Learning Analytics for Supporting Seamless Language Learning using E-book with Ubiquitous Learning System

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ABSTRACT

Seamless learning has been recognized as an effective learning approach across various dimensions including formal and informal learning contexts, individual and social learning, and physical world and cyberspace. With the emergence of seamless learning, majority of the current research focus on realizing a seamless learning environment at school or university. However, the utilization of the collected learning logs still remains a challenge yet to be explored. In this study, an e-book with ubiquitous learning system called SCROLL is developed to collect and analyze learning logs in the seamless learning environment. Moreover, this paper presents our analytics in contribution to bridging the learning between eBook learning and real-life learning. An experiment was conducted to evaluate (1) whether VASCORLL 2.0 (Visualization and Analysis System for Connecting Relationships of Learning Logs) is effective in connecting the words learned through eBook to those learned from real-life, and (2) which social network centrality is the most effective to enhance learning in the seamless learning environment. Twenty international students participated in the evaluation experiment, and they were able to increase their learning opportunities by using VASCORLL 2.0. Furthermore, the betweenness centrality was found useful in finding central words that bridge eBook and real-life learning.

Keywords

Mobile learning, Ubiquitous Learning, Seamless learning, Learning analytics, Ubiquitous learning analytics

Introduction

Recently, several researchers in language learning have focused on supporting in-class language learning and out-of-class language learning. In discussing language learning issues, it is often argued how recent technologies such as mobile and ubiquitous support language learning because of the lack of autonomous learning and authentic social interaction. Using mobile and ubiquitous technologies, learners can actively save what they have learned as learning logs anytime and anywhere, thereby sharing and making learning more collaborative.

With the emergence of these technologies, seamless learning is defined as an approach "when a person experiences a continuity of learning, and consciously bridges the multifaceted learning efforts across a combination of locations, times, technologies or social settings" (Wong et al., 2015, p. 9). Several researchers in the seamless language learning field have pointed out that mobile and ubiquitous technologies have enabled students to learn continuously across different contexts (Looi et al., 2015; Milrad et al., 2013). The main characteristics of seamless learning are shown as follows: (1) Encompassing formal and informal learning, (2) Encompassing personalized and social learning, (3) Across time, (4) Across locations, (5) Ubiquitous knowledge access, (6) Encompassing physical and digital worlds, (7) Combined use of multiple device types, (8) Seamless switching between multiple learning tasks, (9) Knowledge synthesis, (10) Encompassing multiple pedagogical or learning activity models (Wong & Looi, 2011).

One of its most important issues is how to bridge in-class and out-of-class language learning because this is inevitable in designing both in-school and out-of-school activities to link what students have learned in school with their daily life experiences and vice versa, particularly, to link what they have learned in their daily lives to their experiences in class. In the field of seamless language learning, majority of researchers reported that seamless learning is expected to enhance the learning effect and motivation. For example, Wong et al. (2014) reported a seamless learning system called MyCLOUD (My Chinese UbiquitOUs learning Days), which allows students to learn the Chinese language in both in-school and out-of-school learning spaces. Uosaki et al. (2010) reported a seamless learning system called SMALL System (Seamless Mobile-Assisted Language Learning support system) to support Japanese students who aimed to learn the English language in a formal and informal setting. Most of these studies focused on realizing a seamless learning environment at school or university. Once realized, the students' learning logs have been accumulated into their server.

Therefore, we contend that learning efficacy can be enhanced by utilizing their accumulated learning logs. Presently, this aspect has attracted little attention. The research issues of learning analytics based on seamless learning environments are as follows:

- How we can utilize the learning logs accumulated in seamless language learning system?
- How can analytics bridge the gap between formal and informal learning?
- How can analytics enhance and support the students' learning experiences?

To address these issues, this study proposed a seamless visualization and analysis system called VASCORLL 2.0 (Visualization and Analysis System for Connecting Relationships of Learning Logs). VASCORLL 2.0 analyzes and visualizes learning logs accumulated in seamless language learning system. The system supports eBook-based learning and real-life learning by integrating the ubiquitous learning system called SCROLL with e-book system. To evaluate (1) whether VASCORLL 2.0 is effective in bridging the words learned in eBook to those learned in real-life, and (2) which social network centrality is the most effective to enhance the learning opportunities for seamless language learning, an experiment was conducted.

Literature review

Authentic learning and seamless language learning

Many empirical research have found that classroom-only learning is not conducive to enhance the learners' communicative skills, such as listening and speaking, and sustaining their learning motivation. To provide effective language learning, it is necessary to consider in-class learning and out-of-class learning or authentic learning. Effective language learning is characterized by the active and constructive production of thoughtful linguistic artifacts in authentic learning settings (Ellis, 2000).

Authentic learning is either experimental learning or real-life learning. To bridge in-class learning and real-life language learning, most Seamless Language Learning (SLL) studies have been conducted from learning technologists' perspective, which typically prioritizes the utilization of mobile affordances. In addition, these studies have been designed to introduce seamless learning environments into universities or schools (Wei, 2012; Ogata et al., 2015; Chai et al., 2016). However, they did not consider the learning analytics perspective for supporting seamless learning (Hwang et. al., 2017). In summary, SLL needs to consider seamless learning supports from learning analytics perspectives because the collected learning logs aren't utilized to support learning. We believe that utilizing the collected learning logs lead to enhancing the quality of learning.

To support SLL from learning analytics perspectives, this study proposes seamless learning analytics to bridge eBook-based learning and real-life language learning by analyzing and visualizing the learning logs collected in both formal and informal settings. In the section entitled "SCROLL," this paper describes the seamless language learning for supporting real-life language learning.

E-book learning system and e-book-based learning analytics

E-books represent a combinational figure in printed books and interactive computing technologies. Japanese government has announced their future policy to introduce "instead of" as a policy that introduces e-books in all K12 schools by 2020 (MEXT). The e-book policies of many countries only focus on introducing the technology of e-books into K12 schools (Fang, Liu & Hung, 2011; Shin, 2012). Some of the benefits of e-books have been identified, such as easily portable, easy search, highlighting, copy and paste, and quick updates.

Many previous studies of e-book have addressed above several benefits and enhancing opportunities for learners to interact with the learning contents. For example, Hwang et al. (2017) proposed an interactive e-book-based flipped learning approach to facilitate and bridge in-class learning and out-of-class learning. The contribution of their study is to bridge what learners have learned at home to the in-class activities by using their e-book system. They suggested that it is necessary to consider learning log analysis to better assist students and teachers, as their future works. However, little attention has been paid to visualizing and analyzing the e-book logs. Therefore, it is necessary to explore various analytics in this aspect.

This paper calls the visualizing and analyzing of e-book activity logs as "E-book-based Learning Analytics (ELA)." Some researchers at Kyushu University in Japan reported several analytics using a document viewer system called BookLooper (Ogata et al., 2015; Yin et al., 2014; Kiyota et al., 2016; Mouri et al., 2016a; Mouri et

al., 2016b). The objectives of their studies are as follows: (1) improvement of learning materials, (2) analyzing learning patterns, (3) detecting the students' comprehensive level, (4) predicting final grades, and (5) recommending e-books in accordance with personalization.

With consideration of the discussions of the ELA, we developed an e-book viewer system. In the section titled "E-book system for supporting language learning", this paper describes the e-book system for supporting seamless language learning.

Previous work

E-book system for supporting seamless language learning

Figure 1 shows the interface of e-book library. The teachers or instructors create e-book contents using PowerPoint and Keynote prior to the class and use them in their courses. The uploaded e-book contents are converted to EPUB format and it is supported to access the contents by using smartphones and PCs. Figure 1 (Left) shows each directory in their course. For example, when the learner clicks the directory of the course named "Onomatopoeia class," the learner can see the uploaded e-book contents in the directory. Figure 1 (Right) shows the files in the directories.
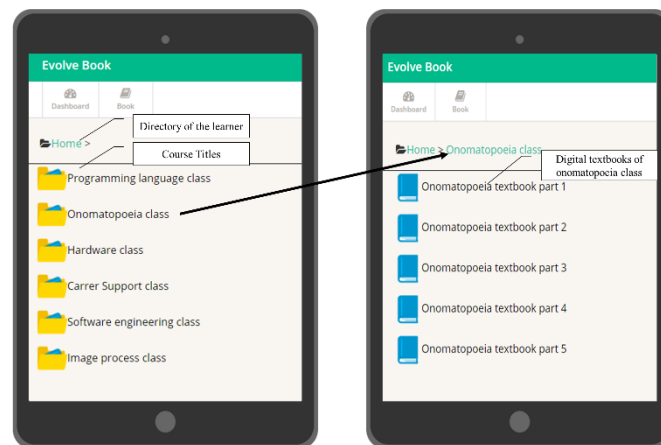

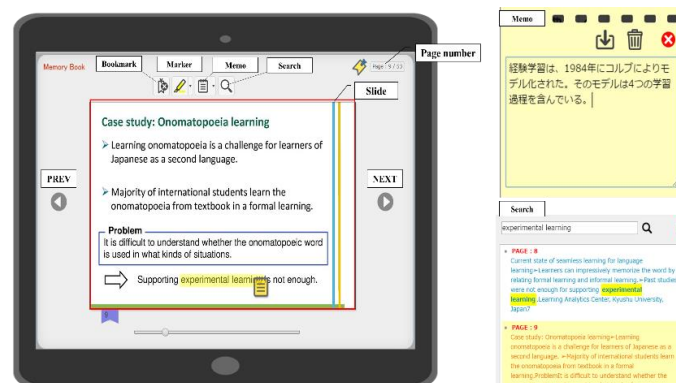*Figure 1.* Interface of the e-book library

Figure 2. e-Book viewer interface

Figure 2 shows the e-book viewer interface and slide descriptions uploaded by the teachers. The learners can read the digital textbooks on their web browser anytime and anywhere. For example, when a learner clicks the memo button on the e-book viewer system, the learner can write a description concerning the target words as shown in Figure 2 (Right-top). In addition, the learner can search the page number corresponding to the target word in the e-book by clicking the search button as shown in Figure 2 (Right-bottom). Their operation logs, such as opening a book, zooming, bookmark, memo, searching words, highlighting important words, and page turning, are collected into the database server.

SCROLL

SCROLL project has started to support real-life language learning for international students since 2011. SCROLL aims to aid users to simply capture, review and reflect their learning logs, reuse and share the knowledge. To simplify the process of capturing the learning experience in their daily life, SCROLL provides a well-defined form to illustrate a learning log. It adopts an approach to share contents with other users based on a LORE (Log-Organize-Recall-Evaluate) model proposed by (Ogata et al., 2011). How the model supports each learning process is described below.

- Log: International students are likely to face some problems such as how to read, write and pronounce words in their daily life. They can save what they have learned with photo, such as location (latitude and longitude), learning place, and date and time of creation as a ULL (Ubiquitous Learning Log) as shown in Figure 3.
- Organize: When an international student adds a new ULL, SCROLL compares it with his past ULL and those of other users, categorize it and shows him related ULLs. By sharing ULLs as shown in Figure 4, past learning and current learning can be linked and their knowledge will be reorganized and reinforced.
- Recall: Learners are likely to forget what they have learned previously. It is necessary to support re-calling their past ULLs. During this learning process, the system support learners to recall what they have learned by using a quiz as shown in Figure 5 (Li et al., 2013; Ogata et al., 2014). The quiz are created automatically from uploaded ULLs. By answering the quiz, the learner's knowledge will be enhanced.
- Evaluate: It is important to recognize what and how the learner has learned by analyzing the past ULLs, so that he or she can improve what and how to learn in the future. Mouri et al. (2014; 2015a; 2015b) developed an innovative visualization system that implemented Time-Map with network based graph theory to support this learning process. For example, when learners use the visualization system, they can reflect on what and how they have learned based on their past ULLs. It is expected that enhancing learning activities to share and reflect ULLs.
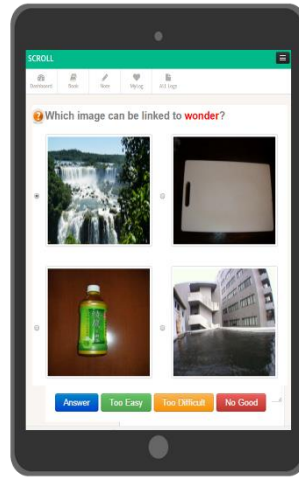

Figure 3. Add a ULL

Figure 4. A ULL

Figure 5. Quiz interface

VASCROLL

Our previous VASCORLL could visualize and analyze learning logs accumulated in SCROLL to support real-life learning (Mouri et al., 2016c). For example, there is a ULL where an international student learned "fan" at the university in the past. It means "扇風機 (mechanical fan)" in Japanese. There is another ULL where another international student learned the same word, "fan" in a different context in the past. In this case it means "うちわ (Uchiwa is a round, flat paper fan with a wooden or plastic handle)" in Japanese. Even if the English word is the same, the meaning might be different if the context is different. By using VASCORLL, they can learn such relationships.

The results of an evaluation experiment indicated that VASCORLL was useful tool in detecting the correlations among learners, words and location in a ubiquitous learning environment. Furthermore, VASCORLL could increase learners' learning opportunities and learners can apply their own experiences to different learning places.

However, the system did not consider learning analytics in the seamless learning in order to find central words bridging e-Book learning over real-life learning. Therefore, this study developed VASCORLL 2.0 based on the previous work.

Method

VASCORLL 2.0 framework

The aim of VASCORLL 2.0 is to support learners to apply what they have learned in class to their daily life experiences and vice versa, particularly, what they have learned in their daily life to e-Book learning. To bridge both e-Book learning and real-life learning, this study designed innovative visualization structures as shown in Figure 6: E-Book Learning Structure (ELS) and Real-life Learning Structure (RLS). ELS consists of three layers, which are called "eBook learner," "Words learned through eBooks," and "learning materials."
- eBook learners: The upper layer shows learners studying in e-book-based learning.
- Words learned through eBook: The intermediate layer shows words that they have learned using e-book viewer interface.
- Learning materials: The Lowest layer shows learning materials uploaded by teachers or instructors.

To visualize the relationships among eBook learner, words learned through eBooks and learning materials, this paper visualizes the relationships based on network with directed graph. How our visualization method does connects relationships of each node? For example, if a learner learns and saves a newly learned word using e-book viewer interface, our visualization method will connect the learner' node in the upper layer in the ELS to the word' node in the intermediate layer in ELS. Moreover, the word' node will connect to the learning material nodes in the lowest layer in ELS. By visualizing these links, teachers and students can grasp which e-book learning contents have the target word.

RLS includes three layers, which are called "Real-life learners," "Words learned in a real-life," and "Locations."

- Real-life learners: The upper layer shows learners studying in an informal setting such as museums, restaurants and city halls using SCROLL.
- Words learned in a real-life: The intermediate layer shows words that they have learned in a real-life setting using SCROLL.
- Locations: The lowest layer shows contextual data such as location and place where they have learned in a real-life setting using SCROLL.
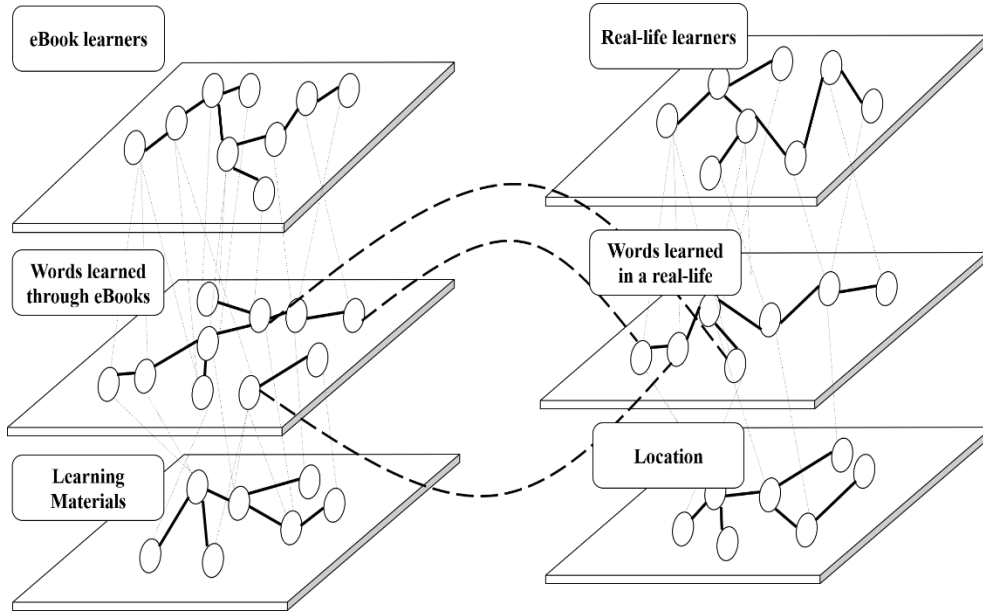

Figure 6. Visualization structures in the seamless learning environments: E-Book Learning Structure (ELS) and Real-life Learning Structure (RLS)

Table 1. Social network analysis

Algorithm	Formula (graph G:=(V,E) with V vertices and E edges)	Details
Degree	$$C_i^D = \frac{k_i}{N-1}$$	Degree centrality is defined as the number of links incident upon a node. That is, it is the sum of each row in the adjacency matrix representing the network. N is the number of node and k_i is the degree of the node i.
Closeness	$$C_i^C = (L_i) = \frac{N-1}{\sum_{j \in G, j \neq i} d_{ij}}$$	Closeness centrality is that the distance of a node to all others in the network. d_{ij} is the shortest path length between i and j, and L_i is the average distance from I to all the other nodes.
Betweenness	$$C_i^B = \frac{1}{(N-1)(N-2)} \sum_{j \in G, j \neq i} \sum_{k \neq i, k \neq j} \frac{n_{jk}(i)}{n_{jk}}$$	Betweenness centrality is that the number of shortest paths between any two nodes that pass via a given node. n_{jk} is the number of the shortest path between j and k, and $n_{jk}(i)$ is the number of the shortest path between j and k that contains node i.

Based on visualization structures in the seamless learning environments described previously, this study presents the centralities using social network analysis as shown in Table 1. Degree, closeness and betweenness centralities are the fundamental measurement concepts for the social network analysis (Latora & Marchiori, 2004; Freeman, 1979). Particularly, we hypothesize that the betweenness centrality could bridge the gap between e-Book learning and real-life learning. For example, if an international student learns word "natto" on e-book content in a formal setting, it might be applied to various learning places such as supermarkets, shopping malls, and restaurants in an informal setting.

However, it is difficult for him/her to know whether it can be learned in other learning environments or where it can be learned. In addition, it is difficult for learners to find which words were most frequently learned by learners in a variety of learning environments. These words could play the most important role to bridge over eBook learning and real-life learning to realize the seamless learning environments.

Implementation

VASCORLL 2.0 interface

Majority of network graph studies have focused on advantages such as good-quality results, flexibility, simplicity, and interactivity. For example, a network layout called "force-directed" uses the force vector algorithm proposed in the Gephi software, which is appreciated for its simplicity and for the readability of the network that helps in the visualization (Mathieu et al., 2014; Noack, 2009; Fruchterman & Reingold, 1991). A network layout called "Yifan Hu multilevel" uses a very fast algorithm to reduce complexity (Hu & Scolt, 2001). The repulsive forces on one node from a cluster of distant nodes are approximated by a Barners-Hut calculation, which treats them as one super-node (Barners & Hut, 1986).
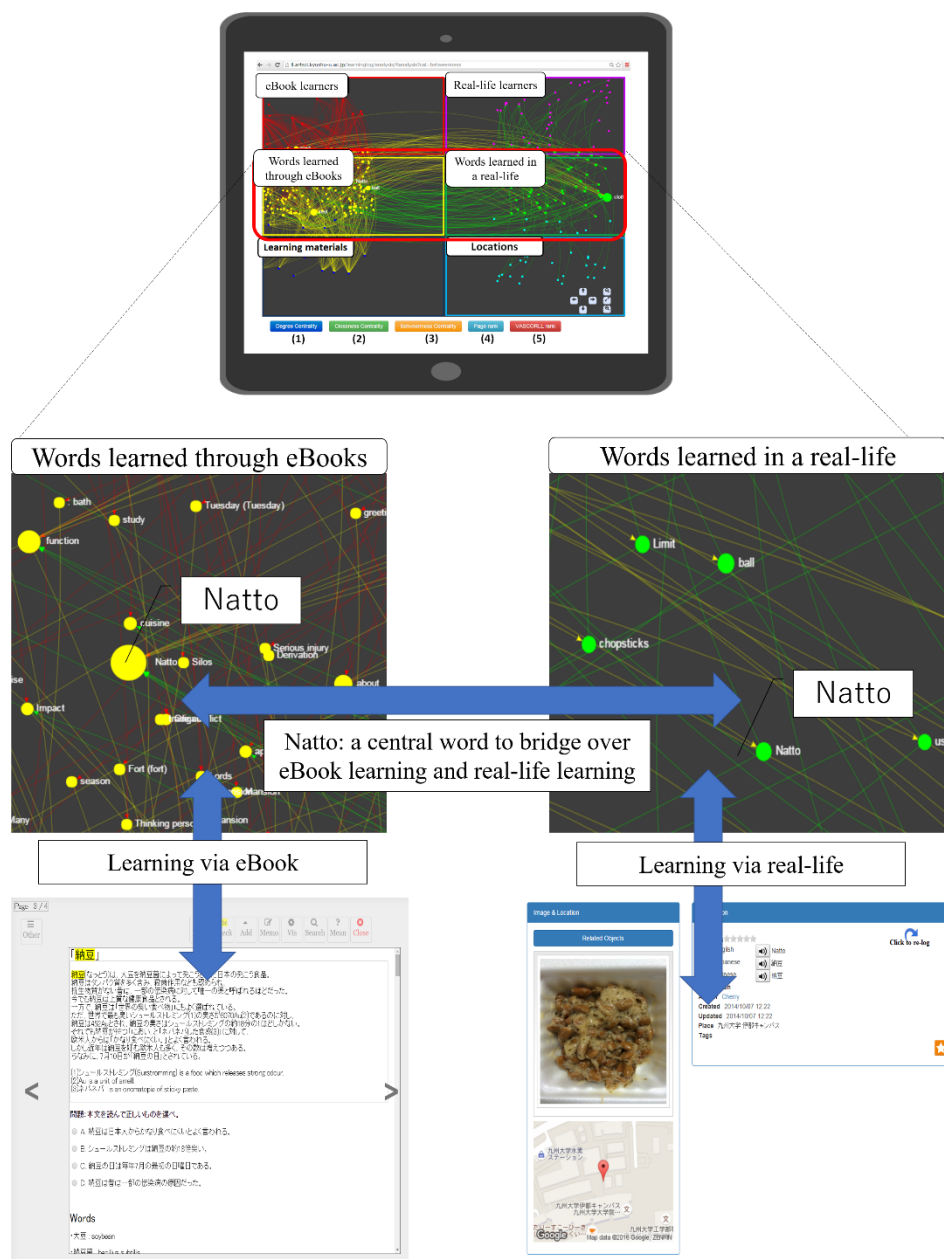

Figure 7. VASCORLL 2.0 interface and learning scenarios

Moreover, Mouri et al. (2015a) proposed Ubiquitous Learning Graph (ULG), which is divided into four areas: top-left, top-right, bottom-left, and bottom-right. In their evaluation experiment, they reported that it is important to establish their nodes' position on the network graph for readability and ease-of-use when visualizing the relationships in the real-world language learning. Considering these points, we developed a network layout called "Seamless Learning Graph (SLG)," which is divided into six areas as shown in Figure 7 (Top): upper-left (eBook learners), center-left (Words learned through eBook), bottom-left (Learning materials), upper-right (Real-life learners), center-right (Words learned in a real-life), and bottom-right (Locations). These areas represent the layers as shown in Figure 6.

The interface implements three centralities based on social network analysis. Buttons (1) to (3) in Figure 7 show each centrality. By clicking them, VASCORLL 2.0 will automatically visualize and analyze all learning logs accumulated in the e-book system with SCROLL. The node size is based on the numerical value of each centrality. Figure 7 (Middle) shows the enlarged graph in both words learned through eBook and in a real-life areas. There are two learning scenarios by utilizing the results of visualization, which are called "Learning via Words learned through eBook" and "Learning via words learned in a real-life" as shown in Figure 7 (Bottom).

- Learning via words learned through eBook: As shown in Figure 7 (Middle), the word "natto" is the biggest size in the words learned through eBook areas. By clicking it, the system moves to the page where the word "natto" appears. In this manner, learners can grasp which e-book and which page includes it.
- Learning via words learned in a real-life: After learning "natto" in the e-book contents, learners can find "natto" in the words learned in the real-life areas. By clicking it, the system moves to the ULLs ("natto" pages of SCROLL) learned in the real-life setting. Unlike the above learning method (1), by utilizing the ULL, they can share and learn other learners' learning experiences (not only words but also time, location and place information) that cannot be learned in the formal setting.

Evaluation

Participants

Twenty international students who are studying at the University of Tokushima and Osaka in Japan participated in the evaluation experiments. The students were from China, Malaysia, Thailand, and Mongolia and aged from 21 to 36 years old. Their length of stay in Japan ranged from 1 month to 5 years. The evaluation experiment was designed to evaluate the following three points:

- Whether VASCORLL 2.0 can increase the participants' learning opportunities ("Learning opportunities" denote that the number of ULLs that the learner uploaded to the system during the evaluation period").
- Whether VASCORLL 2.0 would be benefit in terms of usability in finding important words in the seamless learning environment.
- Which centrality is effective in supporting learning in the seamless learning environment?

Method

A Japanese instructor uploaded e-book contents to the server prior to his/her class. The uploaded e-book contents were categorized according to JLPT (Japanese Language Proficiency Test). At the beginning of the first week, the instructor had a briefing session on how to use e-Book system with SCROLL since it was their first time to use it. They practiced using the e-book system with SCROLL for one week before the information of VASCORLL 2.0. Based on the uploaded ULLs during the first week, the participants were divided into two groups as even as possible in terms of the keenness of language learning: Group A (Experimental group) and Group B (Control group). Figure 8 shows the experimental procedure.

Table 2 shows the number of ULLs that the participants uploaded during the first week before using VASCORLL 2.0. Group A participants uploaded 143 ULLs and Group B participants uploaded 149 ULLs to the system. The means and standard deviations were 14.3 and 6.78 for Group A, and 14.79 and 6.51 for Group B. The t-test shows that there was no significant different between the two groups ($t = 0.201$, $p > 0.05$). This result indicates that the participants of the two groups have learning opportunities before using VASCORLL 2.0. Then, the instructors introduced how to use VASCORLL 2.0.
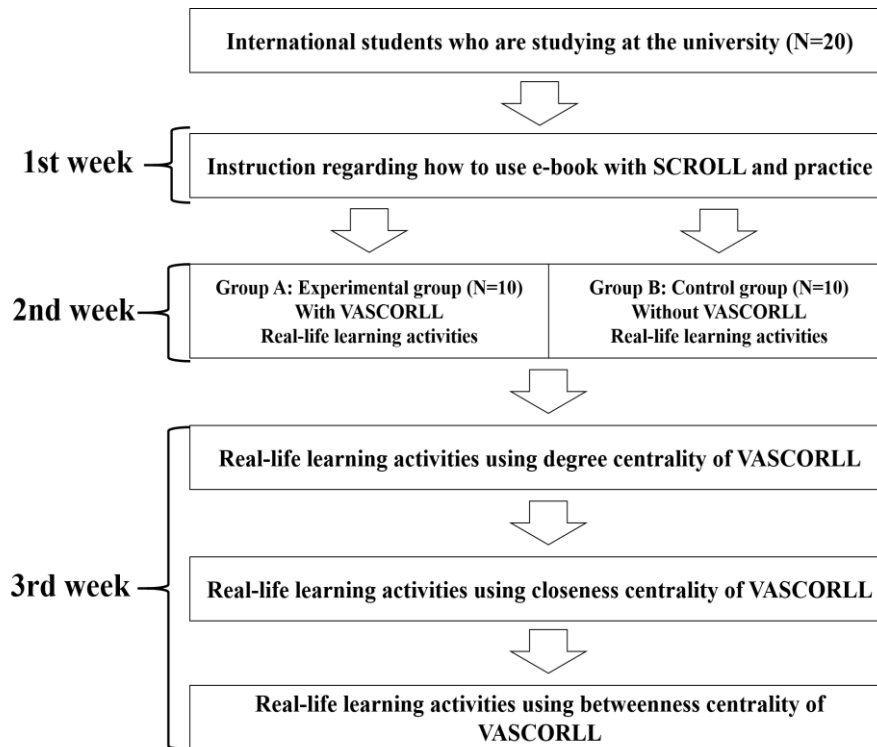
Figure 8. Experimental procedure

Table 2. Number of uploaded ULLs in the first week (practice period)

Group	Number of participants	Number of ULLs	Mean	SD	t	p
Group A	10	143	14.3	6.78	0.201	> .05
Group B	10	149	14.9	6.51		

Group A consisted of 5 Chinese, 4 Mongolians and 1 Malaysian. Group B consisted of 3 Chinese, 5 Mongolians and 2 Thais. Group A learned words in their daily lives and words in the e-book contents using the e-book system with SCROLL and VASCORLL 2.0. Group B learned words in their daily lives and words in the e-book contents without VASCORLL 2.0. The participants used their own smart-phones (iPhone 4s or Android device) to upload their ULLs in formal settings and informal settings anytime and anywhere. The mobile devices used in the evaluation experiment were three iPhone 4s, fourteen iPhone 5s, and three Samsung Galaxy Note 3s. In the second week, they were required to conduct real-life learning activities described previously.

During the third week, both Groups A and B participants evaluated each centrality based on social network analysis during real-life learning activities. The reason for integrating both Group A and B is to evaluate three centralities with enough number of participants in terms of easiness to find words bridging eBook and real-life learning. They learned words using three algorithms: degree, closeness and betweenness. They were asked to use the prearranged one centrality (e.g., participants first had to use degree centrality for two days). After the evaluation experiment, the participants were asked to complete five point-scale questionnaires to evaluate the system performance and usability, as well as the user-friendliness of understanding the contents and finding ULLs using each centrality in VASCORLL 2.0.

Result and discussion

To examine the increase of participants' learning opportunities by our proposed VASCORLL 2.0, we compared the number of the uploaded ULLs of Group A with that of Group B. Two-way ANOVA was applied to understand the effect on the learning opportunities of the different groups (with and without VASCORLL) and the time of measurements (1st week and 2nd week), (Liu et al., 2014). Table 3 shows the means and standard deviations for experimental and control groups in the 1st and 2nd week.

The result of repeated measures analysis showed that interaction effect between group and time of measurements was significant, ($F = 4.11$, $p \leq .1$). In other words, VASCORLL 2.0 was able to increase their learning opportunities. Figure 9 shows the number of their uploaded ULLs from the first to the second week. The

horizontal axis represents the first and second week, and the vertical axis represents the number of their uploaded ULLs. The number of uploaded ULLs of Group A increased better than that of Group B. These results imply that VASCORLL 2.0 plays an important role to increase the number of their uploaded ULLs.

Table 3. Number of uploaded ULLs in the second week

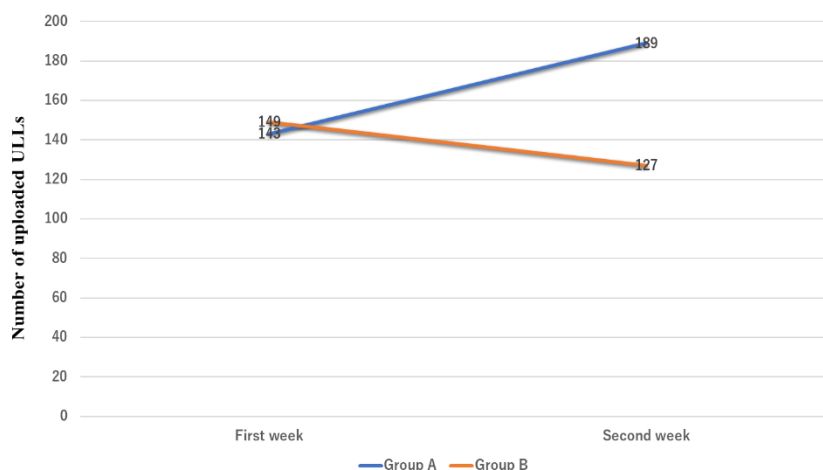|	1st week	2nd week	F	p
Group A	14.3 (6.78)	18.9 (6.41)	4.11	.08
Group B	14.9 (6.51)	127 (6.75)		

Figure 9. Comparison between the number of the uploaded logs during the 1st and 2nd week

Further, a one-way ANOVA was adopted to compare the high-motivated group and low-motivated group. The participants in the top 50% in terms of the number of the uploaded ULLs were categorized as high-motivated, while the others were as low-motivated. Table 4 shows the statistical results. A significance was found in the low-motivated group, implying the low-motivated participants were able to increase the number of their uploaded ULLs using VASCORLL 2.0. Therefore, it was detected that VASCORLL 2.0 was a useful tool to increase their learning opportunities.

Table 4. Summary of analysis of the number of uploaded ULLs in different learning motivation

Learning motivation	Group	Number of participants	Number of ULLs	Mean	F	p
High	Group A	5	119	23.8	3.88	> .05
	Group B	5	80	16		
Low	Group A	5	70	14	5.31	< .05
	Group B	5	47	9.4		

The results of the five-point-scale questionnaires are presented in Table 5 (Best: 5, Worst: 1).

Table 5. Result of the five-point-scale questionnaire for evaluating the usability of the system (Group A)

Question	Mean	SD
Q1. Were you able to connect words learned through eBook to those learned in a real-life by using VASCORLL 2.0?	3.7	0.82
Q2. Were you able to connect words learned in a real-life to the words learned through eBook by using VASCORLL 2.0?	3.9	0.99
Q3. Were you able to learn and find the relationship between words and places by using VASCORLL 2.0?	3.4	0.96
Q4. Were you able to find your newly learned words used in other eBook contents by using VASCORLL 2.0?	3.5	0.87
Q5. Was VASCORLL 2.0 easy to use?	2.6	1.23

Q1 asks whether the participants were able to find that the words they learned through eBooks were connected to the words that other learners learned in a real-life learning setting. Similarly, Q2 asks whether they were able to find that the words they have learned in a real-life learning setting were connected to the words that others have learned through eBooks. The results of Q1 and Q2 revealed that the participants found the words they learned

through eBooks were connected to the words learned in a real-life, vice versa. For example, some participants learned the Japanese word "納豆 (natto)" through e-book contents. By uploading "natto" to the system, the system showed them that other participants have learned it at the shopping mall and supermarkets. In this manner, VASCORLL 2.0 was able to connect the words between eBook learning and real-life learning.

Q3 asks whether the participants were able to find that their newly learned words were connected to the places where other learners learned the identical word by using VASCORLL 2.0. For example, when a participant learned the Japanese word, "料理 (Cuisine)" in eBook, he/she could find that it was connected to the experiences of others at places such as schools and restaurants. By sharing the authentic experiences, VASCORLL 2.0 enabled them to experience indirectly what other people experienced, which connected their eBook learning to the real-life learning.

Q4 asks whether the participants were able to find their newly learned words in other e-book contents. For example, when a participant learned "使用 (Use)" in an e-book material titled "Japanese Learning Beginner Vol.1", the system connected it to other e-book materials such as "Japanese Learning Beginner Vol. 2" and "Onomatopoeia Japanese Learning Vol. 1." In this manner, they could learn that it was a frequently used word in the Japanese language.

Q5 asks whether VASCORLL 2.0 was easy to use. They were asked to evaluate the usability in terms of operability and readability of the visualized graph. The response shows that many participants felt that VASCORLL 2.0 was not easy to use. They were asked to give comments regarding this problem, and the negative comments are as follows:
- The speed of visualizing and analyzing logs in the system is too slow (about 20~30 sec.).
- If visualizing logs using a mobile device, it is hard to read the nodes because of very small screen size. However, if logs are visualized on a personal computer, they become very easy to read.
- It was a little bit difficult to understand how to use the system.

From comments (1) and (2), the participants would suggest that the system developers need to improve the functionality in accordance with their mobile device and system' speed in visualizing a large number of logs. Comment (3) shows that even though we explained the usage of VASCORLL 2.0 prior to the evaluation experiment, some participants did not understand fully how to use it. Thus, our next evaluation should be more carefully planned.

Table 6 shows the result of the five-point-scale questionnaire for evaluating each centrality (degree, closeness, betweenness). Moreover, the participants were asked questions such as "Which centrality is the easiest in understanding or finding central words?" and "Which centrality is the most effective for learning" in order to evaluate each centrality in the seamless learning environment.

Q1-Q3 asked whether the participants were able to understand and find central words using fundamental the social network analysis: degree centrality, closeness centrality, and betweenness centrality. From the results of the questionnaire, most participants preferred to learn and find central words using betweenness centrality because the mean score of the Q3 is the highest.

Table 6. Result of the five-point-scale questionnaire for evaluating each algorithm ($N = 20$)

Question	Mean	SD
Q1. Was the degree centrality easy to understand in finding central words in the network graph?	3	0.91
Q2. Was the closeness centrality easy to understand in finding central words in the network graph?	2.7	1.08
Q3. Was the betweenness centrality easy to understand in finding central words in the network graph?	3.7	0.86

To find the most effective centrality to learn central words, we interviewed the participants to compare betweenness centrality with other centrality.

Degree centrality versus betweenness centrality

Degree centrality enabled the participants to find merely nodes that have many links. Two participants selected the centrality in terms of usability and effectiveness for learning because it is simple and easy to understand the

characteristics as shown in Figure 10. However, most participants commented that it was difficult to find words bridging eBook learning over real-life learning because the size of eBook or real-life learner nodes became larger than those of nodes.

Closeness centrality versus Betweenness centrality

When comparing closeness centrality with the betweenness centrality, the closeness centrality was not useful to find central words in the seamless learning environment. There was no numerical value difference between words learned through eBook and words learned in a real-life, so that the participants could not find central words. Therefore, this paper concluded that the closeness centrality was not a useful centrality in finding central words in the seamless learning environment using our visualization and analysis method.

As shown in Figure 10, majority of the participants preferred to use betweenness centrality than other centrality. We asked them "why you preferred to use the betweenness centrality than the other centrality." Their feedbacks are as follows:

- "The betweenness centrality was very good because it was easy to find words in my e-book contents linking to words in a real life"
- "It was easy to understand. And I learned some words. Then, it recommended some useful words to me (e.g., The different sizes of the nodes (large and small) and color coding such as green or yellow noes were easy to recognize)."

The betweenness centrality was the best centrality of all in terms of easiness to find words bridging eBook and real-life learning. In addition, we compared the betweenness centrality with other centrality. Fifteen participants answered that the betweenness centrality is helpful in finding central words in the seamless learning environment. Seventeen participants answered that it worked effectively in language learning.
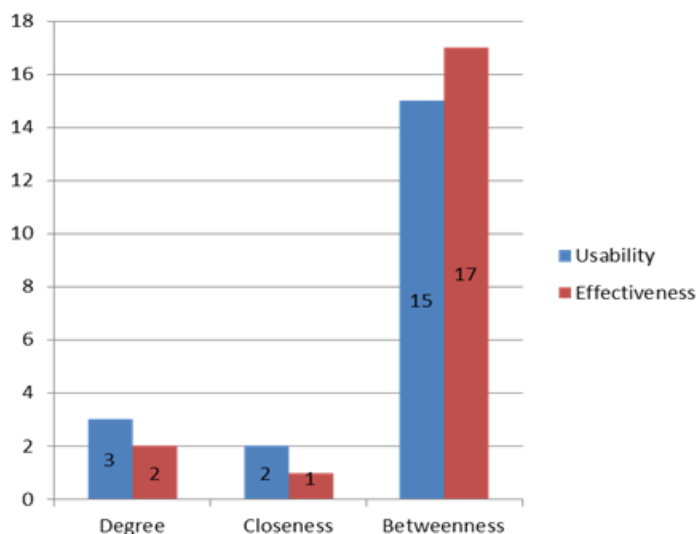

Figure 10. Number of selected centrality by each participant

Conclusion

This paper described a system called VASCORLL 2.0 for visualizing and analyzing learning logs collected in the seamless language learning environment in order to bridge the gap between eBook learning and real-life learning. VASCORLL 2.0 works on cyber-physical setting to link learners in the real world and learning logs that are accumulated in the cyber spaces using e-book system with the ubiquitous learning system called SCROLL. The e-book system with SCROLL enabled international students to learn through two learning activities: e-book-based learning activity and authentic learning activity.

Using these learning activities, we proposed the visualization and analysis methods based on graph theory, social network analysis and graph drawing algorithms in order to find pivotal words in the seamless learning environment. Two types of three-layer structures called ELS and RLS were adapted as the visualization methods. In this manner, teachers and students could easily grasp words bridging between words in ELS and RLS. In

addition, this paper evaluated whether they were able to find the most pivotal words on the network graph using each centrality based on social network analysis.

The evaluation was conducted after the implementation of VASCORLL 2.0. A questionnaire with a five-point-scale conducted after the evaluation showed that VASCORLL 2.0 was a useful tool in finding central words bridging eBook learning and real-life learning. The result of questionnaires for evaluating each centrality showed that the most effective centrality for learning was betweenness centrality. Therefore, we concluded that the betweenness centrality is the most important centrality in the seamless learning environment.

VASCORLL 2.0 will be evaluated repeatedly, with the improved processing speed of visualizing and analyzing learning logs improved. In addition, our future works include applying VASCORLL 2.0 to other application domains such as math, physics, and science education, and long-term evaluations with a sufficient number of participants.

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References

Barnes, J., & Hut, P. (1986). A Hierarchical O (n log n) force calculation algorithm. *Nature, 324*(4), 446–449.

Chai, C., Wong, L., & King, R. (2016). Surveying and modeling students' motivation and learning strategies for mobile-assisted seamless Chinse language learning. *Educational Technology & Society, 19*(3), 170-181.

Ellis, R. (2000). Task-based research and language pedagogy. *Language Teaching Research, 4*(3), 193-220.

Fang, H., Liu, P., & Huang, R. (2011). The Research on e-book-oriented mobile learning system environment application and its tendency. In *International Conference on Computer Science and Education* (pp. 1333-1338). Singapore: IEEE.

Freeman, L. C. (1979). Centrality in social networks: Conceptual clarification. *Social Networks,* (1), 215-239.

Fruchterman, M. E. J., & Reingold, E. M. (1991). Graph drawing by force directed placement. *Software Practice and Experience, 21*(1), 1129-1164.

Hu, Y. F., & Scolt, J. A. (2001). A Multilevel algorithm for wave front reduction. *Society for Industrial and Applied Mathematics Journal on Scientific Computing, 23*(4), 1352-1375.

Hwang, G. J., & Lai, C. L. (2017). Facilitating and bridging out-of-class and in-class learning: An Interactive e-book-based flipped learning approach for math course. *Educational Technology & Society, 20*(1), 184-197.

Hwang, G. J., Chu, H. C., & Yin, C. J. (2017). Objectives, methodologies and research issues of learning analytics. *Interactive Learning Environments, 25*(2), 143-146.

Kiyota, M., Mouri, K., Uosaki, N., & Ogata, H. (2016). AETEL: Supporting seamless learning and learning log recording with e-book system. In *Proceedings of the 24ndInternational Conference on Computers in Education* (pp. 306-314). Bombay, India.

Latora, V., & Marchiori, M. (2004). A Measure of centrality based on the network efficiency. *New Journal of Physics, 9*(6), 1-11.

Liu, C.C., Wu, L. Y., Chen, Z. M., Tsai, C.C., & Lin, H. M. (2014). The Effect of story grammars on creative self-efficacy and digital storytelling. *Journal of Computer Assisted Learning, 30*(5), 450-464.

Li, M., Ogata, H., Hou, B, Uosaki, N., & Mouri, K. (2013). Context-aware and personalization method in ubiquitous learning log system. *Educational Technology & Society, 16*(3), 362–373.

Looi, C.K., Sun, D. & Xie, W. (2015). Exploring students' progression in an inquiry science curriculum enabled by mobile learning. *IEEE Transactions on Learning Technologies, 8*(1), 43-54.

MEXT, Japanese Ministry of Education, Culture, Sports, Science and Technology. (2012). *The Vision for ICT in education.* Retrieved from http://www.mext.go.jp/b_menu/houdou/23/04/__icsFiles/afieldfile/2012/08/03/1305484_14_1.pdf

Mathieu, J., Tommaso, V., Sebastien, H., & Mathieu, B. (2014). Forece Atlas2, a continuous graph layout algorithm for handy network visualization designed for the gephi software. *PLOS One, 9*(6), e98679.

Milrad, M., Wong, L. H., Sharple, M., Hwang, G. J., Looi, C.K., & Ogata, H. (2013). Seamless learning: An International perspective on next generation technology enhanced learning. In Z. L. Berge & L. Y. Muilenburg (Eds.), *Handbook of mobile learning* (Chapter 9, pp. 95-108).). New York, America: Routledge.

Mouri, K., Ogata, H., Uosaki, N., & Liu, S. (2014). Visualization for analyzing ubiquitous learning logs. In *Proceedings of the 22nd International Conference on Computers in Education (ICCE 2014)* (pp. 461-470). Nara, Japan.

Mouri, K., & Ogata, H. (2015a). Ubiquitous learning analytics in the real-world language learning. *Smart Learning Environment, 2*(15), 1-18.

Mouri, K., Ogata, H., & Uosaki, N. (2015b). Analysis of ubiquitous learning logs using social network analysis. *International Journal of Mobile Learning and Organisation, 9*(2), 101-123.

Mouri, K., Okubo, F., Shimada, A., & Ogata, H. (2016a). Bayesian network for predicting students' final grade using e-book logs. In *IEEE International Conference on Advanced Learning Technology* (pp. 85-89). Texas, America: IEEE.

Mouri, K., Okubo, F., Shimada, A., & Ogata, H. (2016b). Profiling high-achieving students for e-book-based learning analytics. In *Workshop on Learning Analytics Across Physical and Digital Spaces* (pp. 5-9). Edinburgh, UK. Retrieved from http://ceur-ws.org/Vol-1601/CrossLAK16Paper2.pdf

Mouri, K., Ogata, H., & Uosaki, N. (2016c). Visualization and analysis system for connecting relationships of learning logs. In *International Conference on Computer in Education (ICCE 2016)* (pp. 315-324). Bombay, India: Asia-Pacific Society for Computers in Education.

Noack, A. (2009). Modularity clustering is force-directed layout. *Physical Review, 79*(2), 1-8.

Ogata, H., Li, M., Hou, B., Uosaki, N., Moushir, E., & Yano, Y. (2011). SCROLL: Supporting to share and reuse ubiquitous learning log in the context of language learning. *International Journal of Research and Practice on Technology Enhanced Learning (RPTEL), 6*(2), 69-82.

Ogata, H., Hou, B., Li, M., Uosaki, N. Mouri, K., & Liu, S. (2014). Ubiquitous learning project using life-logging technology in Japan. *Educational Technology and Society Journal, 17*(2), 85-100.

Ogata, H., Yin, C., Okubo, F., Shimada, A., Kojima, K., & Yamada, M. (2015). E-book-based learning analytics in university education In *International Conference on Computer in Education (ICCE 2015*) (pp. 401-406). Hangzhou, China: Asia-Pacific Society for Computers in Education.

Ogata, H., Uosaki, N., Li, M., Hou, B., & Mouri, K. (2015). Supporting seamless learning using ubiquitous learning log system. In *Seamless Learning in the age of Mobile Connectivity* (pp. 159-170). Singapore: Springer.

Shin, J. A. (2012). Analysis on the digital textbook's different effectiveness by characteristics of learner. *International Journal of Education and Learning, 1(*2), 23-38.

Uosaki, N., Li, M., Hou, B., Ogata, H., & Yano, Y. (2010). Supporting an English course using handhelds in a seamless learning environment, Workshop of the 18nd International Conference on Computers in Education (ICCE 2010), 185-192.

Wong, L. H., & Looi, C. K. (2011). What seams do we remove in mobile-assisted seamless learning? A critical review of the literature. *Computer & Education, 57*, 2364-2381.

Wei, L. (2012). Construction of seamless English language learning cyberspace via interactive text messaging tool. *Theory and Practice in Language Studies, 2*(8), 1590-1596.

Wong, L. H., Chai, C. S., Aw, C. P., & King, R. (2014). Employing the TPACK framework for research-teacher co-design of a mobile-assisted seamless language learning environment. *IEEE Transaction on Learning Technologies, 8*(1), 31-42.

Wong, L. H., Milrad, M., & Specht, M. (2015). *Seamless learning in the age of mobile connectivity*. Singapore: Springer.

Yin, C., Okubo, F., Shimada, A., Kojima, K., Yamada, M., & Ogata, H. (2014). Smart-phone based data collecting system for analysing learning behaviors. In *International Conference on Computer in Education (ICCE 2014)* (pp. 575-577). Nara, Japan: Asia-Pacific Society for Computers in Education.