of learning object selection

When learners click the function button of "word", the system will first split the word into letters and read out each letter. Then, the word will be read out once. Then, the Chinese meaning will be explained using Chinese voice. If learners click the function button of "phrase", the teaching material of phrases will appear on the screen. Then, the phrase will be read out using English and the Chinese meaning will be explained using Chinese voice. In addition, the system will give simple phrase in the easy mode and give more difficult phrase in the advanced mode. Final, while learners click the function button of "sentence", the teaching material of sentences will appear on the screen. Then, the sentence will be read out using English and the Chinese meaning will be explained using Chinese voice. According the easy or advanced mode, the degree of difficulty of the sentence is also different. The illustration of function button is as shown in Figure 5.

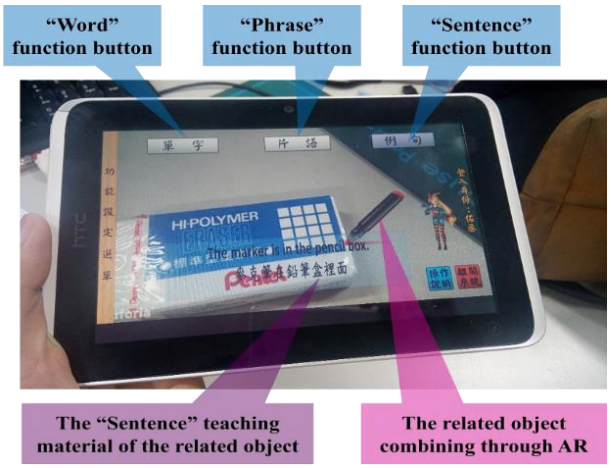

Figure 5. The illustration of sentence function button

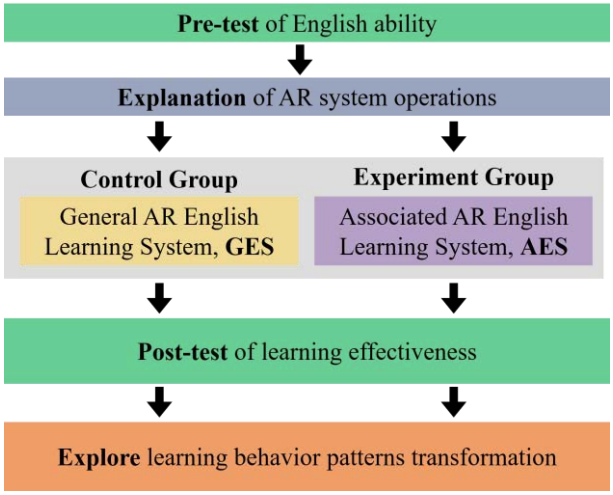

Figure 6. The illustration of experiment procedure

Figure 7. The process of the experiment in classroom

4 Research Design

4.1 Participants

There are totally 4 classes about 82 fifth grade elementary school students whose average age was 11 participated in this study. They were learning English as a Foreign Language and studied English for three hours per week in central Taiwan. A total of 40 students in two classes were assigned to be the experimental group, and 42 in other two classes were the control group. The four classes were taught by the same English teacher, a female teacher with more than ten years of elementary school teaching experience. All students had had previous experience of using a tablet personal computer.

4.2 Experimental Procedure

The overall procedure of this study is presented in Figure 6. Before the learning activity, all students took the pre-test of English ability. The length and frequency of teaching experiments in the two group were the same. The experiment lasted a total of two weeks, there are six classes a week, and each class is about 45 minutes.

During the experiment, students in both groups will use tablet to scan about 50 AR targets of learning objects. However, learners who use the GES system in control group will only learn the original materials and examples in the textbook. On the contrary, in addition to the original materials and examples in the textbook, learners using the AES system will also display additional vocabulary, phrases, and example sentences of virtual related learning objects. The process of the experiment is as show in Figure 7.

After two weeks of teaching experiment, we took the post-test of English ability. Then, according to the behavior data left by the learners in the process of the experiment, the behavioral pattern analysis is carried out. Finally, we will explore the differences in learning behavior patterns among learners of different genders and prior knowledge.

5 Results and Analysis

5.1 Learning Effectiveness between Control Group (GES) and Experiment Group (AES)

As show in Table 1, the mean values and standard deviations of the pre-test score in control group (CG) are 71.17 and 18.99, while those in the experiment group (EG) are 65.40 and 18.12. The *t*-test result ($t = 1.41$, $p > 0.05$) shows that there was no a significant difference between the prior knowledge of the two groups of students. Further, the mean values and standard deviations of the post-test score in control group (CG) are 86.24 and 15.73, while those in the experiment group (EG) are 86.50 and 13.42. The *t*-test result ($t = -0.81$, $p > 0.05$) shows that there was still no a significant difference between the learning effectiveness of the two groups of students.

Table 1. The *t*-test result of the pre-test and post-test scores of the two groups

	Group	N	Mean	SD	*t*
Pre-test	CG	42	71.17	18.99	1.41
	EG	40	65.40	18.12	
Post-test	CG	42	86.24	15.73	-0.81
	EG	40	86.50	13.42	

To answer the research question 1, and in order to understand the differences in learning effectiveness between CG and EG more objectively, the one-way analysis of covariance (ANCOVA) was employed. In ANCOVA analysis, it using the pre-test scores of learning achievement as the covariate, the learning system as the independent variable, and the post-test scores as the dependent variable. Before conducting the analysis of covariance (ANCOVA), it should check that there was no violation of the assumption of homogeneity of regression first. Then, there was no significant difference in the homogeneity of regression (F=2.21, p>0.05), indicating that the two groups of students had similarity prior knowledge of the English word, phrase and sentences before the learning activity. This result is also consistent with the t-test result in Table 1.

Moreover, as shown in Table 2, the results show that the mean score and adjusted mean score of the CG are 86.24 and 84.53 respectively, while the mean score and adjusted mean score of the EG are 86.50 and 88.29 respectively. Excluding the impact of the pre-test score on the post-test, there was still no a significant difference between the two groups (F=3.19, p>0.05).

Table 2. ANCOVA result of the learning effectiveness post-test of the two groups

Group	N	Mean	SD	Mean (adj.)	SE	F
CG	42	86.24	15.73	84.53	1.46	3.19
EG	40	86.50	13.42	88.29	1.50	

Although there were no significant differences of the learning effectiveness in t-test and ANCOVA between CG and EG learners. But as show in Figure 8, when the average score of pre-test and post-test presented on the line chart according to the t-test result in Table 1, we can find the progress rate in EG is higher than CG. The result means that learners who learning English with the AES in EG still have more learning effectiveness than a general AR English learning system.

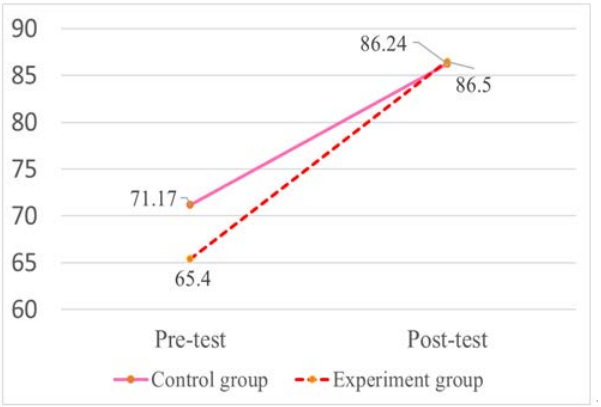

Figure 8. The comparison of progress rate between CG and EG

5.2 Behavioral Pattern Analysis

During the learning activity, the students' learning behaviors were all automatically coded and recorded in the system. The definition of the code, and examples are presented in Table 3.

Table 3. The coding scheme and the definition for learning behaviors in the system

Code	Behavior Description
M	Change learning mode
V	Change pronunciation voice
W	Open or close 'Word' function
P	Open or close 'Phrase' function
S	Open or close 'Sentence' function
H	Read explanation document
SH	Open or close 'Explanation UI'
C1	Select 'Main' learning object
C2	Select 'Related' learning object
B1	'Word' function button clicked
B2	'Phrase' function button clicked
B3	'Sentence' function button clicked
X	Other

To answer the research question 2, the sequential analysis was adopted in this study to explore whether the human factors of gender will affect behaviors when students learning English with an AR learning system or not? According to the history data recorded in database, there were 44 male students who performed about 15514 behaviors, and 38 female students who performed about 8361 behaviors in the AES.

So, in the first step, we have to calculate the probability of sequence occurrence between two different behaviors by using equation **(1)**. According to this equation, "s" represents a starting behavior code, "e" represents an ending behavior code, and "Ns" represents the sum of the number of occurrences from "s" and "e".

$$p(s,e) = \frac{f(s,e)}{Ns} \quad \textbf{(1)}$$

However, the above calculation is the expected probability of the occurrence of the included behavior sequence. So, the second step we must calculate the residual value by equation **(2)**. The residual value represents the difference between the number of actual occurrence and the number of expected occurrences of which behavior sequence.

$$f(s,e) - f(s)p(e) \quad \textbf{(2)}$$

And then, we need to adjust the calculated residual value by equation (3) to a Z-score. According to these two equations, "$f(s,e)$" represents the actual number of occurrences from behavior "s" to behavior "e". "$f(s)$" means the total number of behaviors "s", "$p(e)$" means the probability of behavior "e" occurring.

$$\frac{f(s,e)-f(s)p(e)}{\sqrt{f(s)p(e)[1-p(s)][1-p(e)]}} \quad \textbf{(3)}$$

If a Z-score greater than 1.96, then the trust level of the behavior sequence is as high as 95%. In other words, this also represents a significant level of occurrence of the sequence of behaviors.

Finally, all the behaviors were processed with sequential transition matrix calculations, which are presented in Figure 9 and Figure 10.

Z-score	M	V	W	P	S	H	SH	C1	C2	B1	B2	B3	X
M	-7.81	-7.81	124.56*	-7.8	-7.8	-2.37	-7.29	-8.56	-9.86	-21.29	-13.02	0	-4.5
V	124.56*	-7.81	-7.81	-7.8	-7.8	-2.37	-7.29	-8.56	-9.86	-21.29	-13.02	0	-4.5
W	-7.81	-7.81	-7.81	124.48*	-7.8	-2.37	-7.29	-8.43	-9.86	-21.29	-13.02	0	-4.5
P	-7.8	-7.8	-7.8	-7.8	124.56*	-2.37	-7.28	-8.55	-9.85	-21.28	-13.01	0	-4.49
S	-7.79	21.78*	-7.79	-7.78	-7.78	-2.36	51.92*	9.92*	7.87*	-21.17	-12.89	0	3.37*
H	-2.37	-2.37	-2.37	-2.37	-2.37	21.8*	31.38*	-2.6	-2.99	-6.46	-3.95	0	0.89
SH	-7.46	98.62*	-7.46	-7.45	-7.45	32.05*	2.34*	-7.76	-9.42	-20.34	-12.43	0	-4.04
C1	-8.57	-7.77	-8.57	-8.57	-8.57	-2.6	-5.73	8.69*	-5.8	27.62*	-4.14	0	-4.05
C2	-9.9	-9.78	-9.9	-9.89	-9.89	-3	-3.58	-1.36	22.85*	19.34*	-6.25	0	-2.55
B1	-21.28	-21.28	-21.28	-21.26	-21.26	-6.46	-8.1	14.51*	13.87*	53.66*	-12.35	0	-6.76
B2	-13.02	-13.02	-13.02	-13.01	-13.01	-3.95	-8.78	-2.24	-5.05	-16.83	78.6*	0	-3.66
B3	0	0	0	0	0	0	0	0	0	0	0	0	0
X	-4.2	-4.2	-4.2	-4.19	-4.19	-1.27	8.69	-1.03	0.19	-11.45	-7	0	78.85*

Figure 9. The results of sequential analysis of behaviors with male users

Z-score	M	V	W	P	S	H	SH	C1	C2	B1	B2	B3	X
M	-6.23	-6.23	91.44*	-6.23	-6.22	-1.87	-5.76	-8.77	-9.07	-13.69	-7.97	0	-3.95
V	91.44*	-6.23	-6.23	-6.23	-6.22	-1.87	-5.76	-8.77	-9.07	-13.69	-7.97	0	-3.95
W	-6.23	-6.23	-6.23	91.44*	-6.22	-1.87	-5.76	-8.77	-9.07	-13.69	-7.97	0	-3.95
P	-6.23	-6.23	-6.23	-6.23	91.35*	-1.87	-5.57	-8.77	-9.07	-13.69	-7.97	0	-3.95
S	-6.21	16*	-6.21	-6.21	-6.21	-1.87	32.95*	1.07	8.09*	-13.66	-7.95	0	0.23
H	-1.87	-1.87	-1.87	-1.87	-1.87	13.87*	21.65*	-1.77	-2.3	-4.11	-2.39	0	0.56
SH	-5.92	72.02*	-5.92	-5.92	-5.91	24.06*	1.28	-8.34	-8.63	-13.02	-7.58	0	-3.18
C1	-8.79	-8.51	-8.79	-8.79	-8.78	-2.64	-6.66	2.5*	-9.15	36.36*	-0.81	0	-5.16
C2	-9.13	-8.86	-9.13	-9.13	-9.12	-2.74	-3.57	-6.6	7.8*	25.38*	4.34*	0	-3.76
B1	-13.68	-13.58	-13.68	-13.68	-13.67	-4.11	-2.34	27.74*	20.5*	10.48*	-8.15	0	-2.07
B2	-7.96	-7.96	-7.96	-7.96	-7.96	-2.39	-1.79	0.02	1.77	-11.77	48.96*	0	0.6
B3	0	0	0	0	0	0	0	0	0	0	0	0	0
X	-3.62	-3.62	-3.62	-3.62	-3.62	-1.09	3.11*	-1.23	0.5	-7.96	-4.63	0	54.93*

Figure 10. The results of sequential analysis of behaviors with female user

In these two tables, the letters in row means the starting behavior and the letters in column means the consequent behavior. A Z-score greater than 1.96 implying that the consequent relationship between the two behaviors is significant [31]. For example, for the starting behavior S (i.e., "Scanning the AR learning target"), the Z-scores for S→V (i.e., "Change pronunciation voice") and S→SH (i.e., "Read the system explanation documents") are larger than 1.96, and hence are marked with a "*" to point out the significance of the sequential relationship.

And then, based on the contents in Figure 9 and Figure 10, we can convert it into behavioral transition diagram, as shown in Figure 11 and Figure 12.

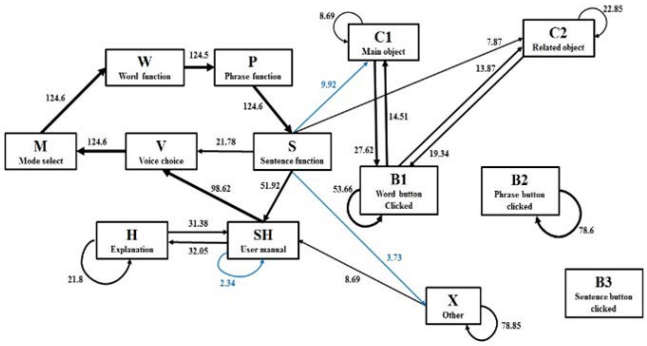

Figure 11. The behavioral transition diagram of the male students

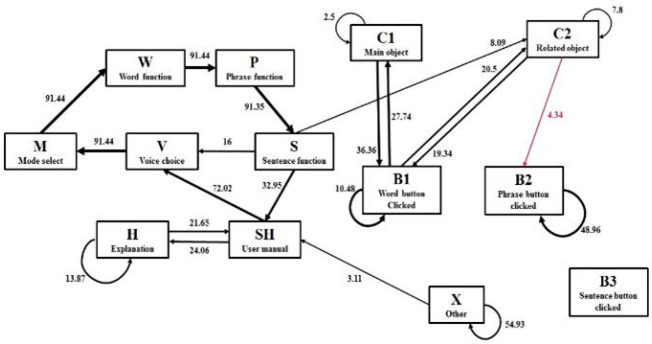

Figure 12. The behavioral transition diagram of the female students

According to the Figure 11, we can find that there is a significant difference between male and female learners in the behavioral transition S→C1. This situation means that male learners are more active than female in finding the next AR learning target. In addition, there is also a significant difference in the behavioral transition S→X between male and female learners. This also means that male learners are more likely to deviate from the main links of learning than female learners. According to the Figure 12, we can also find that the concentration of female is different from that of male learners too. Because female learners are more likely to look at the relevant objects of the phrase teaching materials (C2→B2). So, according to this result, some tips for recommended learning can be further designed for male learners in the future, to improve the fineness of their learning in this kind of AR English learning system.

In the end, unfortunately, after the LSA analyzing on behavior history data, there is no significant difference in behavior transition between the high and low prior knowledge learners.

6 Discussion and Conclusions

6.1 Research Limitation

To avoid teaching experiment conflict with original course schedule, researchers discuss the experiment procedure with an English teacher who have the teaching experience more than 10 years. Researchers also discuss with English teacher for the learning materials (i.e., English words, phrase, and sentences, learning materials difficulty classify) of the system development. The participants of this study were fifth grade students in the middle Taiwan.

However, because the human resources, location, and times are limited. It is very difficult to do a teaching experiment at the same time with the same grade students. So, there were only 82 students as participants and divided into experimental group and control group in this research.
Besides, the results from learners' behavioral history data analysis only apply to the English teaching mode using the AR technology. If the learning subjects other than English, it may get different results. Finally, participants in this research were children come from central city. So, it may also case different outcomes if the participants come from remote area.

6.2 Conclusions and Future Work

Based on the results of the experimental analysis, although there is no significant difference between the experimental group and the control group in quantitative verification, but we still found that the experimental group using the AES had a better improvement in learning performance. If the study can increase the number of participants and prolong the time of teaching experiments in the future, maybe it will have a better chance of comparing significant differences.

Besides, this research also analyzed the learners' behavioral historical data through lag sequential analysis (LSA) method, to explore what are the differences of patterns in the learning process between different gender and English prior knowledge level. Based on the behavioral transition diagram of male and female learners, in the process of learning English with AR, there are truly have some significant differences in operational behavior between different genders. First, the attitude of male learners is more active than that of women when they look for each AR identification target. However, male learners are more likely to deviate from the main links of learning than female learners. That is to say, after scanning the new AR learning object, the primary direction of male learners is not to check at the learning materials, but to do other things. In the contrast, according to the results of the behavioral transition diagram, we can know that women are much more focused on learning than male, because girls are more likely to look at the relevant objects of the phrase teaching materials. Therefore, it is suggested that in the design of this type of AR English learning system in the future, some tips for recommended learning can be designed for male users to improve their concentration.

In addition, C1→C1 and C2→C2 can be found in the behavior sequence transformation diagram of both male and female learners. The condition of these two situations represents the identification condition that may be scanned when learning with AR, which still needs to be improved. That is to say, the identification of AR will be unstable, resulting in the disappearance of expanded virtual information to rescan the identification. Therefore, when using AR for teaching in the future, this is a key point that can't be ignored.

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