Ubiquitous Learning Analytics Using Learning Logs

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ABSTRACT

To the new international students who learn Japanese out-class in Japan, it is too hard to find different suitable ways for different students that have different learning characteristics. This paper considers to solve this problem, which is how to help new international students who learn Japanese for out-class learning according student's own learning frequency. This paper uses learning frequency as the point to understand students' learning behavior characteristics so that distinguish among different learning characteristics. The proposal algorithm in this paper helps international students to find similar students who have the similar information background and similar learning characteristics, and then recommends the new student suitable learning contents. To achieve the goal, this paper uses learning analytics method based on SCROLL system. This paper uses k-means clustering to build student learning frequency model, and predict the relationship between user information and frequency model by classification. After finding the similar student for new student, the system will recommend learning content what the similar have learned to the new student. This paper compares the difference among Bayesian Network, C4.5 and Neural Network in our program.

Keywords

Learning logs, ubiquitous learning, language learning.

1. INTRODUCTION

Recently, more and more students who are learning second language (L2) have begun to use smartphone educational software to study. What's more, mobile devices can influence how information is gathered and used in education [6]. Thus, when learners use mobile devices to study, devices will record not only the learning contents, but raw learning environment data of learners, like GPS, temperature, speed, photos, audios, even battery information. With these information, educational software can analyze learning habits, learning environment, or learning contexts of learners to help learners to study. Therefore, numerous mobile educational applications have begun to focus on learners' learning data to support learners' L2 learning.

Smartphones provide all kinds of educational software to support learners' all aspects of learning both in-class and out-class for seamless language study. Seamless learning allows learners to learn anytime, anywhere, and provides them with multiple ways of learning throughout the day [11]. What's more, Teachers can also use smartphone to give various assistance to help students to study language out-class. Therefore it lets the dream that student can study not only in-class, but also out-class come true. This is the reason that Mobile Assisted Language Learning (MALL) has become a hot hint immediately in the field of education [3].

However, how to make sense to a wide variety of L2 learners out-class has become a problem. Because of the individual difference, educational software cannot use the same learning strategy for different students. SCROLL (System for Capturing and Reminding of Learning Log) was proposed to solve individual difference of L2 learners. SCROLL considers distinguish individual difference by learning habit in context. It means, when international students learn L2 using SCROLL, SCROLL will record not only the learning contents, but also the learning time, learning locations, the photos, even learning speed to record learning habit environment in context by these information. Then SCROLL will save these Ubiquitous Learning Log Objects (ULLOs) as learning habit environments of learners. When SCROLL detects that the student is in his learning habit environment again, SCROLL will remind him to learn what he has learned again to recall this knowledge and recommend him related and suitable learning contents [7]. This proposal approach is good for learner to learn L2 in context by learning habit environment. But SCROLL cannot remind a learner to study if the learner has no or not enough learning logs in SCROLL.

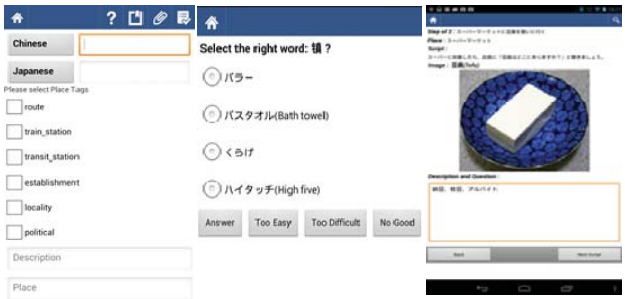
This paper proposes a learning analytics approach to remind the learners, who have not enough learning logs in SCROLL, suitable advices to guide them for their out-class Japanese learning using SCROLL. This paper exploits learning frequency factor to analyze learning characteristics of different L2 learners in SCROLL. Firstly this paper builds learning frequency model (LF Model) with k-means clustering using users' information in SCROLL, and then analyze the information of already exists students to predict what kind of background information will perform what kind of learning frequency with classification, at last recommend suitable learning contents at suitable learning frequency.

2. SCROLL

SCROLL allows the learners to log their learning experiences with photos, audios, videos, location, QR-code, RFID tag, and sensor data, and to share and to reuse ULLOs with others everywhere and anytime [7]. Using SCROLL, language learners can record their learning experience whenever and whatever. SCROLL is a cloud-based application, which runs on different platforms including Android mobile phones, PC and general mobile phones. SCROLL aims to utilize life-log data for the learning process. When international students learn Japanese using SCROLL, there are three kinds of main learning behavior shown in figure 1.

Firstly, international students add words and grammars in SCROLL shown in figure 1. (a). At this time, SCROLL will record words or grammar, location, time, speed and so on that created by students. Secondly, when they answer quizzes in SCROLL shown in figure 1. (b), SCROLL will record the time,

location, quizzes, and the answer. Thirdly, when they use tasks to do experiential learning for Japanese in SCROLL shown in figure 1 (c), SCROLL will record the content of tasks which they used, and time, location, and so on. Additionally, SCROLL can record the duration of study when students learn a kind of language, this paper considers that the duration of Japanese learning in SCROLL begin to calculate from the first learning content, and when the number of new words is not more than one that the student adds to SCROLL last 4 weeks, this paper considers the first week of this period is the end time. And the time from start to end, is duration of study. And the time from start to end, is duration of study.



(a) New learning log (b) Quiz (c) Task

Figure 1. Three kinds learning behavior in SCROLL

After students recorded their learning logs in SCROLL by these functions. SCROLL will remember their learning environments, like GPS information, time and so on. When students move to this environment again, SCROLL will recall the learning contents that they have learned to help them remember them in the same environment, and recommend rerated words.

SCROLL completed the experimental evaluation with 20 Japanese university-sophomores (17 males, 3 females) who were taking the communicative English class at the university. There are two tests in the evaluation, one is pre-test, and the other is post-test. Both of the two tests' full mark is 60. All the students joined these two tests, and got mark. The result shows that all the students' score was improved by using SCROLL to learn English. Therefore SCROLL can enhance language learning. However, there are some deficiencies in recommendation function of SCROLL.

The recommendation function in SCROLL is based on what learner has learned and where the learner has learned. If the learner hasn't learned any learning content before, SCROLL will not recommend any learning content for the learner. Learners cannot find similar learners in SCROLL. It is hard for learners to know what they should learn next. For example, when an international student signs up SCROLL just now, there is no learning log in SCROLL. The algorithm of SCROLL is when a learner adds a learning content to SCROLL, SCROLL will record not only learning content, includes photo, audio, words, but the learning environment, includes time, location, speed, and then from these learning information, SCROLL will analyze out the favorite learning environment of the learner. And when the learner enters into the environment again, SCROLL will recommend him to learn what he has learned there and the related learning content. Therefore, to the learner sign up SCROLL just now, SCROLL cannot give any learning suggestion or show any similar learner for him.

In order to improve recommendation function of SCROLL, this paper uses learning frequency as starting point to find similar L2 learners for the new learners. Firstly, analyzes out learning frequency model of the learner by learners' personal information using k-means clustering algorithm. Secondly, predict out meaningful attributes to find similar learners using decision tree classification algorithm. Thirdly, find out learning contents of similar learners. At last, show these learning contents to users and when SCROLL recommend related learning contents, recommend these learning contents as related learning contents to learner.

In proposal approach, even learner has not leaned one learning content, SCROLL also can find similar learners and suitable learning content for the new learner. What's more, recommendation function in SCROLL will be not only just based on learners' learning habit environment, but also leaners' learning frequency, the key determinant of L2 language acquisition.

3. Related Work

In past decades, there have been several adaptive learning proposal methods to generate learner model to help learners, such as two-source adaptive learning (TSAL) system [10] that is developed by Judy C.R, Adaptive Learning Module which is developed by Rahul Agarwal [2], and the AdaLearn, which is developed by Marwah Alian [1]

The two-source adaptive learning (TSAL) system has suggested that using two-source include Learning Style and Learning Behavior to improve learning performances. The Learning Style parameters include Sequential Processing Skill, Discrimination Skill, Analytic Skill, and Spatial Skill. The Learning Behavior parameters include Learning Achievement, Learning Effectiveness, and Concentration Degree. TSAL uses this two source parameters to generate the presentation style for each learner. Then TSAL will give different learning suggestion to different kinds of presentation styles. The experiments and evaluation has been done with 91 learners in three groups. The result proved the learning achievements and learning efficacy of learners in experiment group have been improved[10].

The Adaptive Learning Module is designed based on learners' learning experience using NetCoach to analyze out learners learning pace, so that adjusting the teaching paces to learners personal learning pace. Different learners have different individualized paces. Thus Adaptive Learning Module let learners to know their suitable individualized paces to achieve the goal of providing the suitable learning contents at suitable learning pace, so that those learners are able to proceed through the learning contents at individualized paces without any adversely affecting their performances [2].

The AdaLearn can be used to give recommendation for individual learners about which kind of course is the most suitable for learners by adapting and fitting learners profile and needs [1]. In AdaLearn, system makes the connection with learner's profile and course's learning contents, and then, predicts which course is the best to the learner.

This paper proposes an approach using learning behavior, learning experience and learner profile in SCROLL to understand learners' learning favorite frequency and finds similar learners for the new learners.

4. Data and Algorithm Preparation

In SCROLL database, there are 3632 student records from 2010 by now. When a learner registers SCROLL system just now, there are just some background information data in SCROLL shown in table 1. Nickname is user's nickname. In table 2, Native Language is user's mother tongue, it is the most important factor to influence L2 learning. For example, if the learner's native language is Chinese, it is easy for him to learn Japanese, because they have the same Chinese characters, and similar pronunciation. Gender also affects user's L2 learning, because the views and idea are difference between male and female. JLPT is Japanese Language Proficiency Test Level, when students study abroad in Japan, they have to take this test and get a level mark to show their Japanese level. Thus this factor can be used to reflect user's Japanese ability directly. Month means how long learner has lived in Japan. Learners who have acquired general knowledge and experience are in a stronger position to learn Japanese than those who haven't. The student, for example, who has already lived in 3 months and been exposed to various Japanese cultures has a stronger base for learning Japanese than the student who hasn't had such experiences. Major can influence learner's L2 learning too. To students, besides L2 learning in daily life, the most article they read and write is their major article. For instance, the student whose major is Computer Sciences knows much more words, sentences, article about Computer Sciences than the student in Life and Culture. Therefore, major can also influence learner's L2 learning in daily life and study.

In order to predict what kind of behavior the new student will perform, it is useful to calculate out the relationship between information background data and learning behavior data. This paper presents some analysis methods to do this prediction with WEKA. (http://www.cs.waikato.ac.nz/ml/weka/)

Table 1. Learning behavior data in SCROLL database.

Id	Name	Words	Locations	Quizzes	Weeks
9	Shin-chan	67	36	493	22
10	Jslee	154	33	948	23
11	Juice	72	25	204	10
12	Coco	181	45	537	8
13	Mr.Miss	152	14	372	14

Table 2: Information background data in SCROLL database.

Id	Native Lang.	Gender	JLPT	Month	Major
9	Korean	Female	N3	4	CS
10	Korean	Female	N4	1	Life
11	German	Male	N2	4	Education
12	Tamil	Male	N2	4	CS
13	Greek	Male	N1	3	SS

5. Classification and prediction

In this paper, in order to predict students' learning frequency and suitable learning contents, our approach exploit clustering and classification analysis method to achieve our purpose. As shown in figure 2, our approach consists of following parts:

- Clustering of already exists data of students to create LF model.
- Classification prediction of new student to find similar students and suitable learning contents.
- Generating recommendation learning contents sequence.

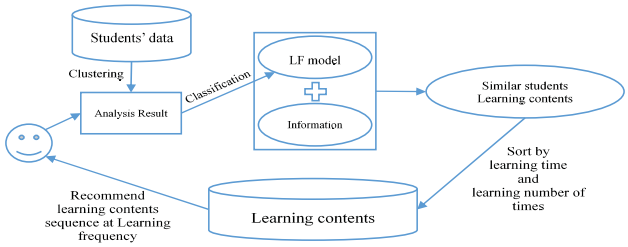


Figure 2. Analysis process.

5.1 Data preprocessing

In SCROLL, there are 3632 student records from 2010 by now. It includes the records of students' learning frequency and information background that when they use SCROLL.

From these data, there are lot of information like learning content, location, learning time and quizzes and so on. But our concern is that students' learning frequency, not weather students can use this skill or not. Therefore only these fields were selected which were required for our data mining process, they are the total number of words, the total number of locations, the total number of quiz and the number of weeks they use SCROLL. By these data, it is easy to calculate out average word learning frequency weekly (WLF), location learning frequency weekly (LLF) and quiz learning frequency (QLF) weekly; this paper calls them learning frequency for short. By learning frequency, students' learning characteristics can be known by analyze their learning frequency.

Additionally, when a student registers SCROLL system just now, we only have some personal information data like native language, gender, Japanese Language Proficiency Test Level (JLPT), month, and major of a student. This paper makes information models by these data so that we can find some connection among them, thus this paper can find some students with similar information background for the new student. It's beneficial for new student to study follow students who have similar language basis.

5.2 Generate Learning Frequency Model

In this paper, in order to find different kinds of learning frequency. It is easy to achieve our target by K-means clustering algorithm. First of all, this paper establishes three coordinates. In these coordinates, x-axis means learning time, y-axis means the number of words, locations or quiz. Thus, the data point in these coordinate means how long he use SCROLL and how many words, different places or how many quizzes they have studied using SCROLL. For example, as the three point data. This student use SCROLL for 22 weeks, learned 67 words, in 36 different locations, answered 493 quizzes.

After establishing coordinates, we do cluster analysis with the group of word and time. These learning data is divided into two clusters, the longest time student use SCROLL is 23 weeks, and the shortest one is 2 weeks. The most number of words is 261, and the least one is 64.

By these rules, student data can be divided into 8 models. The number of these model do not mean this model is right or wrong, it just means a kind of learning frequency. Now, to the learners that already exists in SCROLL, we have known which frequency models they are. Besides, we also can get their learning contents. Therefore, if when the new international student register SCROLL, we can predict similar students and learning frequency for him, SCROLL is able to recommend suitable learning contents for him.

5.3 Learning Frequency Prediction

If a new L2 learner registers SCROLL just now, and has not added a learning log in SCROLL. What SCROLL has about the learner is only the information background. Therefore, it is necessary to know the relationship between learner's information background and learning frequency model. Because we can exploit this relationship to predict what kind of information background will perform like what kind of learning frequency model.

There are 5 kinds of background information, Native language, Gender, JLPT, month, and major. Thus, they can produce at least 5!=120 kinds of combinations. For example, if when SCROLL finds the new learner, SCROLL is able to find similar learners just using Native language and JLPT. This two attributes will be referred to meaningful attributes. System does not have to consider the other three attribute. Besides, decision tree can judge which attributes will be meaningful and generate structure with meaningful attributes, and then predict result. Additionally, this paper considers to find similar L2 learners not only based on learning frequency model, but also the meaningful attributes between each other. Therefore, this paper uses decision tree to make prediction.

After clustering analysis, SCROLL gets learning frequency models of all students in, and saved them to database. This table includes id, nickname, native language, gender, JLPT, month, major and model. Model means learning frequency model of students. We can make prediction by the table.

This paper compared three kinds of classification prediction algorithms. They are C4.5 and Bayesian Network and Neural Network. After training the 3632 records in SCROLL database by WEKA with three kinds of algorithms, it is important to see the accuracy rate of each other in prediction. The result is J48(96.0%), BayesNet (244.4%), and MultilayerPerception(72.7%). From the result, the accuracy of J48 (C4.5) in this data set is much better than the other two. Therefore, this paper choose J48 algorithm to predict learners' learning frequency.

The aim of prediction by J48, not only knowing what learning frequency model the new student will perform, but also getting which property is affecting the selection of similar students. Figure 4.3 shows the tree. This figure shows that not every prediction will use all properties. For instance, if a student's native language is Spanish, and with the major of Technologies Engineering, the result will be predicted by JLPT directly, without considering the property of month and gender. So it is the point that we can use to find similar students for new students. We save this result to database for next procedure.

5.4 Similar Students and Suitable Learning Contents

After prediction, we have got learning frequency model and the relationship between model and information background. Next step is matching similar students for new student, and recommend learning contents for him. During the prediction procedure, we have saved prediction results and property conditions to database. Thus, we can find similar students for new student with those condition. When selecting and recommending learning contents, we also use the recommendation strategy. Procedure is shown as follows:

(1) After we find similar students with learning frequency model and information background, we will get a similar student list.

(2) Find out what they learned in SCROLL database with SQL sentence.

(3) Sort the learning contents by learning time and learning number of times in ascending order per week.

(4) Get learning content sequence.

(5) SCROLL can recommend these learning contents to new student at his learning frequency.

For instance. If a student registered SCROLL just now with the information of English, Technologies/Engineering, 4 month, N2, Female. System's performance is shown as Figure 3.

Firstly, SCROLL get influential properties and predict the learning frequency model by this data set with J48 decision tree.

Secondly, SCROLL find similar information background students with (English, Technologies/Engineering, N2). And with the same learning frequency model 3. Then, list up their learning content, including words, grammar, time, location.

At last, Sort the learning contents by learning time and learning number of times in ascending order per week. Then, recommend to this new student.

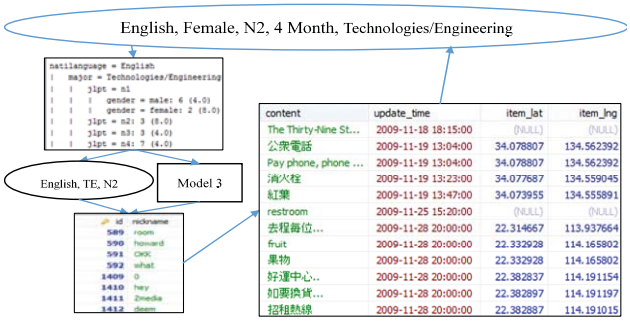


Figure 3. Prediction and Recommendation of New student in SCROLL.

6. Evaluation

6.1 Method

This evaluation experiment has been conducted to find answers to following questions.

- Does this proposal algorithm is helpful for students' L2 learning?
- Are these learning contents suitable for students?

There are 6 international students who are studying abroad in Japan, and learning Japanese. They are not the students in SCROLL yet. Therefore, there is no learning log in their account of SCROLL. The time living in Japan is less than half year. Three of them come from China, another one comes from America, and another one comes from Mongolia, and the last one comes from France. They are all students in the University of Tokushima.

Then, they are divided into two groups, one is study group consisted of 3 students, the other students consist the control group. They all use SCROLL smart phones version to complete this evaluation. SCROLL that students in the experimental group used includes proposal recommendation function, and the SCROLL that students in control group used only includes current recommendation function. They participate in this experimental evaluation for four weeks.

Group A, an experimental group, learns Japanese using SCROLL, which includes the recommendation function in this paper. The Students register system with their personal information like native language, gender, major and so on. Thus, SCROLL can predict their learning frequency and suitable learning contents, then recommend learning contents to them for four weeks. Group B, a control group, learns Japanese using SCROLL with current recommendation function for four weeks as the same.

In order to analyze the result they produced, SCROLL can record their learning logs they use it to learn Japanese every time.

Based on the current recommendation function in SCROLL, when student goes to a place that he has learned words there, SCROLL will notice that he has ever learned the words before and recommend related words or location those are based on student's learning logs, to help him learn from their learning logs. Students of control group used this recommendation function.

The proposal recommendation function is when SCROLL notice student to study, SCROLL will find more suitable words and location information those are not only based on not only him self's learning log but also the similar students', for the student and then recommend these learning contents to student as related words. When SCROLL recommends these learning contents to students, proposal function will control the count of recommendation learning contents as student's learning frequency.

6.2 Result

Table 3 shows the counts of their learning logs of each other in this experiment evaluation.

Table 3. Learning Log Count of experiment group students

User	Words	Location	Quizzes	Weeks
A	74	14	25	4
B	81	17	24	4
C	67	4	17	4
D	37	12	12	4
E	56	13	15	4
F	12	3	20	4

The data in this table means a student in 4 weeks, how many words he has added to SCROLL, and how many location he has learned at, and how many quiz he has answered.

Overall, the students in experiment group add more words than control group, add more location information, and answered more quizzes in 4 weeks. The result is shown in Figure 4. This paper considers that the more words students add to SCROLL, students learn more words. Student A, B, C have added more words than student D, E, F. To the location result, student A, B, D and E live in the same place, and far away from school, the range of activities is larger than C and F, thus A, B, D, E learn Japanese at more different places. Besides A, B, D, E added more location information than C and F.

Student C and student F live nearby, and both near school. They go to the same supermarket and restaurant. But they had a very different result on word counts. Student C added more 55 words than student F. when student C opened SCROLL system web site to learn Japanese, because he signed in SCROLL just now, there was not a lot learning logs of himself and not so many related words for him. But he could see the recommended list for him, and the list showed where, what and how many the similar students had learned, and he chose the word of "Pot" in Japanese, then system showed the word and it was learned by user with nickname of "michi" at supermarket nearby, meanwhile, system shows that "michi" learned the other two words, "Shelf" and "Bottle" in Japanese at that time. Moreover, he could see and "michi"'s every learning log and the other similar students' learning log. Additionally, when he went to the furniture shop, he learned the word of "Conversion plugs" in Japanese. After he added this word to SCROLL, system recommended "Speaker" and "Tissue paper" that had learned by his similar students ever before. Then he saw the speaker and tissue paper and took this two learning logs.

On the other hand, student F added least words in these 6 students, and went to least places. The learning logs she added to SCROLL is shown as Table 4. In this table, Upload time means the time that student upload learning log to system. Content means the word student learned. Item lat and Item lng mean learning log's location information. Because student F also signed in the system just now, and there was no learning logs of herself at the beginning. Thus SCROLL could not give her suggestions to learn Japanese based on her learning logs until she began to use SCROLL to study. The first word she added to SCROLL was "本" means "book" at home. But there is no learner learning at her home before, SCROLL could not give her any learning suggestion but some quizzes. At the fifth day, she went to the supermarket and added a log of "umbrella". Somebody had added some learning logs there, thus SCROLL recommended "Sweeper", "Flower", and "Dustbin" to her, and then she added them to her account. After that, she went to home center to buy shoes, and took the log of "shoes", as the same, SCROLL recommended "Microwave" that had learned other learners to her. Therefore, when she went to the same supermarket or home center, even at home, SCROLL could recommend her to learn some words. But it is wasted for a long time to make SCROLL to adapt her and give her learning suggestion. On the other hand, the proposal algorithm is much faster to adapt learners' learning habits by the other L2 learning factor than the algorithm in SCROLL.

Table 4. Learning logs of Student F in evaluation experiment

Upload time	Content	Item lat	Item lng
2013-05-02	本	34.078583	134.561917
2013-05-07	傘	34.078608	134.561942

From this example, the weak point of SCROLL's algorithm can be seen. Since only when students go to a place where they have learned words there, SCROLL can recommend learning contents for them. Therefore, if student F want to learn more or want to be recommended more learning contents, he has to go to many different places to study. On the other hand, student C did not go to many places either, but he learned much more than student F.

Therefore, even if students do not have to go to many places, proposal algorithm also can recommend them lots of learning contents.

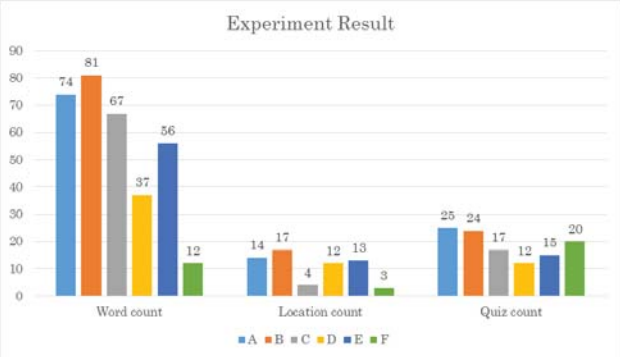


Figure 4. Experiment Result

Student A, B added more words than D and E. In SCROLL's algorithm, when students go to a place, SCROLL will remind him to learn their learning logs and recommend some related words. The related words are chosen by location information and category information. Thus, they are not suitable for students.

Students in experiment group added totally 222 words. Among these 222 words, there are 189 recommended words. Students thought recommended words are suitable for them in learning or some factors else so that students added these words to their learning logs. On the other hand, students in control group added totally 105 words with 42 recommended words. It means, over half of words were learned by students' selves. But to the learning logs of students in experiment group, there are 85.2% logs learning trough proposal algorithm. Therefore, this paper considers proposal algorithm is helpful for students' L2 learning. Since the words in proposal algorithm are chosen by similar students' learning contents. These learning contents are more suitable than SCROLL's algorithm's for students.

7. Conclusion and Future Work

This paper considers to solve this problem, which is how to help new international students who learn second language out-class by learning analytics based on SCROLL system. Because learning frequency is the key factor to the L2 learning, this paper use learning frequency to distinguish learners learning characteristics. In this paper, k-means clustering is used to build learning frequency models to understand learners' leaning characteristics. After comparing the result of C4.5 decision tree, Bayesian Network and Neural Network, this paper determined to use C4.5 decision tree classification to predict what kind of student will perform like what kind of learning frequency. And then, find similar learners and suitable learning contents for the new learner to help him for L2 learning.

By the experiment, a result can be seen. It is useful to help students to learn second language in context based on the difference between learners' learning frequency.

In the future, there are two researches should be done, one is that it is necessary to complete the sequence mining of recommended learning contents in this paper, and the other one is enhance understanding the relationship between context and learning frequency.

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REFERENCES

[1] Alian, M., AL-Akhras, M. (2010). AdaLearn: an adaptive e-learning environment. ISWSA '10 Proceedings of the 1st International Conference on Intelligent Semantic Web-Services and Applications, 21.

[2] Agarwal, R., Edwards, S. H. and Pérez-Quiñones, M. A. (2006). Designing an Adaptive Learning Module to Teach Software Testing. SIGCSE '06 Proc. technical symposium on Computer science education, 259-263.

[3] Baleghizadeh, S., Oladrostam, E. (2010). The Effect of Mobile Assisted Language Learning (MALL) on Grammatical Accuracy of EFL Students. MEXTESOL Journal, The Internet and Technology in EFL/ESL 34(2)

[4] Baradwaj, B.K., Pal, S. (2011). Mining Educational Data to Analyze Students' Performance. IJ. Advanced Computer Science and Applications. Vol.2, No. 6, 2011. 63-69.

[5] Hung, P.-H., Hwang, G.-J, Lin, Y.-F., Wu, T.-H., & Su, I.-H. (2013). Seamless Connection between Learning and assessment-Applying Progressive Learning Tasks in Mobile Ecology Inquiry. Edu. Tech. & Society, 16(1), 194-208.

[6] Johnson, L., Levine, A., Smith, R., & Stone, S. (2010). The 2010 Horizon Report. Austin, Texas: The New Media Consortium.

[7] Ogata, H., Li, M., Hou, B., Uosaki, R., El-Bishouty, M.M. & Yano, Y. (2008). SCROLL: Supporting to Share and Reuse Ubiquitous Learning Log in the Context of Language Learning. IJRPTEL, 6(2), 69-82.

[8] Pedro, M., Baker, R. S.J.d. Gobert, J. (2013). What Different Kinds of Stratification Can Reveal about the Generalizability of Data-Mined Skill Assessment Models. Proc. LAK. 190-194.

[9] Southavilay, V., Yacef, K. Reimann, P., Calvo. A.R.(2013) Analysis of Collaborative Writing Processes Using Revision Maps and Probabilistic Topic Models. Proc. LAK'13. 38-47.

[10] Tseng, J. C.R., Chu, H.-C., Hwang, G.-J., Tsai, C.C. (2008). Development of an adaptive learning system with two sources of personalization information. Computers & Education, 51, 776–786.

[11] Uosaki, N., Ogata, H., Sugimoto, T., Hou, B., Li, M. and Yano, Y. (2011) Supporting English Course with Mobile Devices: How Can We Learn Vocabulary Seamlessly? Proc. ICCE, 329-336.