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BR-MAP: CONCEPT MAP SYSTEM USING E-BOOK LOGS

Masanori Yamada[1], Atsushi Shimada[2], Misato Oi[3], Yuta Taniguchi[2] and Shin'ichi Konomi[1]
[1]*Learning Analytics Center, Kyushu University*
[2]*Faculty of Information Science and Electrical Engineering, Kyushu University*
[3]*Innovation Center for Educational Resource, Kyushu University*
744, Motooka, Nishiku, Fukuoka, 8190395, Japan

ABSTRACT

This preliminary study developed the concept map tool "BR-Map" using learning logs on eBook viewer, and investigated the relationships between self-regulated learning (SRL) awareness, learning behaviors (usage of BR-Map, and one-minute paper and report submission), and learning performance. Psychometric data and learning logs were collected in the lecture course, and their relationships were analyzed using Spearman's correlation analysis. The results indicated that awareness of intrinsic value, use of cognitive learning strategies, and self-regulation had significant correlations with the usage of BR-Map. The awareness of cognitive learning strategies had significant correlation with standard deviation of one-minute paper submission hours. With regard to relationships between the BR-Map usage and learning behaviors, the relationships between the usage of BR-Map and one-minute paper submissions, which was a regularly weekly assigned task, were found.

KEYWORDS

Cognitive Learning Tool, Learning Analytics, Self-Regulated Learning

1. INTRODUCTION

1.1 Cognitive Learning

Cognitive learning research has been conducted for a long time in the field of educational technology research. Not only input but also consideration of, and interaction with, learning materials deepen information processing in both the mind and brain, and promote learning outcomes. Cognitive learning tools play an important role in enhancing learning outcomes, according to many previous researches (e.g., Leopold and Leutner, 2012). Concept maps are an effective cognitive learning tool for the enhancement of learning outcomes. Previous research (e.g., Clariana, et al, 2013; Yamada, 2010) indicated that a concept map makes learners aware of learning objects and the presence of peers. Concept maps promote cognitive learning performance and strategies (Fiorella and Mayer, 2013, 2017).

Perry and Winne (2006) evaluated the effects of the integrated cognitive learning tool, "gStudy," which was developed based on a self-regulated learning (SRL) model that centered on meta-cognitive skills. Learners become aware of academic strengths and weaknesses through metacognition. gStudy records learner's learning behaviors, promotes the cognitive learning process, and gives learners feedback. The concept map seems to be effective not only in improving learning performance but also the enhancement of metacognition. As further research, tracing and visualizing the learning process including the SRL process from input to consideration of concept maps and other learning support systems is desirable for creating an effective learning environment.

1.2 SRL and Learning Analytics

Self-regulated learning (SRL) is one of the important viewpoints for understanding learning behaviors. SRL is the active learning process used to regulate and monitor learning cognition, motivation, and behavior, and to set personal learning goals, including social aspects (Wolters, Pintrich, & Karabenick, 2003; Schunk and

Zimmerman, 2008). SRL also relates to metacognition (Schunk, 2008) and information processing (Winne and Hadwin, 1998). SRL seems to be a useful concept for understanding learners' learning features. The effects of SRL seem to be different for high- and low-performers. Schunk and Zimmerman (1998) further compared the learning behaviors of novice and expert SRL learners. Their results indicated that skillful learners controlled their learning process—such as making their learning plan, monitoring and reflection with their metacognition—and then they felt high self-efficacy, and had high internal motivation and learning performance.

Advances in Information and Communication Technology (ICT) can be of benefit to both learners and teachers to enhance SRL awareness and skills. When using ICT, learners can control when, what, and how they learn, without restrictions of time, learning space, and printed materials (Cunningham and Billingsley, 2003). Greene and Azevedo (2009) suggested 13 indicators of SRL in the context of computer-based learning such as help-seeking, expectation of adequacy of information, time and effort spent in planning. Recent research trends are focusing on the relationships between learning performance and SRL. Winne and his research colleague (2006) developed "gStudy" with a log analyzer, which constituted an early research about SRL in terms of learning analytics. Learning analytics is defined as "to clarify education and learning environment improvement using various data such as logs about learners and learning environment, with information processing methods" (e.g., Ifenthalar, 2015; Ogata et al, 2015). Goda et al (2013) suggested that SRL factors are useful to predict learning performance, and their successive study (2015) suggested that high-level SR learners can control and manage their learning plan in the context of their everyday lives, using a blended learning environment with ICT. Azevedo et al. (2017) suggested a framework for visualizing SRL awareness using multimodal data in e-learning settings. Yamada et al. (2017) suggested that the use of cognitive learning strategies—such as annotation as well as appropriate reading time for learning materials—play an important role in enhancing SRL awareness. Using ICT, learning behaviors that contribute to enhancing SRL awareness can be analyzed to support learning from the perspective of cognitive learning in the flow from input to consideration. This study aims to develop a concept map, "BR-Map," using learning logs stored on an ebook viewer that plays an important role in input, and investigate as a preliminary research the relationship between the usage of the concept map and SRL.

2. METHODS

2.1 Subjects and Course

Forty-four university students participated in this research. The course consisted of eight classes (one per week). The main learning object was to understand educational theories, principles, and history. There were two criteria for the grade: submitting a one-minute paper after every class, and a report. Students had to submit the one-minute paper within a day for a normal grade, but the teacher would accept it one day late (in such cases, the score would be reduced by half). The one-minute paper had to contain an abstract of the class and a discussion. The teacher explained the report themes three weeks before the submission deadlines. Students were required to submit the one-minute papers and reports on LMS.

2.2 BR-Map

BR-Map is a concept map tool using logs stored on an ebook viewer, "BookRoll," (Ogata et al, 2017) displayed in Figure 1. This is a simple and normal concept map tool with an interface as displayed in Figure 2, but BR-Map uses the logs on the ebook viewer. The usage flow of BR-Map is as follows: 1) The learner reads an ebook on BookRoll, 2) Learners highlight part(s) or attach memos on the ebook, 3) Learners open BR-Map, 4) BR-Map reads the logs of highlight(s) and memo(s) from the BookRoll database, 5) BR-Map lists all logs of highlight(s) and memos and displays them as objects on the left pane, 6) Learners click the object on the left pane, and drag-and-drop it on the right pane—the "concept map area," 7) Learners make a concept map by connecting objects using an "arrow". BR-Map allows learners to make many concept maps, using the "tab" function, and to save concept maps as a .png file. BR-Map was developed as a Moodle plug-in. The teacher adds one BR-Map plugin on a section in their course. BR-Map reads all the highlights and memo logs of all ebooks in the course.

BR-Map consists of two parts, the frontend and the server end. The frontend was developed using HTML/CSS and JavaScript using libraries including jsPlumb (for arrow presentation), html2canvas (for concept map presentation), canvg-browser (convert concept map to picture format (png)), EventBus (for event management), download.js (for download function), and jQuery. The server side consists of two servers—a web server using nginx 1.12 and a database server MySQL 5.7. Moodle 2.8.5 and PHP 5.6 were installed on the web server.

2.3 Data Collection

Students were asked to answer the motivational strategies for learning questionnaire (MSLQ) (Pintrich and DeGroot, 1990). The MSLQ, which consists of five factors (self-efficacy (SE), internal value (IV), cognitive strategies (CS), self-regulation (SR), and test anxiety (TA); 44 items in all, rated on a seven-point Likert scale), was used for the subjective evaluation of learners' SRL skills (see appendix). Students were asked to complete the MSLQ in the third class and again in the last class. The second method of data collection was the concept maps. The number of objects and links on the concept map of each learner were counted. The third method was the log of submission times of the one-minute papers and report. The submission time increased the earlier a student submitted the assignment. For example, if a student submitted the one-minute paper one hour before the deadline, the submission time was 1; if a student submitted the regular report 100 hours before deadline, submission time was 100. The final method was to measure report quality. A teacher evaluated the report quality as a score in the range of 0 to 40.

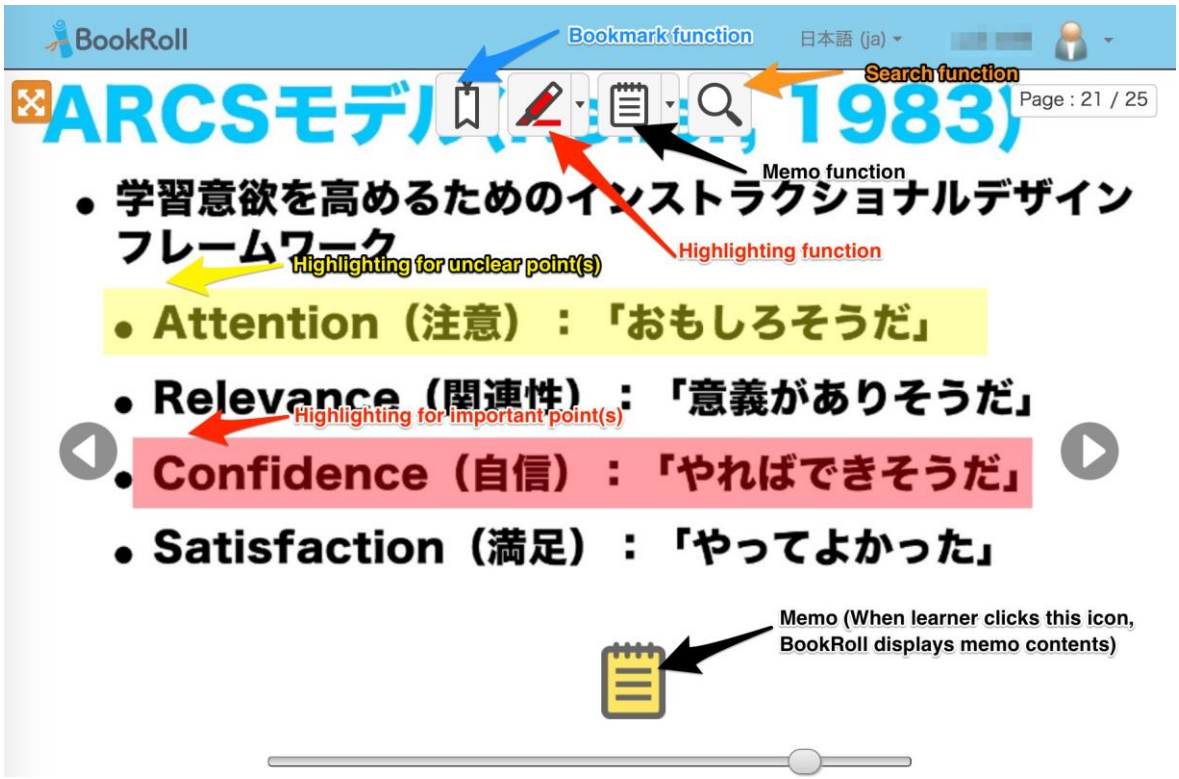

Figure 1. Interface of "BookRoll" (Ogata et al, 2017)

Figure 2. Interface of "BR-Map"

3. RESULTS

Of the 44 first-year students, 24 answered the questionnaire in class. We conducted Spearman's correlation analysis to investigate the relationship between SRL, submission time of the one-minute paper and report, standard deviation of the one-minute paper's submission times and the report score. In sections 3.1 and 3.2 below, we provide the descriptive data, and the results of the correlation analysis are given in section 3.3.

3.1 Descriptive data and Wilcoxon Signed-Rank Test for SRL

Table 1 shows the average, standard deviation, and median results of the Wilcoxon signed-rank test for each SRL factor. The score for each factor was calculated from the sum of each item in each factor. Table 2 displays the descriptive data of the concept map, submission time, and report quality. These results show that MSLQ factors except self-efficacy significantly declined between pre- and post-questionnaires. However, SDs of internal value, cognitive strategy use, and test anxiety declined very much—that is, factors of MSLQ declined overall, but lower-level learner scores improved and individual differences became small.

3.2 Descriptive data for Learning Behaviors

Tables 2 and 3 show learning behaviors and learning performance. In BR-Map usage, learners tended to create nodes more, though learners used link functions to some extent. With regard to submission of the one-minute paper and report, almost all of the learners kept the deadline. Learners tended to submit the one-minute paper between noon and evening. The SD of the one-minute paper submission hours indicated learning habits. For example, if the SD is 0, it indicates that a learner submits the one-minute paper at the same hour every week. In this study, eight out of 24 learners had an SD of submission hour less than 1. One-third of the learners had a stable learning habit. Interestingly, in five of the eight learners, the average of submission hours for the one-minute paper was less than 10 hours in five lectures. This means that these learners submitted their one-minute paper around the end of the day (from 22:00 to 23:59).

3.3 Correlation Analysis

The Wilcoxon signed-ranked test results revealed that awareness of SRL declined significantly overall. However, what kinds of learning behaviors and SRL awareness were affected by the use of BR-Map? Is awareness of SRL, learning behaviors, and learning performance related to the use of BR-Map? To investigate the relationships between psychological perspectives, learning behaviors, learning performance, and BR-Map usage, Spearman's correlation analysis was conducted. The differences between post- and pre-rating data for SRL were calculated. Table 4 shows the results.

Table 1. Average sum scores and Wilcoxon signed-ranked test results for each factor in MSLQ

Item	Average score (SD)		Median		*Z*	sig
	Pre	Post	Pre	Post		
Self-efficacy (min: 9, max: 63)	31.79 (7.45)	32.29(7.90)	32.00	33.00	-0.20	p = 0.84
Internal value (min: 9, max: 63)	46.71 (11.23)	42.08 (4.93)	49.00	42.00	2.82	p = 0.00
Cognitive strategy use (min: 13, max 91)	62.50 (12.51)	57.50 (5.99)	61.50	58.00	2.50	p = 0.01
Self-regulation (min: 9, max: 63)	37.08 (3.45)	33.13 (4.01)	37.50	34.00	3.09	p = 0.00
Test anxiety (min: 4, max 20)	16.29 (5.55)	14.00 (1.69)	16.00	14.00	1.83	p = 0.06

Table 2. Average sum score of nodes and links in BR-Map

Item	Average score (SD)	Median
Node	8.67 (6.79)	9.00
Link	3.88 (3.85)	2.50

Table 3. Average, SD, and median of learning behaviors and learning performance

Item	Average	SD	Median
Submission time for one-minute paper in the deadline (Min 0 – Max: 5)	4.92	0.28	5.00
Delayed submission time for one-minute paper	0.16	0.38	0.00
Sum of submission time (hour) for one-minute paper	26.38	17.51	24.00
Submission time (hour) of S.D. for one-minute paper	2.70	1.89	2.88
Submission time (hour) for report	20.08	31.18	11.50
Report score (Min 0 – Max 40)	32.71	4.97	33.00

Table 4. Spearman's correlation analysis results between MSLQ, node and link in BR-Map, learning behaviors, and learning performance

	Node	Link	One-minute paper submission	One-minute paper delayed submission	One-minute paper submission hours	S.D of One-minute paper submission hours	Report submission hours	Report score
SE	0.20	0.11	-0.04	0.06	0.26	-0.01	0.24	0.01
IV	0.30	**0.49***	0.18	-0.07	0.22	0.31	-0.10	-0.04
CS	0.34	**0.44***	0.18	-0.07	0.26	**0.36†**	0.03	0.04
SR	**0.43***	**0.47***	0.11	-0.19	0.24	0.12	-0.13	0.11
TA	0.09	0.10	0.18	-0.11	0.00	0.06	-0.05	0.02
Node	-	**0.76*****	**0.42***	**-0.54****	**0.53****	0.19	**0.42***	0.22
Link	**0.76*****	-	**0.36†**	**-0.42***	**0.41***	0.15	0.15	0.15
Report score	0.22	0.15	**0.40†**	**-0.45***	-0.20	-0.10	0.08	-

***: $p < 0.001$, **: $p < 0.01$, *: $p < 0.05$, †: $p < 0.1$

The results indicated that self-regulation and the number of links were correlated with the number of nodes, and internal value, cognitive strategies use, and self-regulation were correlated with the number of links. With regard to the relationships between learning behaviors, learning performance, and BR-Map use, the number of nodes was correlated with one-minute paper submissions, one-minute paper submission hours, and report submission hours positively, and with one-minute paper delayed submissions negatively. The number of links on BR-Map was correlated with one-minute paper submission and one-minute paper submission hours positively, and with one-minute paper delayed submissions negatively. However, the usage of BR-Map did not have any significant direct relationships with the report score.

4. CONCLUSION AND FUTURE RESEARCH

This study aimed to develop and conduct a formative evaluation of BR-Map from the perspective of self-regulated learning. It is hypothesized that BR-Map supports SRL skills—in particular, cognitive learning strategies use—directly, and it usage seems to be affected by the learning habit of reading learning materials regularly. The results of this study support the hypothesis to some extent. The usage of BR-Map was significantly correlated with the awareness of self-regulation and the use of cognitive learning strategies in MSLQ, and the submission times and hours of the one-minute paper. However, the usage of BR-Map was not significantly correlated with learning performance directly. According to many previous studies, supporting SRL leads to learning performance (e.g., Wolters et al, 2003; Yamada et al, 2016). There are two possible reasons; one is that learners could not effectively use the concept map on BR-Map for report writing. BR-Map allows learners to understand learning contents in a cross-class manner, but it did not focus on the report theme that the learners wrote. Second, BR-Map seems to enhance the understanding of learning materials, but it did not help learners in developing their ideas on the report theme. The class required learners to select a report theme and write abstracts of the theme and their idea. When learners did not include their idea in their report, it could lead to lower scores.

As future research, there are four points that need to be taken up. First, to improve BR-Map functions. Several learners asked to modify BR-Map, for example, adding memos on BR-Map and displaying the thumbnails of learning materials (slides) on the left pane. These functions seem to improve usability and affect awareness of learning objectives. Second, analysis of the relationships with ebook viewer logs—such as page flipping, highlighting, and memos—is required because these behaviors were considered to have direct effects on comprehension and self-regulated learning (Yamada, et al, 2017), as mentioned in section 1. Third, to analyze learning behaviors and learning performance with more data in order to investigate the effects of BR-Map. And finally, to develop a dashboard to collect and visualize the learning process using BR-Map, which would be essential for enhancing the effects of learning analytics on learning support. BR-Map is a cognitive medium that connects input and consideration. Learning logs stored on BR-Map seem to be useful to understand the learner's learning process. A dashboard to collect and visualize learning logs on BR-Map can be effective in understanding the status of the learner's learning process, which promotes effective learning support.

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