



An application of e-book system in embedded system course: exploring learning effectiveness and behaviors

Prof. Ting-Ting Wu, Graduate School of Technological and Vocational Education, National Yunlin University of Science and Technology

Ting-Ting Wu is currently an Assistant Professor in the Graduate School of Technological and Vocational Education at National Yunlin University of Science and Technology, Taiwan. She received her Ph.D. degree from the Department of Engineering Science at National Cheng Kung University. She received the MS degree in Information and Learning Technology from National University of Tainan. Her research interests include mobile and ubiquitous learning, information technology-applied instructions and intelligent learning systems.

Dr. Rustam Shadiev, Department of Engineering Science, National Cheng Kung University

Dr. Rustam Shadiev is the postdoctoral research fellow at the Department of Engineering Science, National Cheng Kung University, Taiwan. His research interests include learning and instruction in on-line synchronous learning environment, human-computer interaction for collaboration, and speech to text recognition (STR) technology for learning.

Prof. Yueh-Min (Ray) Huang, Cheng-Kung University

Dr. Yueh-Min Huang received his MS and Ph.D. degrees in Electrical Engineering from the University of Arizona, respectively. He is currently a distinguished professor of the Department of Engineering Science and associate dean of Engineering College at National Cheng-Kung University, Taiwan. His research interests include e-Learning, embedded systems and artificial intelligence. He has co-edited 3 books published by Springer Verlag and has published over 200 refereed journal papers. His works have received over 4500 Google citations in recent 5 years. Dr. Huang has received many research awards, including best paper awards, such as GCCCE2013 and national competition prizes, such as the first prize of ARM Code-O-Rama 2012. He is also a winner of the distinguished research award of the National Science Council, Taiwan in 2010 and 2013, respectively. Dr. Huang is in the editorial board of several SSCI- and SCI-indexed journals such as *Interactive Learning Environments* and *Wireless Communications and Mobile Computing*. He was the technical program chair of International Conference on Web-based Learning (2013) and the general chair of AECT International Conference on the Frontier in e-Learning Research 2013 (ICFER) and the e-Learning Forum Asia 2014. Dr. Huang became a Fellow of British Computer Society (FBCS) in 2011 and a senior member of the IEEE.

Prof. Chin-Feng Lai, National Chung Cheng University

Chin-Feng Lai is an associate professor at Department of Computer Science and Information Engineering, National Chung Cheng University since 2014. He received the Ph.D. degree in department of engineering science from the National Cheng Kung University, Taiwan, in 2008. He received Best Paper Award from IEEE EUC 2012. He has more than 100 paper publications. He is an associate editor-in-chief for *Journal of Internet Technology* and serves as editor or associate editor for *IET Networks*, *International Journal of Internet Protocol Technology*, *KSII Transactions on Internet and Information Systems*. He is TPC Co-Chair for the 12th IEEE International Conference on Computer and Information Technology (IEEE CIT-2012) and was selected an honorary member of the Phi Tau Phi Scholastic Honor Society of the Republic of China in 2009, TC member of Multimedia Systems & Applications Technical Committee (MSATC), IEEE Circuits and Systems Society, 2009 and Co-Chair of the Interest Group on Multimedia Services and Applications over Emerging Networks of the IEEE Multimedia Communication Technical Committee During 2012-2014. His research focuses on Internet of Things, Body Sensor Networks, E-healthcare, Mobile Cloud Computing, Cloud-Assisted Multimedia Network, Embedded Systems, etc. He is an IEEE Senior Member since 2012.

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Abstract

In many non-English-speaking countries, reading textbooks in English is a difficult and challenging. This is especially true for university students who study professional literature with complex and unfamiliar terminologies but they are not English majors. Recent evidence suggests that e-books have a great potential in education; for example, assistant tools provided in e-books can effectively enhance reading comprehensions as well as improve learning outcomes. Therefore, this study applies an e-book learning system to an embedded system course. Apart from general auxiliary functions, the e-book learning system provides different ways of reading with multimedia annotation support and a professional knowledge database of terminologies. Furthermore, the system enables students to translate and highlight important terms, sentence or paragraph. One experiment was carried out in this study to test the feasibility of the e-book learning system. Results of the experiment showed that experimental students (who learned with the system) outperformed those who in the control group (who learned by using traditional approach). Analysis of experimental students' portfolios showed that checking professional knowledge database, translation, making annotations, speed reading and intensive reading were most common learning behaviors during the reading process.

Introduction

In the era of globalization, English becomes the international language for interaction and communication¹. This is particularly true for international trading, recreation, entertainment and learning. In many non-English speaking countries, it is common to use professional English textbooks written by widely-recognized international scholars. Although reading such textbooks is the important source to acquire professional knowledge, usually for novice, unexperienced university students and students whose native language is different from English (i.e. EFL or ESL learners) it is difficult to read textbooks of professional courses in English^{2, 3}. In engineering science related departments where professional techniques and complicated theories are common, students not only should understand the knowledge in books⁴, but also recognize the composition of terms, meanings of vocabulary and grammatical structure^{5, 6, 7}. To make things worse, they should spend more time looking up unfamiliar vocabulary and comprehending learning content. Thus, for most students, reading textbooks in English is extremely difficult.

In recent years, with the rise of e-book, many studies have explored the application of e-book in education from different perspectives^{8, 9, 10, 11, 12, 13, 14}. E-book is easy to carry and it features functions that make learning more convenient and enable access to diverse learning content. Besides, with multiple functions of notes, diverse media presentation and permanent process recording, it provides users with multi-functional and highly convenient reading model¹⁵. According to research on e-book-based learning, multiple functions of e-book positively enhance learning of professional vocabulary and comprehension of reading^{10, 11, 12}. For instance, research of Grimshaw et al. was based on two different reading methods, e-book and paper book in order to probe into effects of different types of content on students' reading comprehension. According to research findings, multimedia and multi-functional e-book significantly influence reading interest and it effectively enhance learners' reading comprehension capacity¹⁶. Korat and Shamir explored the effect of e-book based reading instruction on learners' reading and vocabulary use competence. The result showed that reading multimedia e-book significantly reinforces reading and vocabulary use competence¹¹. In addition, Korat treated learners of different ages as subjects. By e-book based learning, the said researcher tried to recognize the change of learners' vocabulary understanding, reading comprehension and article reading competence. The results indicated that vocabulary use, reading comprehension and article reading of learners of different ages improved through e-book assisted reading¹⁰.

Based on the advantages of e-books reported in related literature, in this study, we introduced characteristics and advantages of an e-book system used for an embedded system course. The e-book system provides not only common functions, but also features speed reading, intensive reading, main concept reading and professional knowledge database of terminologies of embedded system. In additions, it offers various multimedia annotations and assistance learning functions. All students' reading activities can be recorded in back-end learning portfolio database of the e-book system. The information stored in students' learning portfolios allows them to monitor their own reading progress, achievements and issues. In this study, we attempted to test the feasibility of the e-book system as well as to explore students learning behavior during the e-book-assisted reading. The following research questions were addressed in this study: (1) Do students who use the e-book system perform better on post-test compared with students who use traditional textbook? (2) Do students' learning behavior during reading process by using the e-book system influence reading effectiveness of textbook in English?

E-book learning system

Users of e-book system mainly adopts mobile tablet as the learning tool of e-book. The entire system, including fore-end and rear-end frameworks, is shown in Figure 1.

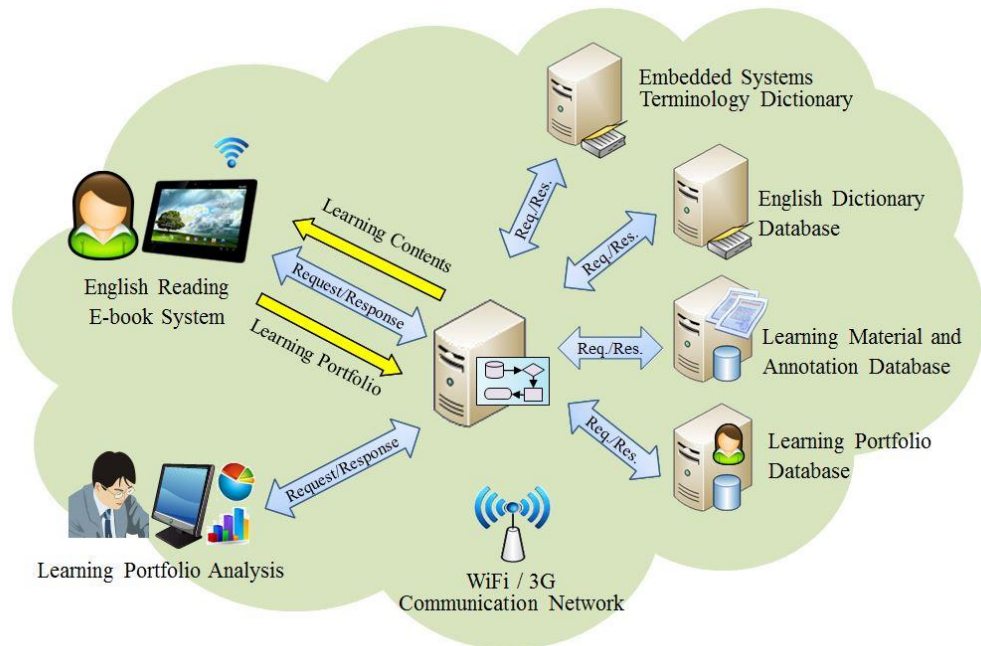


Figure 1. Architecture of E-book System

The system is constructed in WiFi or 3G (including 3.5G HSDPA and 3.75G HSUPA) wireless communication network environment. Students can read textbooks on the e-book system through the environment. By using those assistance tools provided by e-book, students can reinforce efficiency of textbook reading. The whole learning process will be transmitted to rear-end subsystem and saved in the learning portfolio database. Articles read by students are constructed in learning content database in advance. Since the e-book system provides annotation function, the learning content database includes all students' annotations which were made during the reading process. In addition, the function of instant translation of vocabulary from English into Chinese is provided by the system; it is based on online English-Chinese dictionary server accessed through HTTP Request. By HTTP Response obtained, the programs analyze HTML and acquire the needed translation. Besides, as to demand for the embedded textbook in English, a professional knowledge database for terminologies of embedded system at rear end is constructed. During reading, when encountering unfamiliar terms, students can search for professional explanation, definition and description through the knowledge database. Thus, students would more profoundly understand and comprehend knowledge related to the embedded system. In addition, the system provides not only common linear reading, but also features speed reading, intensive reading and main concept reading. Students can immediately acquire the key content needed in order to enhance efficiency and efficacy of textbook reading.

More importantly, the system provides teachers with statistical analysis of students' reading portfolio so that teachers are able to control students' learning process and situation (e.g. average amount of vocabulary looked up, ranking of vocabulary in textbook frequently looked up, analytical result of students' competence, statistics of time for students to accomplish reading, analysis of difficulty of articles through all students' learning process, etc.).

The interface of e-book system is shown in Figure 2. It is installed as one application on tablet PC. A screen is divided into two portions: article reading and operation of assisted functions.

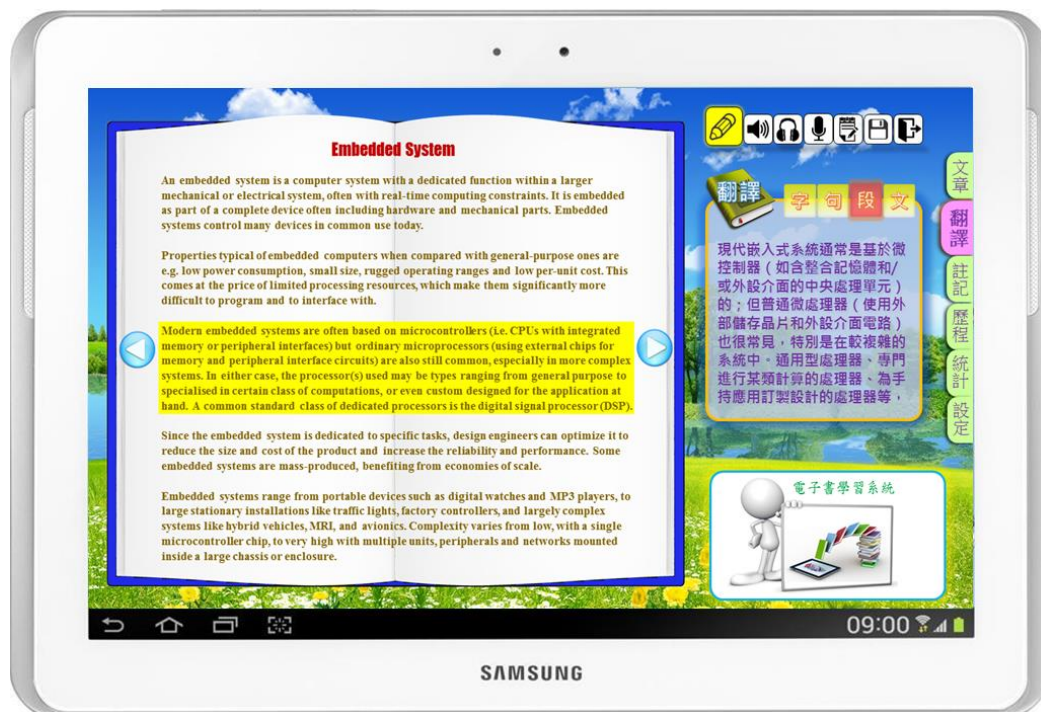


Figure 2. Interface of E-book System

- (1). Article reading: it is on the left side of interface. It shows reading content of textbook and the highlighted by a learner. It also provides users with model of page turning.
- (2). Operation of assisted functions: it is on the right side of interface. In addition to basic operations, it provides more complete vocabulary, sentence, paragraph and full text translation. Besides, article information, reading annotations, learning portfolio, statistical analysis, related setting, etc. are facilitated in the system. Module of functions is based on hidden side page markers which can be shown upon being clicked

Research design

Participants

Two classes of freshmen university students who studied the embedded system course in one private Taiwanese university participated in the experiment. One class with 48 students was assigned to control group, i.e. B (Book) and the other group with 50 students to experimental group, i.e. E (E-book). In the experiment, group B students used a traditional paper-based textbook in English as instructional material. Students in group E learned by using the e-book system. Content of textbook was the same for two groups and yet the same teacher instructed for both groups. The e-book system allowed experimental students to annotate learning content, it provided explanation of professional terms, instant translation (e.g. vocabulary, sentence, paragraph and full text), multiple reading models and pronunciation. In order to make students more engaged in the experiment, students' performance was graded.

Experimental process

There were three classes of the embedded system course every week during one semester (18 weeks). From Week 1 to Week 8, two groups were given lectures in the classroom. Week 9 was the week for university midterm exam. Results of this exam were used in this study as pre-test results to represent students' prior knowledge. The experiment started after midterm exam. In Week 10, the teacher introduced and explained the experimental activity. Besides, the experimental group was instructed how to use the e-book system and were given some time for practice with it. Experimental activity took place from Week 11 to Week 17. During that time, in the first half of the classes, the teacher lectured in classroom and then conducted reading and discussion sessions. Students were asked to read individually and then discuss their reading with peers. That is, students learned course related knowledge and also shared it with other; in this way their reading comprehension and professional knowledge acquisition could be enhanced. In reading discussion activity, group B students recorded their notes and annotations by hand writing. Group E students could use the system to read learning material and take digital annotations on learning content. Thus, the system recorded learning behavior and operational processes of students in group E in rear-end learning portfolio database. The teacher and technical specials provided assistance to students in both groups with regard to learning activity and the e-book system. The experimental procedure is shown in Figure 3. Week 18 was university final exam and results of the exam were used in this study to represent post-test results (i.e. students' learning achievement).

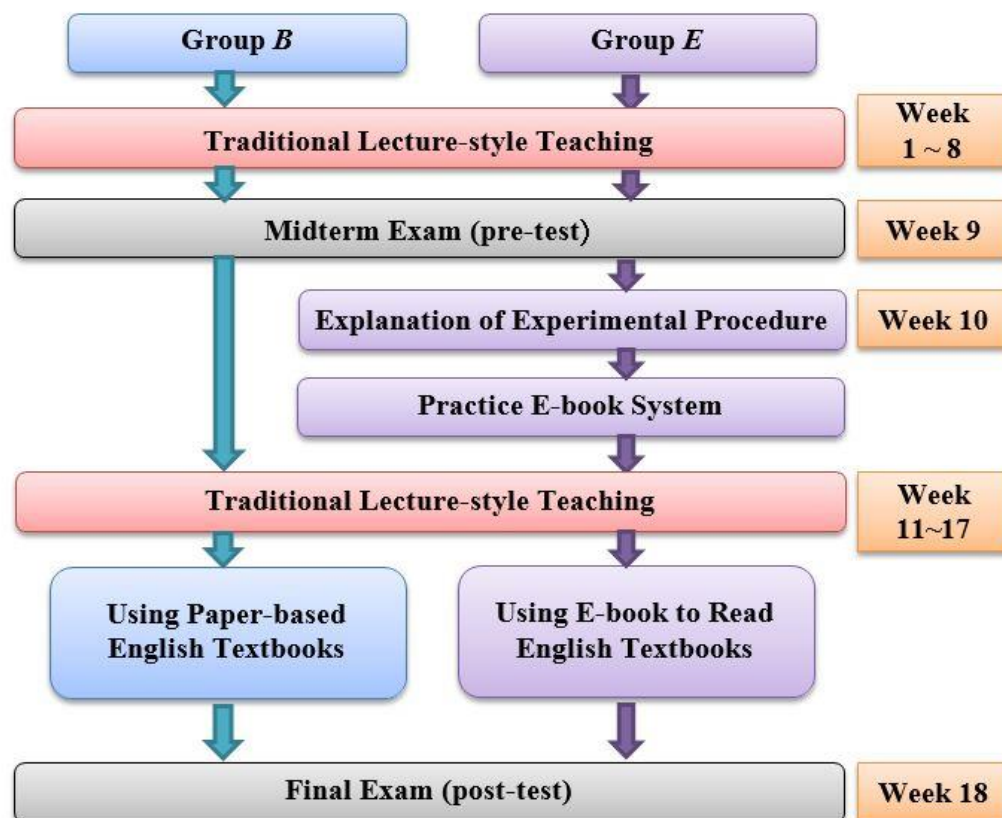


Figure 3. Experimental Procedure

Evaluation tools

Evaluation of learning effectiveness

Learning effectiveness was measured by comparing the difference between control and experimental students on pre-test and post-test results. The tests items were designed by the experienced teacher in the embedded system course. Items were related to learning content covered in this study.

Evaluation of learning behavior

Students' learning behavior was recorded as learning portfolios and then the relationship between learning behavior and reading efficacy was analyzed. Learning portfolios were coded, classified and categorized. Categories were used for the Lag Sequential Analysis (LSA) to carry out a module assessment on relationship, sequence and frequency of learning behaviors. Items of classification are shown below: Reading (R): the system interface presents the content of textbook for students reading. Text Annotation (TA): students click

the text annotation function and create text annotation on learning content. Figure Annotation (FA): students click the figure annotation function and create annotation with some figures. Voice Annotation (VA): students click the voice annotation function and make annotation by recording his/her own voice. Looking up Professional Terms (PN): students look up the professional terms through the embedded system terminology database. Vocabulary Translation (VT): students use the translation function to translate unfamiliar vocabulary. Sentence Translation (ST): students use the translation function to translate a sentence. Paragraph Translation (PT): students use the translation function to translate a paragraph. Article Translation (AT): students use the translation function to translate the whole article. Speed Reading (SR): students choose the speed reading model, and the system would highlight the important terms in each sentence. Intensive Reading (IR): students choose the intensive reading model, and the system would highlight the most important sentences in whole article. Main Concept Reading (MR): students choose the main concept reading model, and the system would highlight the most important sentence in each paragraph.

Research results

Analysis of learning effectiveness

This study used IBM SPSS Statistics 20 for the analysis of data collected. To analyze learning effectiveness, independent samples t-test was administered. We compared pre-test and post-test scores of group B and group E. Table 1 shows pre-test results of group B and group E and result of statistical analysis. Based on the result of t-test, prior knowledge of students in two groups is not significantly different ($p > .05$).

Table 1. Results of the pre-test analysis.

Group	N	Mean	Std.Deviation	t	<i>p</i>
group B	48	80.89	1.76	-.638	.525
group E	50	81.14	2.01		

Table 2 shows post-test scores of two groups and results of t-test. According to the table, post-test scores of two groups are significantly different ($p < .05$). That is, experimental group's post-test scores are slightly higher than that of control group. Hence, we infer that functions of the e-book system are useful for reading process and using them can enhance learning achievement. Although the e-book system did not considerably reinforce textbook reading competence, the immediate and rapid personalized tools can assist students in reading activities.

Table 2. Results of the post-test analysis.

Group	N	Mean	Std.Deviation	t	p
group B	48	82.83	1.93	-1.827	.035*
group E	50	83.70	2.68		

* $p < .05$

According to the results of dependent t-test shown in Table 3, the p value of the two groups was $<.05$; therefore, there was a significant difference between pre-test and post-test scores of two groups. Further observation of each group's scores showed that the learning effectiveness of group B improved after integration of reading discussion of textbook. Therefore, students' comprehension and judgment abilities could be further improved through the reading and discussion learning strategies. However, the learning effectiveness of the group B was still inferior to the group E. Test scores of group E significantly improved after using the e-book system implies that the diversified support tools of the e-book system could provide appropriate assistance during the reading activities.

Table 3. Dependent sample t-test of two groups.

Group	N	Mean	Std.Deviation	t	p
group B	48	80.89	1.76	-8.373	.000*
		82.83	1.93		
group E	50	81.14	2.01	-4.823	.000*
		83.70	2.68		

* $p < .05$

Analysis of learning behavior

Portfolios data analysis gave us a clear picture of students' learning behavior to use the e-book system during reading process. First, this study reorganized the classification items from the learning portfolio database. Second, sequence and frequency of behaviors through the Lag Sequential Analyses was accessed. Analytical results are shown in Table 4. The value of each cell in Tables 4 represents the frequency of behavior occurrences. In other words, the behavior of column item occurred immediately after the behavior of row item.

Finally, statistical analysis and calculation by using z score proposed by Allison and Liker¹⁷ were conducted. Through systematic and structural statistical analysis, it probes into correlation and significance of learning behaviors. Result of statistical analysis is shown in Table 5. Statistical analysis result of z score indicates that value is great than +1.96; that is, a significant correlation between two learning behaviors exists.

Table 4. The LSA assessment results of group E.

	R	SR	IR	MR	TA	FA	VA	PN	VT	ST	PT	AT
R	0	1221	1782	890	1560	189	50	1574	1418	936	673	329
SR	1332	34	1419	599	895	29	17	1068	997	649	398	173
IR	373	980	5	201	1332	92	12	1674	1486	952	723	351
MR	329	148	479	0	198	9	0	309	237	86	9	0
TA	1387	879	1323	183	598	7	0	849	623	438	217	98
FA	129	21	75	5	0	0	0	103	83	32	17	2
VA	30	11	6	0	0	0	0	19	8	0	0	0
PN	1388	1091	1639	287	1338	118	56	887	563	215	194	67
VT	1183	892	1295	179	956	73	17	619	527	196	129	53
ST	853	612	921	79	296	8	2	487	372	179	78	7
PT	653	285	695	5	217	7	3	517	452	239	54	3
AT	212	135	287	0	205	2	0	537	438	95	37	0

Table 5. The z score results of group E.

	R	SR	IR	MR	TA	FA	VA	PN	VT	ST	PT	AT
R	-10.93	6.03	10.84	2.53	9.38	-5.68	-9.23	9.57	8.37	3.18	1.28	-3.07
SR	7.29	-9.45	8.43	0.13	2.76	-9.63	-9.97	4.36	3.89	0.85	-1.96	-6.25
IR	-2.47	3.75	-10.62	-5.31	7.07	-7.65	-10.03	10.07	8.85	3.46	1.76	-2.97
MR	-3.16	148	-1.05	-10.91	-5.84	-10.45	-11.13	-3.35	-4.86	-7.87	-10.53	-10.89
TA	7.75	2.26	6.92	-6.02	0.08	-10.61	-10.89	2.03	0.67	-1.49	-4.98	-7.31
FA	-6.84	-9.45	-8.41	-10.65	-10.96	-10.89	-10.97	-7.23	-8.03	-9.58	-9.93	-10.76
VA	-9.67	-10.43	-10.64	-10.92	-10.59	-10.73	-10.74	-9.84	-10.56	-10.59	-11.03	-10.89
PN	7.93	4.97	9.94	-4.05	7.42	-7.13	-8.98	2.41	-0.03	-5.09	-5.98	-8.77
VT	5.76	2.68	6.64	-6.16	3.56	-8.56	-9.95	0.48	-0.35	-5.91	-6.71	-9.11
ST	2.15	0.32	2.98	-8.27	-3.67	-10.51	-10.81	-0.94	-2.86	-6.08	-8.35	-10.62
PT	0.95	-4.15	1.56	-10.66	-5.03	-10.59	-10.74	-0.58	-1.24	-4.79	-9.06	-10.79
AT	-5.16	-6.68	-3.97	-11.03	-5.23	-10.83	-11.12	-0.13	-1.57	-7.47	-9.38	-10.98

Results presented in Table 5 were further visualized in Figure 4. Thickness of lines in the figure indicates the degree of the relationship. The figure gives us a clear picture of the relationship, intensity and correlation of group E students' learning behavior. Based on Figure 4, when reading textbook by using the e-book system, students preferred to use speed reading and intensive reading functions. When students encountered unfamiliar vocabulary, they would look it up in the system's professional knowledge database or use vocabulary translation. Then, students would make annotation to that unfamiliar vocabulary to obtain its meaning. Moreover, according to the figure, when students read textbook by using general reading model and intensive reading model, they tended to look up the professional terms and use the function of sentence translation.

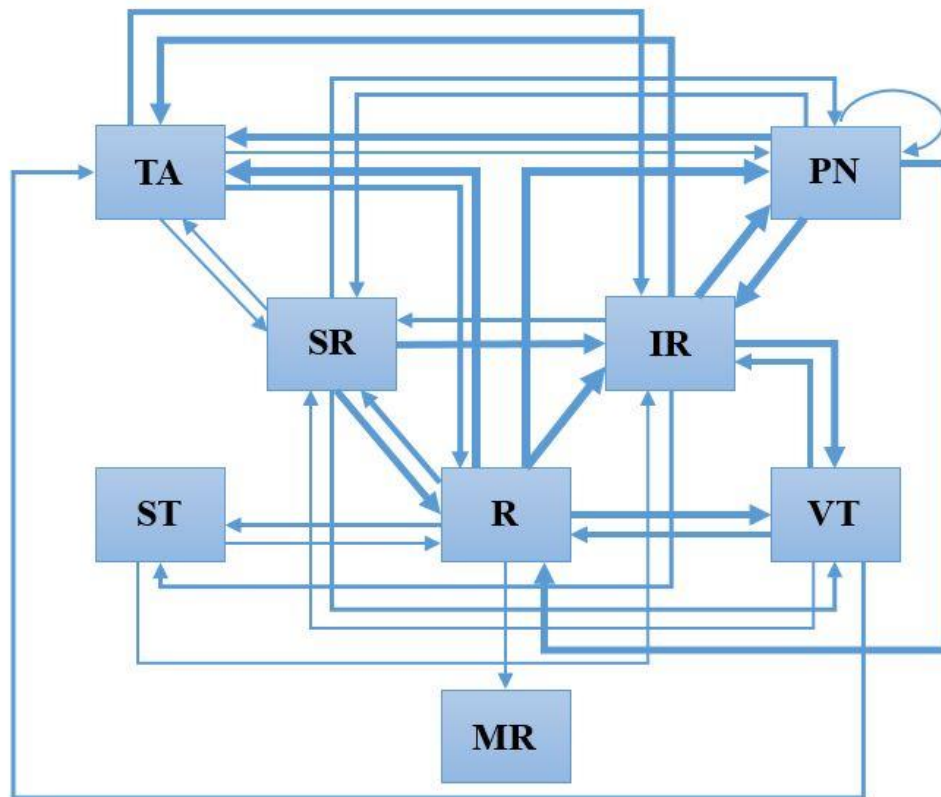


Figure 4. The relationship of group E students' learning behavior

Conclusion and future works

In non-English speaking countries, reading textbook, especially those that were designed for professional courses and contain many unfamiliar and complex terminologies, is a difficult and challenging. Most novice and experienced students suggest that reading such textbooks is a slow and time-consuming process. According to related literature, e-books have a great potential to facilitate reading and enhance learning achievement. Therefore, one e-book system was introduced in this study for an embedded system course. The system features a variety of functions that support reading process. For example, when students read a textbook, they can look up the professional terms, and translate an unfamiliar vocabulary, a sentence, a paragraph or whole article. Students can then take annotations in which they include definition or translation of new vocabulary, sentence or paragraph. Furthermore, the system highlights important terms in each sentence or most important sentences in a paragraph or whole article. Thus, students are able to focus on more important parts of learning material and avoid difficulties experienced during reading process.

According to experimental results, students who read textbook by using the e-book system (Group E) have better learning achievement. The reason is that diverse tools provided in the e-book system lower students' reading difficulties. Multiple reading models present the content differently according to students' needs. In addition, checking professional knowledge database serves as explanation and description of terms for students and effectively reinforce their acquisition and internalization of professional knowledge. Moreover, rich annotation function assists students' cognitive process of reading comprehension and increases students' comprehension competence in textbook reading. In addition, based on analysis of learning behavior, most of students prefer speed reading and intensive reading, and they can effectively adopt the professional knowledge database and translation function to assist their reading process. Furthermore, students prefer using word annotation function during textbook reading activity.

This research is still ongoing. In this paper, it assesses learning effectiveness of the e-book system on reading process. In the future, we will explore and analyze reading comprehension competence. In addition, we will explore students' cognitive load and anxiety during the reading process with and without the e-book system.

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