Exploring Learning Behavior Transformation Patterns in an AR English System: A Study of Gender Differences

Yu-Che Huang[1], Ting-Ting Wu[2], Yueh-Ming Huang[1] and Frode Eika Sandnes[3]

[1] National Cheng Kung University, Tainan 701, Taiwan ROC
[2] National Yunlin University, Yunlin 64002, Taiwan ROC
[3] Oslo Metropolitan University, Oslo, Norway
`featherflew@gmail.com`

Abstract. The aim of this research is to explore learners' learning behavior differences in a customized augmented reality (AR) English learning system (CARELS) by analyzing the learners' behavioral history. The results show that male learners lost the scan directions of AR learning targets more often than female learners, while female learners learning in one AR target was more careful and detailed compared to male learners. One implication of these results is that researchers should consider the gender difference, and give adaptive feedback or teaching materials when designing this type of AR English learning system.

Keywords: Learning Behavior, Augmented Reality, English learning, lag sequential analysis.

1 Introduction

Language is the most essential medium of interpersonal communication. In the era of globalization, English has become the most common language of international communication [1]. English is also the mainstream language of the world today [2], there is no doubt that English proficiency is an important communication skill. Taiwan is an EFL (English as Foreign Language) English learning environment. According to the education curriculum outline published by the Ministry of Education of Taiwan, children start taking formal English courses from 3rd grade [3]. However, in the traditional English teaching environments, teachers usually explain the static contents of the textbooks in a passive learning process [4]. This way of learning makes it hard for learners to effectively apply what they have learnt to real life, and this situation still needs to change. In recent studies many scholars have pointed out that it is important to change the teaching methods and strategies to increase the motivation and interest of learners to learn English [5, 6]. Moreover, it is crucial that different types of knowledge become meaningful and better connected to real life during the learning process [7]. In other words, the influences of learning scenarios are of vital importance for EFL learners [8]. According the *Spatial Contiguity Principle* and *Temporal Contiguity Principle* of 12 multimedia design principles proposed by Mayer [9]

corresponding and associated information can be generated immediately besides the learning object. Augmented reality (AR) is a technology that combines virtual information with the real-world image [10]. This technology allows the learning process to better meet the principles proposed by Mayer [9].

2 Literature review

2.1 AR applied to education

AR involves importing the images, objects, and scenes generated by computers to the real environment. Its purpose is to enhance the effect of perception. That is, the virtual objects are added to the real environment. This technology must have three characteristics: (a) combine the virtual and the real world, (b) be able to interact immediately, (c) be necessary in 3D space [10]. Milgram, Takemura, Utsumi, and Kishino [11] regarded real and virtual environments as a closed set as shown in Figure 1. The left represents a purely real environment and the right represents a purely virtual environment. Virtual reality attempts to replace the real world, while augmented reality involves augmenting the virtual picture generated by computers into the real environment.

Fig. 1. The definition of AR proposed by Milgram et. al [11].

There are many applications of AR technology to language learning. For example, Hsieh and Lin designed an AR system for English vocabulary learning which had immersive learning outcomes. The experimental results showed that the learners were willing to use the system. Chang, Chen, Huang and Huang also built an AR game-based English vocabulary learning system. The above two English vocabulary learning systems are both based on AR technology, but the methods are different. The former used English vocabulary magic books so that learners could scan the learning objects in the books while the latter scanned the 3D learning objects directly to conduct learning. The advantage of the latter is that it can scan real objects in a real environment. It does not need extra teaching objects. However, the above teaching systems are all only for simple English words or vocabulary. The applications of related words or example sentences are lacking. In addition, it is inconvenient as additional objects are required. Therefore, we developed a customized English learning system based on AR technology. It is hoped that through the combination of the real situation and the virtual information, the learning motivation and effectiveness of learners can be enhanced.

2.2 The influence of human factors in learning

It has been pointed out that important human factors include: gender differences, prior knowledge and cognitive style [12]. The results of the experimental analysis show: female learners more often and easily lose the direction of the problem than male learners. Expert learners like to learn with flexible learning paths, while structured content is more conducive among novice learners. In addition, people with different cognitive styles like to use different search strategies [17]. Thus, the aim of this study was to explore learners' learning behavior through the lag sequential analysis (LSA) method, with particular focus on gender differences.

2.3 Learners' behavioral patterns

Cheng and Tsai [13] pointed out that analysis of learners' learning behaviors is considered as an effective method for understanding how students behave in detail. It ha been suggested to explore and analyze learning behaviors with different learning performance of learners, to understand what the key points cause the difference between high and low achieving learners [14-16]. Lag sequential analysis (LSA) can helps researchers to examine the statistical significance of a certain behavior being followed by another behavior, and a visualized diagram of behavioral patterns can be rendered using this method [17]. Behavior transform patterns refers to the sequential relationships between each types of coded topics. It can be determined by calculating the statistical significance of a behavioral sequence of a certain behavior followed instantly by another. Interestingly, there is much research that explore learners' behavioral patterns in different types of learning systems, but usually they focus on the relationship of learning effectiveness between control groups and experiment groups, which is only learning using different learning strategies. That is to say, most studies usually discusses the differences of learner's behavior on the learning strategies topic in kinds of learning system.

However, if educators only teach students and analyze their behaviors with some learning strategies but did not consider students' personal differences, it may not achieve the best teaching improvement. This study therefore explored learners' behavioral transform patterns with a particular focus on gender difference.

3 Research method

3.1 Customized AR English learning 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 2.

Fig. 2. The operating procedures of the AR English learning system.

As stated above, after students scan the AR learning target, 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 word, phrase or sentence function button will appear on the top center of the screen, the process of operation as shown in Figure 3.
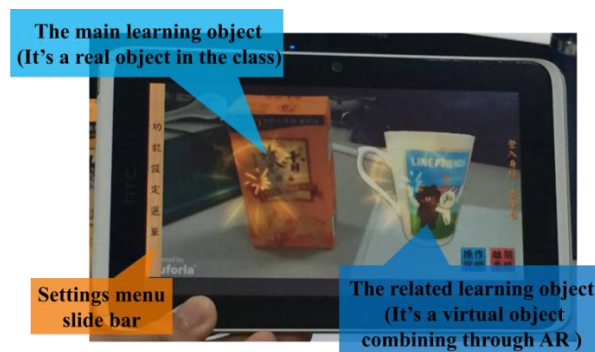
Fig. 3. Learning object selection.

When learners click the "word" button, the system will first split the word into letters and read out each letter. Then, the word will be read out once. Next, the Chinese meaning will be explained using a Chinese voice. If learners click the "phrase" button, the teaching material of phrases will appear on the screen. The phrase will be read out loud using English and the Chinese meaning will be explained using Chinese. In addition, the system gives simple phrases in the easy mode and give more difficult phrases in the advanced mode. Finally, while learners click the "sentence" button, 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. Such design is to meet the *Modality Principle* of 12 multimedia design principles proposed by Mayer [9]. The design allows the learners to use auditory and visual senses to receive a single message. This interface is shown in Figure 4.
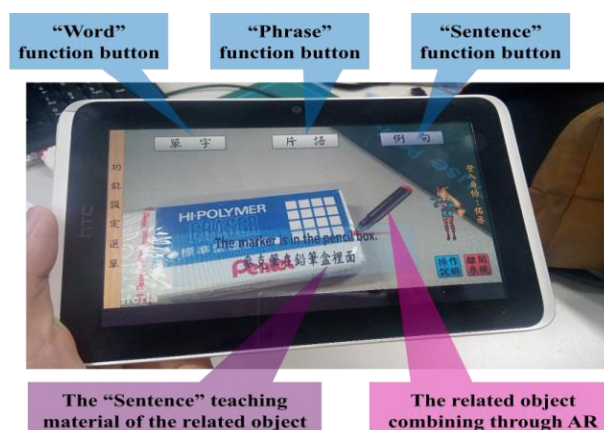

Fig. 4. The illustration of sentence function button.

3.2 Coding scheme and behavioral data collection

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 1.

Table 1. The coding scheme and the definition for learning behaviors in the system.

Code	Behavior
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

3.3 Experiment participants

There were a total of 4 classes with about 82 fifth grade elementary school pupils whose average age was 11 who participated in this study. Of these 44 were male and 38 were female. In addition, they were learning English as a Foreign Language (i.e., EFL) and studied English for three hours per week in central Taiwan. 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 previous experience of using a Tablet Personal Computer and were familiar with using their fingers to draw on a tablet.

4 Experiment Results

Based on the frequency transition tables, we then conducted sequential analysis and further determined whether the connection between each sequence reached statistical significance. The Z-score value of each sequence was calculated to determine whether the continuity of each reached the level of significance and a Z-value greater than +1.96 indicates that a sequence reaches the level of significance ($p < .05$) [17, 18]. In that case, the codes obtained from the male students and female students yielded the adjusted residuals tables (see Tables 2 and 3).

Table 2. 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	-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	3.73*
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*

$*p < 0.05$.

Table 3. The results of sequential analysis of behaviors with female 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*

$*p < 0.05$.

Furthermore, we deduced the behavior-transfer diagrams between male and female students, which are presented in Fig. 5, respectively. This figure illustrates all sequences that have reached significance and the numerical values in the figures are the sequences' Z-scores and the arrow indicates the direction of transfer for each sequence.
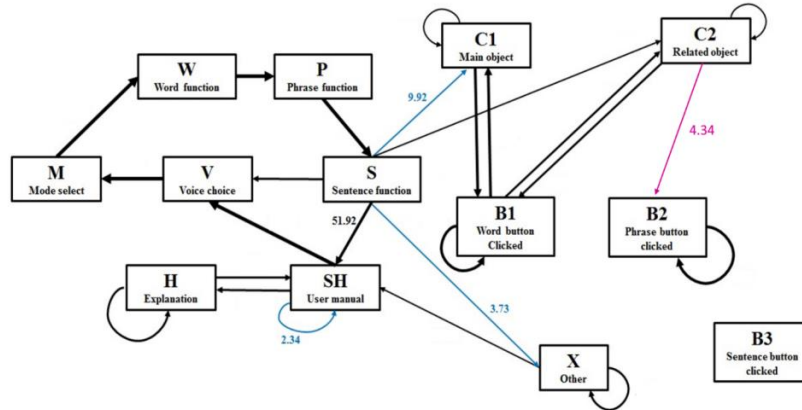
Fig. 5. The behavioral transition diagram between male and female students.

According to the behavioral transition diagram, we found male and female students demonstrated similar behavior sequences in the learning procedure, where → indicates a unidirectional sequence and ⇆ indicates bio-directionality. However, 4 unidirectional sequences were different for male students (blue line) and female students (pink line), i.e., SH → SH, S → SH, S → C1, S → X and C2 → B2. These behavior sequences demonstrate some interesting trends.

5 Discussion and conclusions

In the students' learning achievement, no significant difference be-tween the two genders were found. At first, by observing the behavior pattern associated graphs, we found that male students were more active than female students when searching for the next AR targets (S → C1, $Z = 9.92$). Then, according to the unidirectional sequences S → X ($Z = 3.73$), it was found that male students do something unrelated to learning activities more often than female students after opening or closing the "sentences function". In other words, male students stray from AR learning activity easier than female students. So, for the male students, it is suggested to add a correction method or function in this type of AR English learning system, to help learners return to the correct learning process during the learning activities. In addition, according to the unidirectional sequences C2 → B2 ($Z = 4.34$), we can observe that female students click the phrase button more often than male students after selecting related object actions. From this result, female students' concentration of attention is higher than males' in this kind of AR English learning activity, because female students were more likely to read extra related learning materials. Therefore, one could design some suggested learning tips for the male students in this type of AR English learning sys-

tem to improve the level of detail in their learning process. It is also suggested to provide extra learning contents in the system for the female students.

Acknowledgements

References

1. Spolsky, B. and E.G. Shohamy, *The languages of Israel: Policy, ideology, and practice*. Vol. 17. 1999: Multilingual Matters.
2. Smith, R., *Global English: gift or curse?* English Today, 2005. **21**(2): p. 56-62.
3. Hwang, G.-J. and S.-Y. Wang, *Single loop or double loop learning: English vocabulary learning performance and behavior of students in situated computer games with different guiding strategies.* Computers & Education, 2016. **102**: p. 188-201.
4. Savignon, S.J., *In Second Language Acquisition/Foreign Language Learning, Nothing Is More Practical than a Good Theory.* Issues and Developments in English and Applied Linguistics (IDEAL), 1988. **3**: p. 83-98.
5. Chang, C.-C., et al., *The impact of college students' intrinsic and extrinsic motivation on continuance intention to use English mobile learning systems.* The Asia-Pacific Education Researcher, 2013. **22**(2): p. 181-192.
6. Jong, B.-S., et al., *Using game-based cooperative learning to improve learning motivation: A study of online game use in an operating systems course.* IEEE Transactions on Education, 2013. **56**(2): p. 183-190.
7. Knobelsdorf, M. *The Theory Behind Theory-Computer Science Education Research Through the Lenses of Situated Learning*. in *International Conference on Informatics in Schools: Situation, Evolution, and Perspectives*. 2015. Springer.
8. Golonka, E.M., et al., *Technologies for foreign language learning: a review of technology types and their effectiveness.* Computer Assisted Language Learning, 2014. **27**(1): p. 70-105.
9. Mayer, R.E., *Multimedia learning*, in *Psychology of learning and motivation*. 2002, Elsevier. p. 85-139.
10. Azuma, R.T., *A survey of augmented reality.* Presence: Teleoperators & Virtual Environments, 1997. **6**(4): p. 355-385.
11. Milgram, P., et al. *Augmented reality: A class of displays on the reality-virtuality continuum*. in *Telemanipulator and telepresence technologies*. 1995. International Society for Optics and Photonics.
12. Bremner, S., *Language learning strategies and language proficiency: Investigating the relationship in Hong Kong.* Canadian Modern Language Review, 1999. **55**(4): p. 490-514.

13. Cheng, K.H. and C.C. Tsai, *The interaction of child–parent shared reading with an augmented reality (AR) picture book and parents' conceptions of AR learning.* British Journal of Educational Technology, 2016. **47**(1): p. 203-222.
14. Hou, H.-T., *Exploring the behavioral patterns of learners in an educational massively multiple online role-playing game (MMORPG).* Computers & Education, 2012. **58**(4): p. 1225-1233.
15. Hwang, G.-J., et al., *Interaction of problem-based gaming and learning anxiety in language students' English listening performance and progressive behavioral patterns.* Computers & Education, 2017. **106**: p. 26-42.
16. Lai, C.-L. and G.-J. Hwang, *A spreadsheet-based visualized Mindtool for improving students' learning performance in identifying relationships between numerical variables.* Interactive Learning Environments, 2015. **23**(2): p. 230-249.
17. Bakeman, R. and J.M. Gottman, *Observing interaction: An introduction to sequential analysis.* 1997: Cambridge university press.
18. Bakeman, R. and V. Quera, *Sequential analysis and observational methods for the behavioral sciences.* 2011: Cambridge University Press.