Correlation of Professional English Reading VS. Eye Gazing and Frequency of Rereading Eye Movement

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Abstract: Over the past decades, English has become one of the major international languages widely used by many countries. Taiwan, being an international partner, has strived to improve its nationwide English proficiency to advance with international settings. This study investigates the correlation between eye movements of both 1) gazing time (fixation) and 2) frequency of re-reading (number of fixation) the vocabulary of familiar and unfamiliar professional English subjects, for those of both technical and vocational professionals of English as Foreign Language (EFL) participants, while reading professional English, to reading fluency. A newly invented eye chasing device has been used to monitor visual reading progress experiment. Fifteen technical high school students, who have completed Technological and Vocational Education Joint College Entrance Examination of Taiwan (TVE JCEET) in 2014, participated in the experiment. Their reading fluency are measured based on the results of eight questionnaires and answers (Q&A) after reading 8 professional English articles from computer engineering, mechanical, bio-medical, and business subject fields. SPSS 21 was used for descriptive and correlation statistics. Both hypotheses are accepted with results showing that readers from technical background spent more time fixing on reading familiar professional subjects, and mildly inverse relation on frequency of re-reading of professional English contexts. The combination use of multiple visual displays is recommended not only to improve English as foreign language (EFL) users' training and practice but also to enhance quality on professional English readings.

Keywords: Vocabulary of familiar and unfamiliar subject, gazing time (fixation), frequency of reread (number of fixation), eye chasing device (ECD), professional English reading (PER), Technological and Vocational Education Joint College Entrance Examination of Taiwan (TVE JCEET)

1. Introduction

1.1 Purpose and Objective

Over the past decades, English has grown to become one of the major international languages widely used by many countries (Nunan, 2003). Taiwan, Republic of China (Tw, R.O.C.) being an international partner of the global village, has constantly been striving to improve its nationwide English proficiency to advance ~~alignment~~ with international settings (Lin, 2011). While short of literature studies on expert English reading and eye configuration, this study intends to investigate the correlation between eye movements of both 1) gazing time (fixation) and 2) frequency of re-reading (number of fixation) on the vocabularies of familiar and unfamiliar subjects, when situation occurs on re-reading professional English texts, to reading fluency. A newly invented ECD has been used to monitor this visual reading observation experiment. 15 recently completed their TVE JCEET have been invited to participate in this experiment.

This research aims at finding possible association on reading fluency of professional English subject contents, to human eyes reading pattern of technical and vocational based English as Foreign Language (EFL) participants, particularly on fixation of vocabularies, and on frequency of re-reading

the words. This research also attempts to serve as a reference to help bridge future researchers of possible advancement for EFL reading with help of visualization device. To contribute to the development of enhancement, this research has come up with following objectives:

1. To explore the differences between eye reading gaze time and reading fluency among technological and vocational students.
2. To detect the relationship between eyes rereading the words and reading fluency among technological and vocational students.

2. Literature Review

2.1 Background and Reading Fluency

In the past, with lack of proper tools, scholars were unable to fully identify the eye reading pattern of EFL readers when they read professional English materials, especially on those of familiar and unfamiliar fields to build the links with reading fluency. In ~~the~~ recent studies, there have been a growing number of researches conducted on ECDs' applicability, and putting them to test on general education, biological, and psychological studies (Clark & Clark, 2010; Orquin & Mueller Loose, 2013; Rayner, 2009) . With the construct of eye chasing device by the National Taiwan Normal University (NTNU), the authors are able to explore the relationships of eye movements to professional English reading.

Literacy is important for human development and interaction. Therefore, educators have attempted various approaches and methods to advance learners' literacy and knowledge, while the knowledge and literacy acquired are transferable and appropriate to expand on learning scopes and applicable for broad range of skills utility (Koo, Becker, & Kim, 2014; Kuhn, Schwanenflugel, & Meisinger, 2010; Lin, 2011; Peregoy & Boyle, 2000). Vision is an important function of learning literacy by means of visually reading for knowledge absorption (Clark & Clark, 2010; Lin, 2011; Orquin & Mueller Loose, 2013). To increase the speed and fluency of learning and the ability to demonstrate the generalized responses across fields, theory of Instructional Hierarchy (IH) by Haring and Eaton (1978) is further explained by Ardoin and Daly (2007) stated that knowledge and information are stimulus. Hence repeated practice and enhanced accuracy of response and perception to stimuli have greater control over behavior and recognition. Learners are more likely to be able to generalize from their existing knowledge and apply their wisdom and skills to new circumstances. However, numerous exemplars of targeted stimuli in multiple situations need to be implied by variety for generalization of application in order to link with practical situation (Kuhn et al., 2010; Stokes & Baer, 1977). Consequently, with more exemplars and stimuli from previous training and language learning, people of technical backgrounds may exercise a better set score of reading fluency through generalization, despite of reading unfamiliar professional English.

Reading fluency, regardless of various definitions, focuses on the consensus of accuracy, automaticity, and prosody as central components (Hudson, Pullen, Lane, & Torgesen, 2008; Kuhn et al., 2010; Rasinski, Reutzel, Chard, & Linan-Thompson, 2011) . Reading fluency is then defined in terms of rate and accuracy, simultaneously decoding and comprehending, recognition and understanding of what has been visualized and read (Hudson et al., 2008). To syndicate the former studies, and extend on the research, the authors have added reading and fluency with visualization and PER. In the process of finding the relationships on gazing time (fixation), frequency of re-reading (number of fixation) the vocabularies of familiar and unfamiliar subjects and topics from various PER, the authors have adopted a newly invented low cost but high quality ECD to monitor the eye movements.

2.2 Eye Chasing Device References and English as Foreign Language (EFL)

Former studies have used eye chasing device for different studies (Cole, Gwizdka, Liu, Belkin, & Zhang, 2013; Mayer, 2010). The studies have shown that participants who spent more duration on ECD required the greater amount of attention on emphasis and access (de Koning, Tabbers, Rikers, & Paas, 2010; Ho, Tsai, Wang, & Tsai, 2014). English learners, of both native and foreigner, differ from

one another, as the classrooms and programs that serve them. Despite of the diversity among second language readers, one common factor, as an equation of the process of reading English is essentially similar among the readers of native or non-native English speakers (Ardoin & Daly III, 2007; Fitzgerald, 1995; Goodman & Goodman, 1978). The process contains decoding of characters to linguistic they represent to thrash out at meaning. What disseminates between EFL and native English readers are the cognitive linguistic and experiential resources of reading, particularly the reading fluency (Fitzgerald, 1995; Goodman & Goodman, 1978; Peregoy & Boyle, 2000). As further noted, the direct correlation to reading fluency in English comprises "(a) English language proficiency, (b) background knowledge related to the text, and (c) literacy abilities and experiences, if any, in the first language" (Peregoy & Boyle, 2000).

2.3 Technological and Vocational Education Joint College Entrance Examination of Taiwan

The Technological and Vocational Education (TVE) system is important to nurture human resources in Taiwan. Under the commission of Taiwan Ministry of Education (MOE), English is one of the mandatory tests. Therefore, the test is a well-respected and legitimate exam. The results and associated backgrounds consequently provide the valid and consistent records for this research perseverance.

2.4 Research Questions

To accomplish the purpose of this study, the following two questions were proposed.

1. What is the relationship between eye movements on fixation, for people of English as foreign language (EFL), with technical background (TB), to professional English reading fluency (PERF)?
2. What is the relationship between eye movements on number of fixation, for people of English as foreign language (EFL), with technical background (TB), to professional English reading fluency (PERF)?

2.5 Hypothesis

Base on the questions proposed and the literatures reviewed, this research intends to test the following hypotheses (Figure 1):

1. There is an inverse correlation between participants of technical background and the time spent on reading unfamiliar professional English. In ~~an~~other words, even though they may be reading unfamiliar subject, with technical background, participants may spend normal or lesser time gazing.
2. There is an inverse correlation between the frequencies of rereading the vocabularies of unfamiliar subject for participants of technical background on contents of professional English. In other words, even though they may be reading unfamiliar subject, with technical background, participants may spend normal or lesser number of times on fixation of words.

3. Methodology

3.1 Research Framework and Process

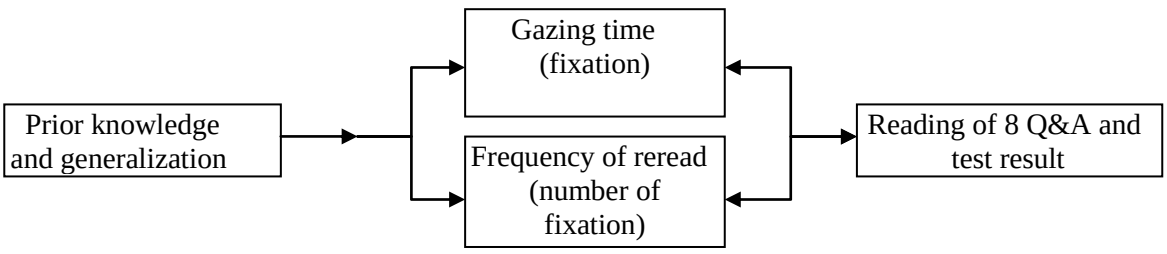

Figure 1. Observation of eye movement through eye chasing device.

3.2 Material

To conduct this experiment, 4 same sets of ECDs, head stabilizers, laptop computers, 8 (predesigned and preloaded into laptop computers) PER articles (with 2 from Mechanic, 2 on Computer Engineering, 2 from Bio-Medic, and 2 on Business), 8 (predesigned and preloaded into laptop computers) questionnaires, of one for each of reading article were used for this experiment, to promptly went through the experiment. To identify the unfamiliar words read, 15 participants were asked to circle out the words of unfamiliarity on physical printouts prepared by authors, after completion of reading the same 8 PER articles and responding to the 8 (Q&A)s electronically. All data were collected and analyzed.

3.3 Participant

Due to availability, the participants (n=15) are from Neihu Vocational High School who are majoring in Computer and Engineering majored students. They completed their TVE JCEET in 2014. This is to ensure that they have sufficient level of English knowledge and technical background for this experiment. This research has excluded the components of gender, age, social and economic status of participants. The sample population were volunteered to take part in the pilot test.

3.4 Design, process, and Procedure

Invitations for this experiment have been sent out to a number of local vocational and technical high schools. There were only 15 volunteers who would like to participate in the pilot test. To identify the focal possible PER outcomes from those with technical and vocational backgrounds, this research has invited the students who just completed their TVE JCEET for observations. On the date of experiment, one NTNU Professor and five research assistants went to Neihu Vocational High School to conduct the investigation. Participants were each equipped with one ECD, positioned individually against each one of the four head stabilizers, and sat in front of the four laptop. Participants were told to read a set of 8 pre-loaded professional English articles (2 from computer engineering base, 2 on mechanical base, 2 on bio medical field, and 2 from business related). Participants did not make known to the reading materials. After reading each article, the participants were required to answer 8 comprehension questions by selecting their answers. Participants were not assigned the time frame to complete the readings and comprehension questionnaires; however, they were accounted for by the proctors for analysis later. Four participants started the test at the same time, but performed the PER and answering the questions separately. Upon completion, participants were then asked to circle out the unfamiliar vocabulary words, of the same 8 professional English articles read electronically, on physical copies. Data were collected and analyzed afterward.

3.5 Instrument

Four recently produced EyeNTNU-180 eye chasers were used for monitoring and recording eye movements of 15 participants while reading professional English articles and responding to 8 Q&As. Each of EyeNTNU-180 set includes a laptop computer; a camera in front to record eye movements. The laptop is responsible for presenting 8 aforementioned professional English articles and questionnaire. In this experiment, a sampling rate is 180Hz (sampling 180 times per second). To avoid errors in eye chasing measurement caused by shaking of head and inconsistency of eye movement, a head stabilizer rack was used to fix head position. The distance between the screen and participants were set to 60cm straight apart. The normal time duration of a fixation of this experiment was set to 80 milliseconds.

3.6 Tools and Data Collection

EyeNTNU-180 was employed to collects eye movements, and calculates average time of visualization and coordination. Through these two parameters and ROI (Region of Interest), the Total Contact Time (TCT) and Number of Saccade (NOS) are able to be generated to provide verification of fixation and number of fixation of the words read. Four laptops were used separately on each one of the 4 separate experimental stations. The screen height was adjusted to individual's visual level, where participants were able to face straight on the screen. To avoid major or sudden physical lurching, which may affect eye positioning; participants were each placed on a head stabilizer comfortably on chin cushions throughout the experiment. Fixation Calculator, software designed from open source was used to examine the data of inspected components. One major focal indicators of the Range of Interests (ROI) were categorized by ROI-splitter software and eye movement analyzer to evaluate eye movement data to generate scan paths, gazing time, frequency of rereading the words, average and total contacts.

	Average time of unfamiliar word fixation (ms / word)	Average time of unfamiliar word fixation standard deviation (ms / word)	Average time of familiar word fixation (ms / word)	Average time of familiar word fixation standard deviation (ms / word)	Average number of saccade (NOS)	Average number of normal direction scanning and reading (ANNDSR)	Percentage of saccade (NOS / (Total Average NOS + ANNDSR))
Mechanic	359.41	79.934	102.81	16.271	791	8217.5	8.78%
Computer engineering	332.61	65.568	102.24	13.588	915	8213	10.02%
Bio-Medic	236.11	50.570	98.81	11.746	645	6406.5	9.15%
Business	201.54	46.319	97.11	12.027	670.5	6092.5	9.91%

Figure 2. Descriptive Statistic for Vocabulary of Familiar and Unfamiliar Subjects: Gazing Time (Fixation), Frequency of Reread (Number of Fixation), and Standard Deviations.

SPSS 21 software was used for descriptive statistics and Pearson correlation. The average time spent on gazing at unfamiliar vocabularies for Business subject is (201.54 millisecond (ms) /word, standard deviation 46.319), Bio-Medic subject is (236.11 millisecond/per word, standard deviation 50.570), Computer engineering is (332.61 millisecond/per word, standard deviation 65.568), and Mechanic is (359.41 millisecond/word, standard deviation of 79.934); while the average time spent on fixation of familiar word for Business subject is (97.11 ms/word, standard deviation 12.027), Bio-Medic of (98.81 ms/word, standard deviation 11.746), Computer engineering being (102.24 ms/word, standard deviation 13.588), and Mechanic subject of (102.81 ms/word, standard deviation 16.271), as shown in Figure 2. The term saccade is defined in this research as re-reading of the words and visually tracing backward at vocabularies of normal reading sequence (contrary to normal sequence of logical reading). Figure 2 shows the average number of times of saccade for Business subject being (670.5), Bio-Medic being (645), Computer engineering of (915), and Mechanic subject being (791); while the average number of normal directional sequence of reading and scanning at the contexts of Business subject is (6092.5), Bio-Medic (6406.5), Computer engineering (8213), and Mechanic of (8217.5). To take NOS and divides it by the denominator of Total Average NOS plus ANNDSR, the authors are able to measure the percentage of frequency on saccade, for each one of the professional English reading subjects, as shown in Figure 2. Figure 3 is a sample diagram of the 4 PER articles' eye maps; the lines are the visual scanning paths traveled, where the different coloring indicates the time of fixation, with no coloring means skipping of the words, and darker colors indicate longer fixation and repetitive saccades accumulated.

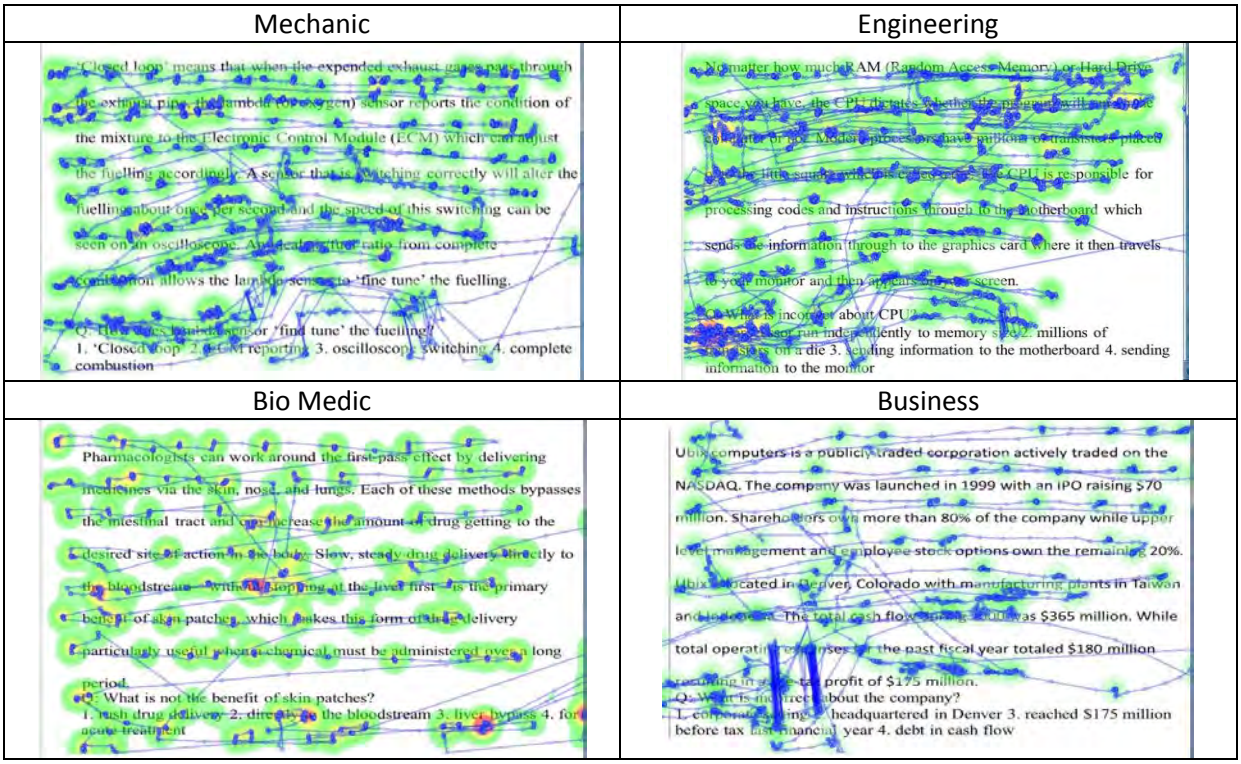

Figure 3. This is a sample eye map, the lines indicate visual scanning paths' of participant, with different colors indicate different degree of fixation and number of fixations.

4. Results and Discussions

It has been observed, from Figure 2 that participants on average spent more time gazing at unfamiliar vocabulary words of Mechanic subject, and their identical background in technical field of Computer Engineering. However, the average time spent on reading the unfamiliar words of Bio Medic and Business fields are about 100 ms per word lesser than the former ~~two~~. Mechanic and Computer Engineering, subjects wise though independent, are closer in academic study, therefore they are often grouped together under Engineering school, but Bio-Medic and Business professional subjects. The reason for longer fixation time may be explained by the similar causes provided by the former studies stated in literature review section that readers tend to devote more time and efforts browsing at recognizable contents. It is also possible because people are more willing to spend extra time reading at the contexts they are able to associate with, and are able to understand fluently than the unfamiliar subjects, i.e. in this experiment of Bio-Medic and Business professional English readings. Figure 2, indicates that the average time spent on fixing at familiar words fall around 100 milliseconds (ms) per word and the time spent is consistent throughout all the 4 professional subjects, regardless of the differences among the 4 professional English reading subjects experimented for this research.

To calculate individual professional reading field's Percentage of Saccade, the authors took the Number of Saccade (NOS) as nominator and divide it by (Total Average Number of Saccade plus Average Number of Normal Direction Scanning and Reading) as denominator. The resulting percentages fall in between 8.78% ~ 10.02% (8.78% for Mechanic, 9.15% for Bio-Medic, 9.91% for Business, and 10.02% for Computer Engineering). Figure 2 indicates that Percentage of Saccade is steady throughout all four different PERs. In Total Average Number of Saccade, this technical background participants' saccade frequency reduced noticeably when reading unfamiliar subjects. It could be explained that the behavior changes because of human rejection and un-anticipation of reading ~~at~~ unfamiliar subjects. These behavioral reflections can be identified through scan path. From the eye map scan path in Figure 3, the participant spent more time and intensity reading identical technical

background of Computer Engineering and related Mechanic than Bio-Medic and Business professional English reading.

	Mechanic UNFV	Mechanic FV	Computer Engineering UNFV	Computer Engineering FV	Bio Medic UNFV	Bio Medic FV	Business UNFV	Business FV
Mechanic UNFV	1	0.498	.915**	0.473	0.635	0.298	.668**	0.415
Mechanic FV	0.498	1	0.326	.886**	0.199	0.689	0.282	.434**
Computer Engineering UNFV	.915**	0.326	1	0.301	.755**	0.106	0.777	0.288
Computer Engineering FV	0.473	.886**	0.301	1	0.355	.628**	0.353	0.404
Bio Medic UNFV	.635*	0.199	.755**	0.355	1*	0.091	.908**	0.034
Bio Medic FV	0.298	.689**	0.106	.628*	0.091	1**	-0.044	.576*
Business UNFV	.668**	0.282	.777**	0.353	.908**	-0.044	1**	0.087
Business FV	0.415	0.434	0.288	0.404	0.034	0.576	0.087	1

** Correlation is significant at the 0.01 level, * Correlation is significant at the 0.05 level.

Figure 4. Pearson correlation (2-tailed) table showing the relationships between the familiar and unfamiliar vocabularies of 4 PERs from Mechanic, Computer Engineering, Bio-Medic, and Business subject fields, with N = 15. Familiar vocabulary = FV, Unfamiliar vocabulary = UNFV.

Figure 4 shows the gazing times Pearson's correlation between the familiar and unfamiliar vocabulary of 4 professional English readings performed by Mechanic, Computer Engineering, Bio-Medic, and Business students. It is recognized that regardless of professional reading subjects, when readers come across to unfamiliar vocabularies, there is a uniformity of positive significance on the time speed on reading. For Engineering participants, the time spent on fixation and re-reading the words correlations are much stronger among the Computer Engineering and Mechanic participants, but not for Bio-medic and Business PERs. It is also observed that all significant relationships are positive in trend.

5. Conclusion

There are a growing number of researches conducted on eye chasing devices; however, after reviewing various literatures, the authors noted that professional English reading and eye movement together from English as foreign language has not been explored. Therefore, this lack of research has prompted the authors' intention to explore the correlation between eye configurations of English as foreign language users / learners with technical background, and their PERs of eye fixation and frequency of re-reading the vocabulary. With English being one of the major international languages widely used throughout most settings, the authors also intend to contribute this study to improve the EFL language usage in Taiwan.

Reading is an important part of learning, as reading focuses on the consensus of accuracy, automaticity, and prosody combined in reading fluency. Theories based on Instructional Hierarchy (IH) believe that instructed and repeated practice and reinforcement improve accuracy and may further develop perceptions through stimulations. Therefore repeated eye fixation and gazing may improve reading fluency through vocabularies and minds association. These associations can be processed through prior knowledge as stated in literature reviews and in this research experiment. With the help of ECD, the authors are able to carefully examine the correlation, with participants' eye movements, among the variables. As the result of research experiment and the literatures studied, the two hypotheses

are accepted by the authors. The eye movement and visualization serve as important functions of learning, the authors would suggest EFL to combine multiple visual equipment and tools to enhance English as foreign language users' training and practice. It may dramatically enhance the quality of professional English reading.

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References

Ardoin, S. P., & Daly III, E. J. (2007). Introduction to the special series: Close encounters of the instructional kind—how the instructional hierarchy is shaping instructional research 30 years later. Journal of Behavioral Education, 16(1), 1-6.

Clark, R. E., & Clark, V. P. (2010). From neo-behaviorism to neuroscience: Perspectives on the origins and future contributions of cognitive load research. *Cognitive load theory*, 203-228.

Cole, M. J., Gwizdka, J., Liu, C., Belkin, N. J., & Zhang, X. (2013). Inferring user knowledge level from eye movement patterns. *Information Processing & Management, 49*(5), 1075-1091.

de Koning, B. B., Tabbers, H. K., Rikers, R. M., & Paas, F. (2010). Attention guidance in learning from a complex animation: Seeing is understanding? *Learning and instruction, 20*(2), 111-122.

Fitzgerald, J. (1995). English-as-a-second-language learners' cognitive reading processes: A review of research in the United States. *Review of Educational research, 65*(2), 145-190.

Goodman, K. S., & Goodman, Y. M. (1978). Reading of American Children Whose Language is a Stable Rural Dialect of English or a Language Other Than English. Final Report.

Ho, H. N. J., Tsai, M. J., Wang, C. Y., & Tsai, C. C. (2014). PRIOR KNOWLEDGE AND ONLINE INQUIRY-BASED SCIENCE READING: EVIDENCE FROM EYE TRACKING. *International Journal of Science and Mathematics Education, 12*(3), 525-554. doi: 10.1007/s10763-013-9489-6

Hudson, R. F., Pullen, P. C., Lane, H. B., & Torgesen, J. K. (2008). The complex nature of reading fluency: A multidimensional view. *Reading & Writing Quarterly, 25*(1), 4-32.

Koo, J., Becker, B. J., & Kim, Y.-S. (2014). Examining differential item functioning trends for English language learners in a reading test: A meta-analytical approach. *Language Testing, 31*(1), 89-109.

Kuhn, M. R., Schwanenflugel, P. J., & Meisinger, E. B. (2010). Aligning theory and assessment of reading fluency: Automaticity, prosody, and definitions of fluency. *Reading Research Quarterly, 45*(2), 230-251.

Lin, H.-Y. (2011). The impact of intellectual capital with knowledge management on Taiwan MICE industry (Master thesis). *National Taiwan Normal University Graduate Institute of International Human Resources Development*, 1-117.

Mayer, R. E. (2010). Unique contributions of eye-tracking research to the study of learning with graphics. *Learning and instruction, 20*(2), 167-171.

Nunan, D. (2003). The Impact of English as a Global Language on Educational Policies and Practices in the Asia - Pacific Region*. TESOL quarterly, 37(4), 589-613.

Orquin, J. L., & Mueller Loose, S. (2013). Attention and choice: a review on eye movements in decision making. *Acta psychologica, 144*(1), 190-206.

Peregoy, S. F., & Boyle, O. F. (2000). English learners reading English: What we know, what we need to know. *Theory into practice, 39*(4), 237-247.

Rasinski, T. V., Reutzel, D., Chard, D., & Linan-Thompson, S. (2011). Reading fluency. *Handbook of reading research, 4*, 286-319.

Rayner, K. (2009). Eye movements and attention in reading, scene perception, and visual search. *The quarterly journal of experimental psychology, 62*(8), 1457-1506.

Stokes, T. F., & Baer, D. M. (1977). An implicit technology of generalization1. *Journal of applied behavior analysis, 10*(2), 349-367.

Testing Center for Technological & Vocational Education of Taiwan (TCTVET). (2014). Retrieved from http://www.tcte.edu.tw/en/