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PACARD: A Personalized adaptive card-based interface that enable learners to access and recall learning element efficiently

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Abstract: Recently, card-based interface is leading to a new trend of designing mobile software and application among popular social networks like Pinterest, Facebook, Twitter or Google Now. It is due to the fact that cards pattern is most flexible to be appeared properly on various screen sizes of mobile devices and to be structured toward users preference. Nonetheless, there are very rare developers who bring card-based interface into education field. In other word, there are barely studies that focus on the effectiveness of card-based interface on a personalized adaptive mobile learning. Thus card-based design for an adaptive mobile learning system still remains unclear. To this end, we developed a Personalized Adaptive self-learning mobile application function called PACARD, where the card-based interface was implemented. Additionally, an empirical study was conducted among thousands online users during two weeks to evaluate how PACARD affect on students' learning achievement and user retention, we also observe how our adaptive mechanism meet user preference. Regarding learning achievement, PACARD results in better learning outcomes. Regarding users retention, the result shows PACARD can be for increasing user retention. Regarding users preference, users were more likely attracted by learning items that are related to their own learning progress.

Keywords: Card-based interface, Personalized Adaptive, Mobile interface design, Mobile Learning

1. Introduction

The growth of mobile communications industry is considered as big chance for changing education in various ways. Specifically, learning on mobile device has become the common way for nowadays learners. Among mobile learning systems, researchers have indicated that adaptive learning systems can make positive contributions to students' learning outcomes (Dreyer & Nel, 2003). Thus, it is essential to focus on developing efficiently adaptive mobile learning application, which can provide tailored learning material for individual learner and also can brings best advantages of mobile device to users. One of the most advantages of those devices is the mobility in which student can carry their device to any place. Among mobility characteristics, small size and lightweight are always considered as features of mobile device, but it also is counts as disadvantage of those (Albers & Kim, 2002). For instance, small screen size not only limits the way contents appeared but also makes navigating task more difficult (Ziefle & Bay, 2006). In addition, people consume content differently on different screen sizes. Thus to arrange contents for delivering an optimal user experience on various screen sizes is a challenging issue (Arning & Ziefle, 2007; Huang, 2013; Kathleen, Chris, & Elliot, 2004) Therefore, there is a need to discover a design approach to overcome such challenges. According to the current finding of many experts in web-design, to address those issues, card-based design can be considered as a possible solution (Adams, 2015; Cutter, 2015; Klementi, 2015; Lake, 2014).

A card is tangible metaphor of a piece of paper with unique related data that serves as an entry point to more detailed information (Google, 2015). For example, a card could contain a photo, text, and a link about a single subject. To be contained on cards, contents are being broken down into individual components, and those containers can be (1) programed to fit different types and sizes of screen, (2) classified toward personal learning material for each individual learner.

To this end, this paper begins by discussing the possible benefits of card-based design on mobile device, followed by presenting appropriate learning strategies such as space repetition and adaptive sequencing. Accordingly, it then goes to discuss the architecture of practical self-learning application uses **PACARD** (**P**ersonalize **A**daptive **CARD**-based interface). In our study, PACARD is the design model of a function called "**Cards page**". In other word, Cards page is friendly name of PACARD where abovementioned learning strategies were implemented. In brief, the aims of this study are three-folded:

- To evaluate effect of Cards page on students learning outcome.
- To observe how Cards page improve user retention.
- To observe how adaptive mechanism of Cards page meet user preference

2. Literature review

2.1 Benefits of card-based design on mobile device

A card is basically a small document that holds information to be shown. There is no doubt that cards have been around for a very long time (Klementi, 2015), it firstly appears in 9th century for games, then people started handing business cards (Pruzan, 2006). Nowadays, cards are fast becoming the best design pattern for mobile devices. However, up to now, card-based interface, yet it has not been investigated commonly among researchers. Despite the lack of card-based formal study, card-based interface is still leading new trend of designing interface for mobile application (Cutter, 2015). The first example of card-based design interface is Twitter, a favorite social network. They recently launch cards, which is a way to attached multimedia inline with tweets (Adams, 2015). In the meanwhile, Google also is rethinking information distribution, away from search, to personalized information pushed to mobile devices (Adams, 2015). Their design pattern for this is cards. Simultaneously, much of Facebook now represents cards. Furthermore, many parts of iOS7 are now card based, for example the app switcher and AirDrop. In brief, card-based interface can be seen as a pattern for mobile application design (Adams, 2015; Lake, 2014)

Although there is still a lack of research on card-based design, designer are reaching a common understanding that why card-based are more and more opportunities to be applied in mobile devices. In particular, design on card is flexible (Adams, 2015). For example, cards can be stacked vertically, like an activity stream on a phone. They can be stacked horizontally, adding a column as a tablet is turned 90 degrees. They can be a fixed or variable height. We also can hint at what is on the reverse, or that the card can be folded out. In addition, in the digital world we can embed multimedia content, photos, videos, and music, so cards could be used for multi purposes (Cook, 2014). To be appeared on cards, those multimedia contents will be divided into small topics and then structured toward user preferences. Because of that reason, many websites has been re-designing its interfaces toward cards, which can be used as a solution for an adaptive interface (Adams, 2015; Cutter, 2015; Klementi, 2015). Furthermore, (Sanchez & Branaghan, 2011) suggests that through adaptive design, can promote optimal use of small technologies.

2.2 Card design

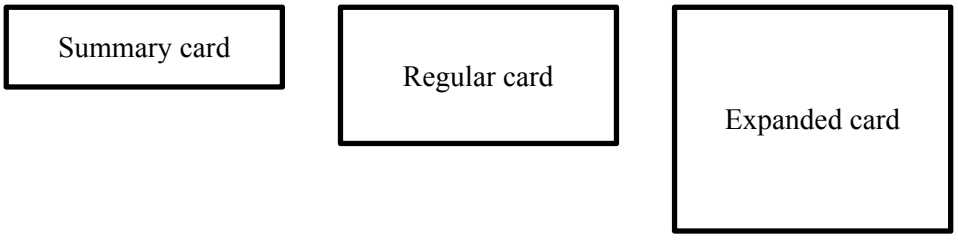

Figure 1: Summary card, regular card and expanded card

According to Google design guideline (Google, 2015) a card is a piece of paper with unique related data that serves as an entry point to more detailed information. Cards have a constant width and variable

height. They can be presented in many forms such as summary card, regular card or expanded card (see Figure 1)

In the physical world, cards can be turned over to reveal more, folded for a summary and expanded for more details, stacked to save space, sorted, grouped, and spread out to survey more than one. Those characteristics can be simulated into digital world. In addition designer can take advantage of animation and movement, scrolling, adding buttons (Adams, 2015).

2.3 Leitner system, spaced repetition, forgetting curve and adaptive sequencing.

Learning strategies that are presented in Cards page include "*spaced repetition"* (*Leitner system)* while "*forgetting curve"* is adapted for reviewing strategy. The *Leitner system* is a widely used method of efficiently using flashcards that was proposed by the German science journalist Sebastian Leitner in the 1970s (Leitner). It is a simple implementation of the principle of "*spaced repetition"*, where the software adjusts the repetition spacing interval. Material that is hard appears more often and material that is easy less often, with difficulty defined according to the ease with which the user is able to produce a correct response. Most new items will eventually be forgotten after only a single encounter, and in order for item to be remembered over time, they need to be reviewed on a regular basis (Baddeley). According to "*Forgetting curve*" concept, Reviewing material in the first 24 hours after learning information is the optimum time to re-read notes and reduce the amount of knowledge forgotten (Von Foerster, 2003). Cards page can provide pertinent *adaptive sequencing* by calculating the optimal intervals between reviews for each individual card and prepares each day a list of cards which learner should review before they forget them.

3. System design

3.1 System Architecture

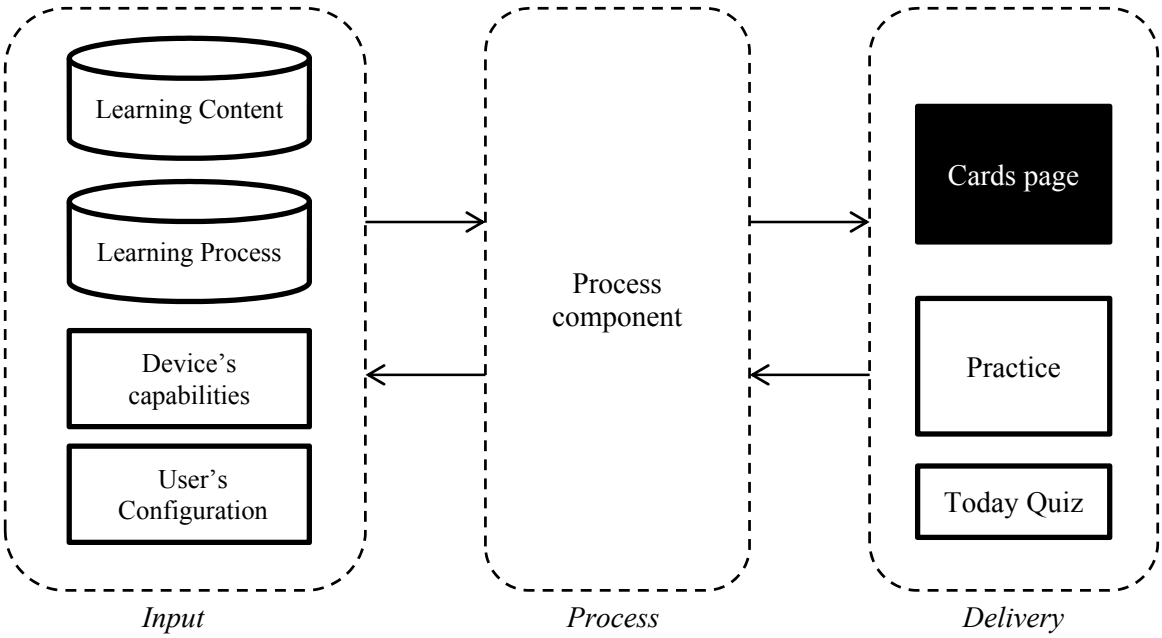

Figure 2: System Architecture

The system is logically divided into following three components: *Input, Process* and *Delivery* (see Figure 2). An *input* component is to (1) import all the databases includes lessons, flashcards, quizzes, users' memo (2) Store information of learning process such as lessons or flashcards that have been reviewed by learner at a certain time or the percentages of correct answers have been provided by learner during one certain test etc. (3) Collect information of device's capabilities, for example the size of screen, whether it support capture image or record voice etc. (4) Collect user configuration such as how

many cards and which type of cards should be shown in the Cards page upon one session, quantity of each card's types etc. *Delivery* component includes Cards page, Practice part and Today Quiz. Practice part contains sub-modules where occur learning actions, those actions description are saved back to learning process database via *Process* component*s*. *Process* component is to analysis the database regarding the *input* sources. It collects necessary information from the databases and determines which type of information it should send to the Cards page and Today Quiz components for display. In brief, it is the core of *adaption process.*

3.2 Learning activity flow Diagram

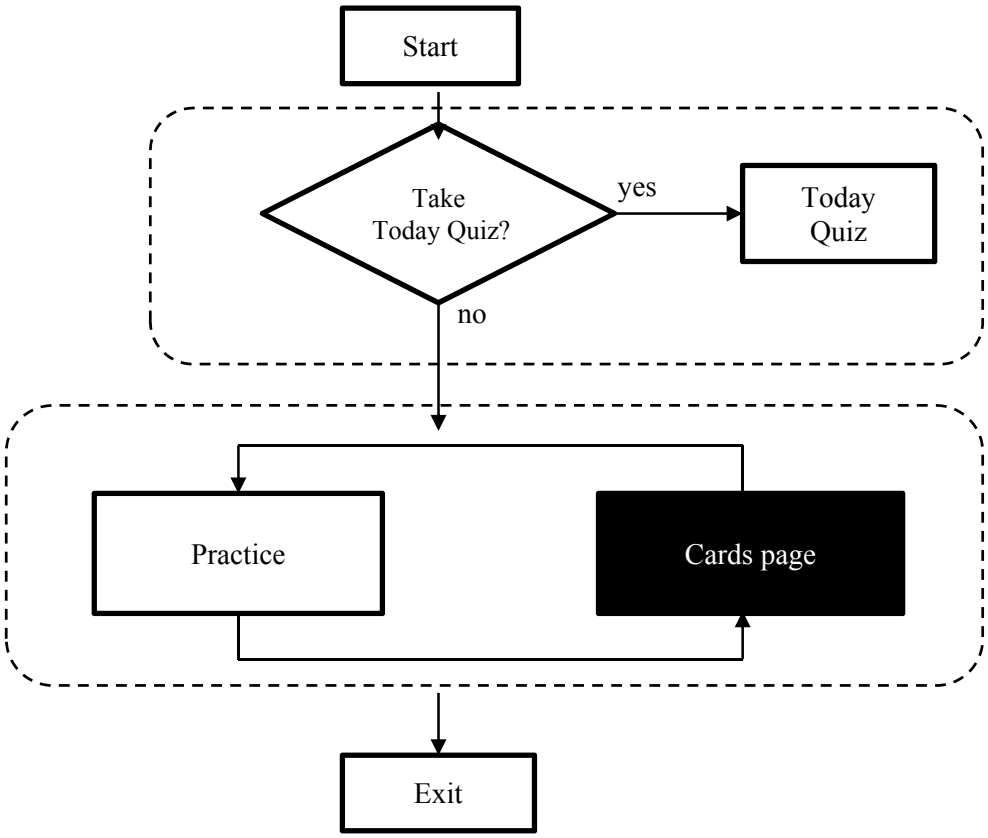

Figure 3: Learning activity flow Diagram

As presented in Figure 3, when the system is started, there is a Today quiz option pops up. Today quiz is designed to offer user a chance to review what they have learned in previous login session. It's optional choice, thus if learner skips this quiz, they will get directly into the main interface of application. The main interface of application logically contains two modules Practice and Cards page. Practice module includes all the Lessons, Flashcards, Multi-choice questions and Memo part while Cards page module is in charge of providing card-based interface that allow users to review what they have done in Practice module.

In particular, Cards page module responds on every task that done by user in Practice module in adaptive ways. For example, in Practice module, they enter Quiz part to do some practices with multi-choice question after that they switch to Flashcard set to check on some vocabularies and then go to Memo option to create "fishes" note. Afterwards, user enter Cards page, those contents are presented in stream of cards, which are "multi-choices question", "body vocabulary" "fishes" cards (See Figure 4). In other words, Cards page module works as a learning assistance which tracks and re-presents everything in card format for conventional reviewing.

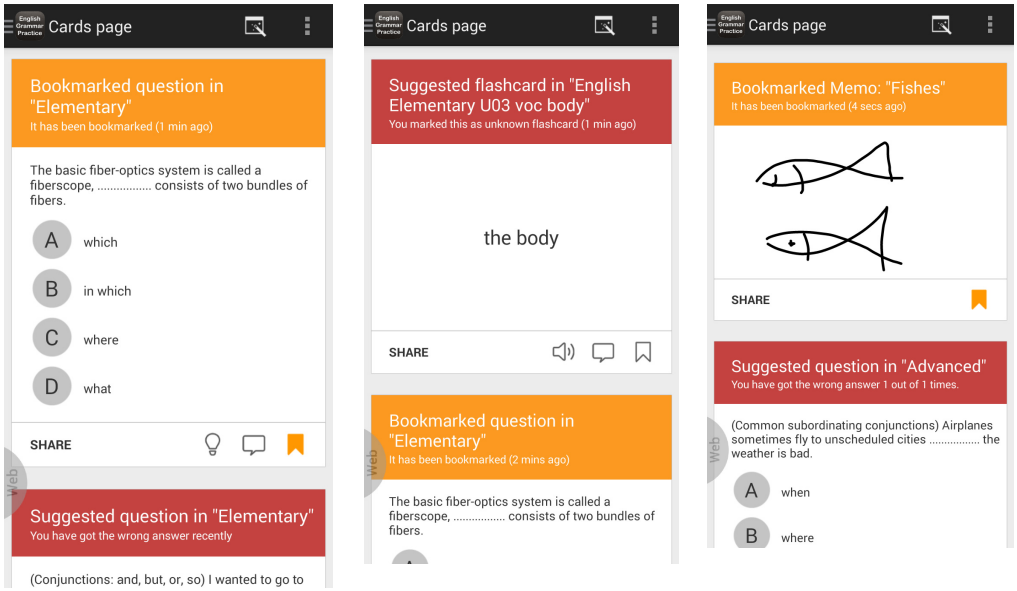

Figure 4: Example of cards on Cards page

3.3 Card design

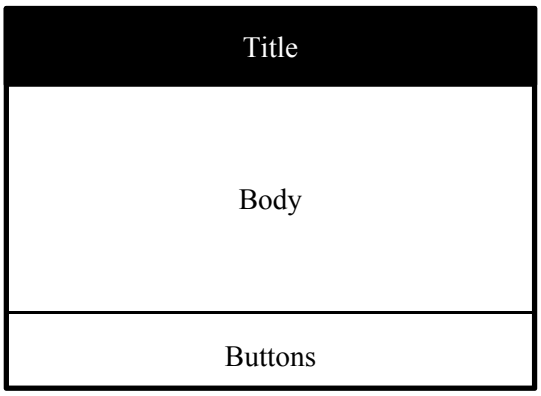

Figure 5: Card prototype

In general, our card prototype contains three parts (Figure 5): Title, Body, and Buttons. Regarding the title, cards are titled with "*Bookmarked", "Suggested" and "Random"*, which are three types of cards, that are colored in orange, red, grey respectively. Regarding the body, it includes contents of learning material such as a preview of a lesson, first side of one flashcard, a multi-choice question or a memo.

- *Bookmarked card* is pushed out when users bookmark any item, personal memo card is added in this group by default.
- *Suggested card* aims to simulate "spaced repetition" learning strategies. This type of cards are pushed out when users done following tasks:
  - Read a lesson: the preview of this lesson appears in the main body of the card. Users can expand it to access to whole article.
  - Mark a flashcard as "*known/unknown"*: the first side of this flashcard is presented in the body part; users can tap into card to flip to other side of the card.
  - Select either *wrong/correct* answer of a multi-choice question: User can also retake the question on the Cards page. There were several researches shown that multi-choice questions are not suitable to be applied "spaced repetition" because wrong answer options might affect user retention (Butler, Marsh, Goode, & Roediger, 2006; Roediger Iii & Marsh, 2005). This is mitigated or eliminated when there is quick feedback about the right answer (Butler & Roediger, 2008). Hence, we also bring this solution into Suggested-question card.
- *Random card* is pushed out randomly.

Regarding the buttons, this part has *"share" "bookmark/un-bookmark" "hint", "comment*" buttons. Specifically, "*share*" and "*bookmark/un-bookmark*" are commonly applied for all kind of cards while "*hint*" is only provided for multi-choice question card, and "*comment*" is available for all cards except card that presents a memo. Furthermore, Cards page also take advantages of touch screen in which user can do "*flip*" and "*swipe*". For example, use can *flip* over the question card to access the history for recent answers or they also can *swipe* on any card to mark that card as mastered items. Once a card was mastered, it is no longer appeared on Cards page.

3.4 Adaptive sequencing

- **Cards page**: According to spaced repetition concept, Cards page responds on following actions "Read a lesson", "Mark a flashcard as unknown", "Select wrong answer of a multi-choice question", "Create memo". If the status of any item changes, for example, from "unknown" to 'know", from "wrong" to "correct", it will disappear from Card page then be added into **Today quiz** in next day.
- **Today quiz**: According to "*Forgetting curve*" concept, to improve users retention on what they learned, the already taken learning materials will be put in "Today quiz" for users to review after 24 hours.

4. Methodology

4.1 The software

PACARD design concept is not particularly for one specific learning subject, we are expecting it can be applied in almost knowledge domains. Furthermore, due to the limited space of each card block size, the most appropriate item format to be appeared in card should be type of question- answer, personal note, notification, or short abridgement of one particular topic etc. that are easily visible on small pieces. To demonstrate the whole process of Cards page, in this study, we use English Grammar subject for implementation.

4.2 Participants

To evaluate the efficacy of Cards page, we put the software named "English Grammar Practice" on the Google Play store, which is the most popular Android application market. Then we collected data of 3182 online users during two weeks. According to Google Analytics, users mainly distributed in Asia (53.92%) Europe (29.59%). Gender were 58% male and 42% female. In addition, nearly haft of participant age between 18-24, followed by 25-34 (See more detail in Table 1)

Table 1: Summary of characteristics of 3182 users:

Age	18-24 (49.7%); 25-34 (27.1%); 35-44 (14%)
Gender	Male (58%); Female (42%)
Continent	Asia (53.92%); Europe (29.59%); Africa (9.6%); Americas (6.1%)
Device	Tablet (12%); Mobile (88%)

There were three studies:

Study 1: To evaluate effect of Cards page on students learning outcome: For this study, among thousands of active users, we randomly assigned those users into two groups. Group 1 contains users who using English Grammar Practice application without Cards page function. Group 2 contain users who using English Grammar Test application with Cards page. People whose the time consumed on the application similarly were selected as evaluated objects. In particular, users who spent around 15 minutes to 20 minutes per week were added into the study. Thus, after filtering, there were 229 users on group 1, and 189 users on group 2.

Study 2: To observe the user retention: Retention of the application can be seen as one factor to measure the attitude of users for the application. Bain & Company, working with Earl Sasser of Harvard Business School, analyzed the costs and revenues derived from serving customers over their entire purchasing life cycle. They showed that, increasing customer retention rates by 5 percent increases profits by 25 percent to 95 percent (Sasser, 1990), In our study, we measured retention by examining how long learners stay active. We recruited group 1 and group 2 of study 1 to observe the difference of user retention under the treatment *with/without* Card page.

Study 3: To observe how adaptive mechanism of Cards page meet user preference: in this study, we selected top 1000 users whose the highest time spent on Cards page for data analysis.

4.3 Data collecting

We tracked users' learning tasks and behaviors automatically. The data were collected and classified into four categories, as below:

- **General information**: includes data that are relevant to the information (if any) about country, gender, age and device screen size.
- **Time consuming**: includes data that are relevant to time consumed on each log-in session, on each day, and total using period.
- **Using behavior**: includes data that are relevant to quantitate of each type of cards, for example, quantitate of bookmarked cards, suggested card, random cards that are appeared/taken by users.
- **Learning achievement**: includes data, which are relevant to percentage of correct answers provided.

5. Results and discussion

5.1 Study 1: To evaluate effect of Cards page on students learning outcome

As abovementioned in the system architecture, students either can take quiz (quiz is the combination of multi-choice questions) in the practice module or Cards page. Thus to evaluate the effect of Cards page on students learning achievements, we compared the percentage of all correct answers provided by students on both groups. The percentage were calculated via the formula as below:

$$\text{Percentage of correct answers} = \frac{\text{Quantity of correct answer provided}}{\text{Quantity of total questions taken}} \times 100$$

As shown in Table 2, mean percentage under group 2 is 68.83, which is significantly larger than that under group 1 (m=66.45 p= .035). This means that under the use of Cards page, students obtained significantly greater achievements than those without Cards page. One possible explanation for this is the Cards page works under *spaced repetition* simulation, that support students better recall on what they learned in previous moment, which also supports students to track their current learning status and then provide suitable related learning material to each individual. With this support, users might perform better at learning outcome than those who don not have this scaffold. In other word, our adaptive mechanism has positive effect on users learning performance.

Table 2: Descriptive statistic and independent sample T-test of score

	Class	N	Mean	Std. Deviation	Std. Error Mean	Mean difference	t	Sig. (2-tailed)
Percentage of correct answers.	Group 1	229	66.45	11.116	.735	-2.379	-2.112	.035
	Group 2	189	68.83	11.548	.861			

5.2 Study 2. To observe user retention with/without Card page.

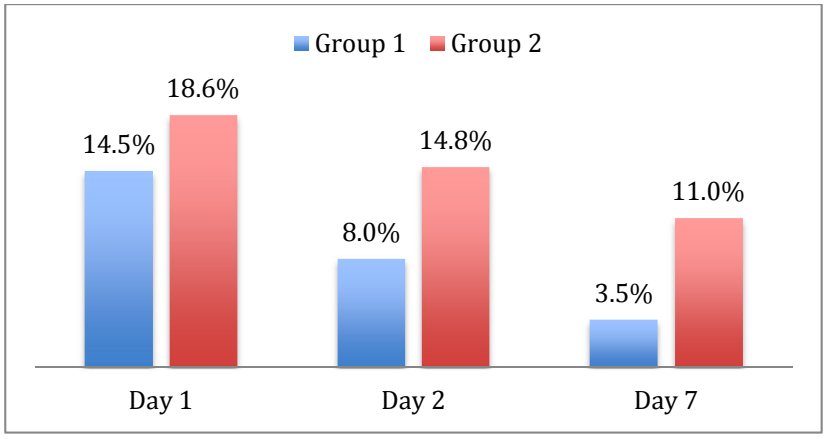

Figure 6: Comparison on user retention between group one and group two.

From the Figure 6, the group 2 had significant longer retention than those in group 1. In particular, 18.6% of users in group 2 stuck around a day after downloading an application while the number of group one was 14.5%. Day 2 retention of group 2 slightly decreased to 14.8%, but it was down to 8.0% for those in group 1. Similarly, Day 7 retention of group 2 went from respectable 14.8% to 11% while it plummeted from 8% to 3.5% in group 1.
The reason causing this difference might because the Cards page plays as a reminder role. It reminds students about the flashcard items that remains "unknown", or the "unsolved" questions; therefore students might get engaged to continue finding the solutions for those items.

5.3 Study 3. To observe how adaptive mechanism of Cards page meet user preference

In order to measure the user preference on the type of cards, we define the "be taken" card behaviors. A card can be seen as "be-taken" if user perform any actions on it, such as: View a flashcard, comment on a question, give a hint, select an answer for multi-choice question, view a lesson etc. In this study, the percentage of be-taken cards were calculated via the formula as below:

$$\text{Percentage of "be-taken" cards} = \frac{\text{Quantity of "be-taken" cards}}{\text{Quantiy of all popped up cards}} \times 100$$

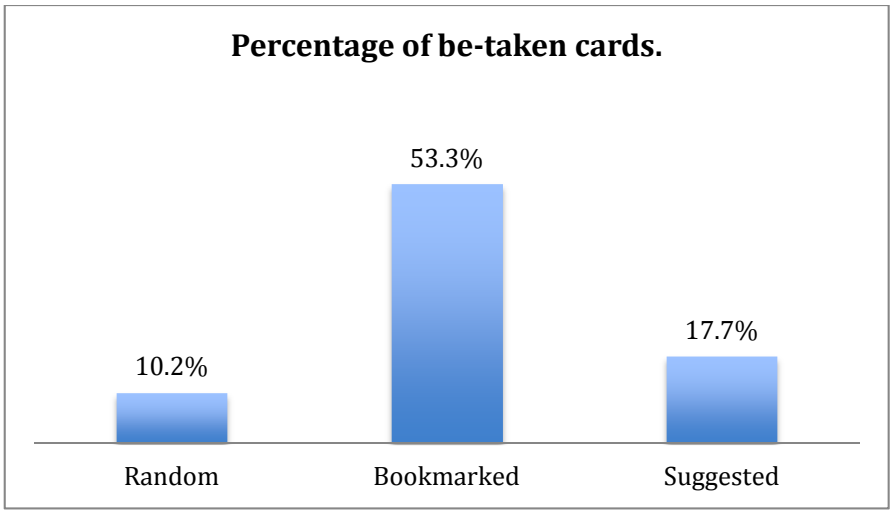

Figure 7: Percentage of be-taken on each type of cards.

Interestingly, in Figure 7 we obverse bookmarked items were the most likely to be-taken (53.3%) compared to others type suggested and random (17.7% and 10.2 % respectively). Specifically, the details on card-type distribution are presented in Figure 8, as below:

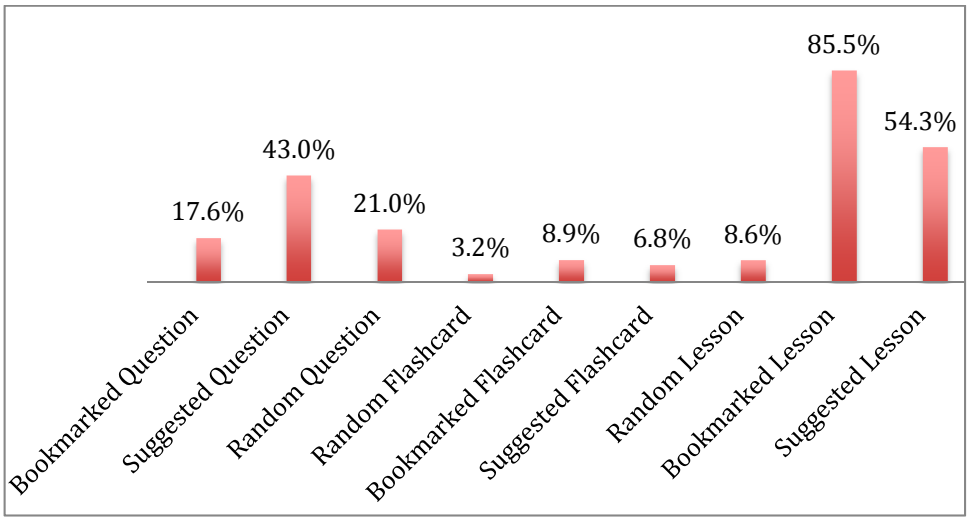

Figure 8: Distribution of be-taken on each type of cards in percentage.

Firstly, among all type of cards, Bookmarked-lesson cards were the highest item with 85.5% be-taken opportunities. Suggested-lesson items came to second position (54.3%), followed by Suggested-question (43%). From the above results, there are several possible explanations for this. Regarding bookmarked cards performances, bookmarking an item can be seen as intentionally action for later reviewing purpose, thus people are more likely attracted by items marked by them, especially for bookmarked lesson, which learner can gather knowledge from, plays a certain role during their learning process. In other hand, be-taken Suggested-lesson and Suggested-question cards were a bit lower compared to the highest one; it might because our suggestion lessons did not really meet the learner's preference. It is due to the fact that Cards page suggests every item related to users' learning tasks. Some of those might not the learning target items but only for referent purpose.

Secondly, Flashcard group had the lowest chance (vary from 3.2% to 8.9%) to be taken by learners. It is quite interesting symptom since flashcards is commonly used in language learning, but it could be explained by the learning contents introduced by this application. In particular, It is about English grammar, thus the most popular format of available learning materials is normally presented as an article or quiz (fill in blank, or multi-choice questions), and flashcards is quite new to introduce grammar-learning contents. Indeed, this reason also is in agreement with first finding that bookmarked-lesson and suggested-question were the most preferred to be-taken type.

6. Conclusions

This research proposes and evaluates Cards page, the **P**ersonalize **A**daptive **CARD**-based interface that provides learning material in an adaptive way. The results from the study show that Cards page results better learning outcomes and longer user retention. In addition, the bookmarked-lesson and suggested-question cards produced highest chance to be taken by users, thus we might need focus more on those preferences in order to improve our adaptive mechanism. From the founding of this research, card-based design has great potential to be applied widely in the future, thus educators have an alternative for their future educational application design.

Limitation and future study: The results from the TodayQuiz were skipping due to the insufficient data, thus we aim to improve this part in next study. Moreover, future studies could pivot on different subjects such as math or physic, and expand the research variables. Finally, forming an adaptive card-based application design guideline is our next target.

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