

Sequence Pattern Mining for the Identification of Reading Behavior based on SQ3R Reading Strategy

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Abstract: SQ3R (survey, question, read, recite, and review) is an efficient reading method that has confirmed the benefits of learning performance in numerous studies. To demonstrate that the e-book reading environment can also obtain the benefits of SQ3R, we conducted a course with 60 students, classify students into two groups based on the SQ3R ability. The results show that in the context of e-book reading, students' behavior: (1) create a memo and modify it regarding the reviewing content (CMeP) and (2) create a memo and modify it at the next login (CMeO) is related to recite and review steps in SQ3R. Furthermore, the above two e-book reading behaviors are positively related to students' learning performance and learning engagement.

Keywords: SQ3R, reading strategy, computer-assisted learning

1. Introduction

With the rapid development of learning technology, computer-assisted learning has gradually spread to schools at all levels. In recent years, the advantage of the digital learning environment built by computer technology lies in the ability to record students' historical learning actions in the learning log. Therefore, by measuring the students' engagement from learning logs, students' learning situation can be effectively and deeply to explore. Therefore, measuring the student's engagement through the learning log has attracted the attention of some researchers (Flanagan & Ogata, 2017; Jovanović *et al.*, 2017; Yin *et al.*, 2017). In addition, the use of learning techniques is also a key factor for effective learning. Therefore, the introduction of e-books into learning has become a new trend in recent years. From the above description, this study has introduced ebook reading environment named as BookRoll (Ogata *et al.*, 2015, Flanagan & Ogata, 2017) into course. Then, this study aims to extract actions from students' tracking logs in learning environment to explore students' learning patterns.

In the learning process, reading is the basic foundation of learning. Besides, the reading strategies adopted by students will have an impact on the reading performance. Therefore, this study will explore students' reading strategies in e-books. To guide students to perform efficient reading, Robinson (1946) has proposed SQ3R reading strategy which consists of the five steps of Survey, Question, Read, Recite, Review. Therefore, the research questions in this study are proposed as following.

- **RQ1 :** In reading e-book process, exploring the relationship between reading actions and learning outcome.
- **RQ2 :** For the groups classified by SQ3R reading strategy, explore the relationship between SQ3R reading strategy and learning performance.

2. Methods and experiments

2.1 Participates

The experiment was conducted with 60 students, with a total of eight weeks at a university in Taiwan. The course was divided into before-class reading material preview, classroom learning and after-class review. Classroom learning includes teacher lectures, concept summaries, exercise exercises and quizzes, and after-class review includes after-class reflection and homework exercises. In this paper, we focus on students' activities on before-class preview. Students' reading log will be recorded by BookRoll (Ogata et al., 2015, Flanagan & Ogata, 2017).

2.2 Learning actions in BoorRoll

Students' participation in this course can be observed through the log of the BookRoll system. According to the proposed reading functionalities in BookRoll, this study encoding students' reading actions from the logs. We define nineteen codes from the logs recorded by the students for each operation of the e-book, and divide them into four categories: Page, Bookmark, Marker, Memo. Page is a page-related action such as Next, Prev, Jump. Bookmark is a bookmark-related action, such as Add Bookmark and Delete Bookmark. Marker is a tag-related action, such as Add Marker, Delete Marker and Marker. Memo is related to the memo-related action such as Add Memo, Delete Memo, Change Memo and Memo. Table 1 shows the constructed 19 codes from BookRoll.

This study defines three types of reflection process, which are the same page, jump page, and re-login. Take Change Memo as an example, Same-page modification (CMe) means that when a student modifies memo, he has stayed on the same page since he last modified or added this memo. Page-change modification (CMeP) means that when a student modifies memo, he has changed the paged since he last modified or added this memo. Re-registration (CMeO), which means that when a student modifies memo, he has re-logged in the system since he last modified or added this memo. The original Change Memo will be recoded into the above three categories as CMe, CMeP, and CMeO. The other three actions (Delete Marker, Delete Memo, and Delete Bookmark) are also divided into three categories according to the same logic.

Table 1. The codes of reading actions in BookRoll.

Category	Code	Description	Code Sequence
Page	N	Go to page forward	N
	P	Go to page backward	P
	J	Jump to a specific page	J
	O	Open the ebook	O
Marker	AMa	Add a marker to the current page	AMa
	DMa	Adding a marker to the current page and then deleting this marker during viewing the current page	AMa...DMa
	DMaP	Add a marker to this page, and come back to delete this marker after viewing the others pages	AMa...[N/P/J]...DMa
	DMaO	Add a marker to this page, and come back to delete this marker after re-login this ebook	AMa...[O]...DMa
Memo	AMe	Add a memo to the current page	AMe
	DMe	Adding a memo to the current page and then deleting this memo during viewing the current page	AMe...DMe
	DMeP	Add a memo to this page, and come back to delete this memo after viewing the others pages	AMe...[N/P/J]...DMe
	DMeO	Add a memo to this page, and come back to delete this memo after re-login this ebook	AMe...[O]...DMe
	CMe	Adding a memo and then change the content in this memo during viewing the current page	AMe...CMe

Category	Code	Description	Code Sequence
	CMeP	Adding a memo and then come back to change the content in this memo after viewing the others pages	AMe...[N/P/J]...CMe
	CMeO	Adding a memo and then come back to change the content in this memo after re-login this ebook	AMe...[O]...CMe
Bookmark	AB	Add a bookmark to the current page	AB
	DB	Adding a bookmark to the current page and then deleting this bookmark during viewing the current page	AB...DB
	DBP	Add a bookmark to this page, and come back to delete this bookmark after viewing the others pages	AB...[N/P/J]...DB
	DBO	Add a bookmark to this page, and come back to delete this bookmark after re-login this ebook	AB...[O]...DB

2.3 SQ3R learning strategies for ebook reading actions

SQ3R reading strategy aims to guide students how to perform effectiveness reading to improve their reading comprehension, and SQ3R reading strategy which include of Survey, Question, Read, Recite, and Review steps is proposed by Robinson (1946). SQ3R emphasizes browsing the full text structure first, and then reading in detail. It is considered to be a very effective reading strategy, which helps to understand the full text and increase the memory retention rate. The survey step aims to grasp the structure of the article and the logic of the author to arrange the structure of the article, have a preliminary understanding of the full text. The question step is mainly to ask questions as a guide for the next stage of reading. According to the previous questions, read step focus on finding the answer from the reading article, and write down the answer in students' own words. The question proposed by students themselves can be guide students reading article into more directional to guide students more understanding and improve students' retention memory of article. In addition, students' question can also make teacher to know the level of students' reading comprehension. After finishing reading article, recite step aims to guide students to summary and recite the content for the key points of article by themselves. Students can back to read article again when they forget the content of key points. Without open the textbook, review step focus on guiding students to recall the article's structure and raised question to answer. If student can't answer the raised question, go back to the recite step.

3. Results and discussion

To reply RQ1 (In reading e-book process, exploring the relationship between reading actions and learning outcome), this study applied Spearman correlation analysis to explore the relationship between the actions and learning performance. The Spearman correlation coefficient is a test statistic based on the covariance to measure the statistical relationship or association between two variables. For representing students' reading actions, some researchers have constructed ebook reading actions (Yamada et al., 2017). Based on the extracted ebook reading actions from previous studies. Table 1 showed the constructed 19 actions from learning logs in this study. Table 2 shows the descriptive statistics results for the extracted actions and Spearman correlation coefficient.

Table 2. The results of Spearman correlation between the reading codes and learning outcome.

Category	Actions	Mean/Std.	Spearman Correlation
Page	N	1591.67/878.59	.11
	P	711.75/524.3	.09
	J	37.72/45.55	.21
	O	114.15/53.61	.10
Marker	AMa	145.23/111.28	.29*
	DMa	9.73/11.67	.33*
	DMaP	1.62/2.7	.29*

Category	Actions	Mean/Std.	Spearman Correlation
	DMaO	3.83/6.86	.33**
Memo	AMe	53.6/32.73	.45***
	DMe	0.67/1.16	.25
	DMeP	0.68/1.32	.16
	DMeO	0.25/0.57	.42**
	CMe	18.05/14.87	.41**
	CMeP	31.07/28.96	.26*
	CMeO	15.0/22.58	.27*
Bookmark	AB	3.03/5.9	.05
	DB	0.93/1.24	.05
	DBP	0.25/0.79	.05
	DBO	0.13/0.59	-.05

This study has extracted actions include of Page, Marker, Memo, and Bookmark categories. From the Spearman correlation results showed in Table 2, the actions belong to the Marker and Memo categories have significant relationship with learning performance. The range of Spearman correlation coefficient values for Marker and Memo categories are .29~.33, and .27~.45, respectively. It means that the actions belong to Marker and Memo categories have positive relationship with learning performance.

To reply RQ2 (For the groups classified by SQ3R reading strategy, explore the relationship between SQ3R reading strategy and learning performance), this study firstly classified students through their reading actions, and then extracted reading patterns through LSA. From the previous research studies, we can know that the SQ3R reading strategy is one of the most effective reading strategy. In SQ3R reading strategy, the question, recite, and review steps in the SQ3R strategy has great influence on students' reading comprehensive. Corresponding to reading actions in BookRoll, the AMe, CMe, CMeP, CMeO actions are the most related to question, recite, and review steps in the SQ3R. Therefore, this study will apply the k-means method to classify students' reading by using AMe, CMe, CMeP, CMeO actions. We classified students' reading actions into high (G_H) and low (G_L) reading engagement groups. For the G_H and G_L groups, Table 3 shows that the descriptive results of AMe, CMe, CMeP, CMeO actions.

Table 3. The descriptive results of AMe, CMe, CMeP, CMeO actions for the G_H and G_L groups.

Group	# of Students	Means/Std.				
		Midterm score	AMe	CMe	CMeP	CMeO
G_H	19	86.79/11.74	38.05/25.86	15.52/10.98	34/34.86	11.36/25.12
G_L	41	76.27/13.24	17.2/12.19	6.7/8.67	9.92/13.9	2.31/10.49
t-value		2.96**	9.26***	9.23***	4.54***	5.36***

From Table 3, the number of G_H and G_L groups are 19 and 41, respectively. Besides, the students' midterm score in G_H group has significantly higher than the students' midterm score in G_L group ($t=2.96$, $p<.01$). Besides, the reading engagement of AMe ($t=9.26$, $p<.001$), CMe ($t=9.23$, $p<.001$), CMeP ($t=4.54$, $p<.001$), and CMeO ($t=5.36$, $p<.001$) for students in G_H group are significantly higher than students in G_L group. This is the reasons for students in G_H group can obtain significantly higher midterm score than students in G_L group.

4. Conclusion

This study aims to demonstrate the SQ3R benefits in the e-book. We extract 31 reading actions from the BookRoll log, and 9 reading actions belonging to the marker and memo categories are positively correlated with the students' learning performance. The result shows that students' learning performance is influence by the students' number of reading actions. On the other hand, to prove the assumption, this study classifies students into two groups based on the SQ3R reading strategy. We can observe that students with high engagement will perform the recite and review steps of SQ3R through reading

patterns related to CMeP and CMeO patterns. Furthermore, based on the reading patterns extracted from the LSA, this study considered five association rules which could enable students to improve their reading engagement. According to the results, students with a higher number of reading patterns related to CMeP and CMeO actions will have a higher probability has higher engagement.

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