YoungJoo Jeong
CS & HCI
Class of 2009
May, 2009

Undergraduate Senior Thesis Research
Advisors: Ananda Gunawardena
Kenneth Koedinger

"Share or Not to Share?

The Benefits of the Use of Tablet PC Flash Cards Application in an Educational Setting"

Abstract

The goal of this research is to explore the benefits of the use of the Tablet PC Flash Cards application as a possible collaborative learning tool in an educational setting. A Tablet PC is a computer that has a touch or pen-enabled screen that allows the users to write or draw on the screens instead of typing on a keyboard or using the mouse. Being able to use a digital pen as an input device is especially useful in drawing and writing math equations. Tablet PC Flash Cards application ("application") was created to enhance learning by providing an easy mechanism to create the cards and an intelligent testing algorithm to more effectively study the material. In this research, we measured how much of study material individuals cover when creating the flash cards and how many students were needed to cover most of the materials to study. Also, the participants' inclusion and exclusion criteria for creating the study material were studied. An expert of the material (the participants' teacher) also created flash cards which were used as the control group. We found that for the material that the students already learned in the class, about four students were needed in average to cover 72% of the material. For the new material that the students haven't learned yet, in average only three students were needed to cover 86.6% of the material. Furthermore, half of the participants created some of the cards for the materials that they knew they would answer correctly and half of the participants created some of the cards for the material that they thought they should review more. However, these participants are not mutually exclusive. All of the participants felt comfortable sharing their flash card files ("deck") with each other and many of them were excited to use new technologies for their everyday studying and felt that using the application was "cool" and "fun." The findings of this research let us know that sharing the flash cards with others students would be beneficial as they would not only cover more material but also because some of them create the cards only for the things that they could answer correctly. Thus, when they study the cards created by others, they will have a greater chance of

studying the material that they wouldn't have studied otherwise. These findings give us a better idea as to how to create an effective collaborative learning tool.

Background

In fall of 2007, a special topic course in Pen-Based Computing was offered in Carnegie Mellon University in order to create Tablet PC applications that could be used by real world users. As learning process is often painful and very time-consuming for many people, I wanted to create an application that would make learning process more efficient, effective, and perhaps even fun. As a part of this course, with two other computer science students, I created the Tablet PC Flash Cards application. There were two main goals for this application: to design an application that can be easily used by anyone who can hold a pen, and to maximize learning by intelligently testing the users the most optimal materials that they need to learn in order to have a high memory retention rate. There are two main modes in this application: the "edit" mode and the "game" mode. In the edit mode, the users create the flash cards by drawing on the user interface with their digital pen. In the game mode, the application asks the users the cards that they just created. The application tells the users whether they answered the cards correctly or not. An algorithm is used to track these scores on each card and use these scores to intelligently ask the users the cards that they need to review. In previous versions of this application, different algorithms were used to test their effectiveness. The current version of the application also enables the users to review the cards sequentially as well. This feature was added after studying the use cases in the classroom environment as we found that the learning materials are often built upon previously learned materials.

There are many advantages of this application over physical flash cards or other online flash cards applications. First, unlike the other online flash cards applications, this application saves the "deck" file, a collection of flash cards, on the users' computers. So it is easy for them to move the deck to anywhere and email it to others if desired. Currently, many online flash cards applications do not allow the users to save the cards on their computers. So, it is difficult to share the files with other people offline or even study the cards without an internet connection. Also, unlike the physical flash cards or other online applications, it is easy to edit the cards and save multiple revisions of the decks without losing the original deck. Furthermore, the intelligent algorithm allows the users to effectively study the cards in less time.

After a few user testing and revisions, this application was deployed in Ellis School in Pittsburgh, Pennsylvania in its eighth grade geometry course. Every student enrolled in this course has a tablet PC laptop. As an independent research in spring of 2008, I have continued to enhance this application by observing the use cases at Ellis School and developing additional functionalities that the students and the teacher needed. These functionalities include the ability to add and save images, save the entire flash cards as a single file, and being able to iterate through the cards sequentially in the game mode rather than using the intelligent algorithm. This last feature was useful in initial learning when the students did not know much about the material in the deck. However, the students noted that the intelligent testing algorithm was useful when they were reviewing the material before their tests. The teacher in this course created the deck and played the game mode with the students during the class by projecting his screen on the screen. Then he asked the students to create the decks on their own and upload them on their course directory. After he reviews students' files, he encouraged the students to use the other students' decks to study. This is when the possible use of this application as a collaborative learning tool was first explored.

It is the goal of this senior thesis research to explore the benefits of the use of this application as a possible collaborative learning tool in an educational setting. Before developing this application as a collaborative tool, it was important to first verify whether using this application with other students or even sharing the decks with others would be more beneficial than using it alone. While observing the students' use of this application, it was apparent that each student emphasize on different points in the material. Hence, I wanted to research how much of material each student covers when creating the cards and what their inclusion and exclusion criteria are when creating the cards. The findings of this research would let us know whether sharing the deck with others would be beneficial and it will determine how to recreate this application as a better collaborative learning tool.

In Bonnie John's study of "The evaluator effect in usability studies: problem detection and severity judgments," she measured how the problem detection rate increased as the number of evaluators increased. She found that about four expert evaluators were needed to detect almost all of the usability problems. Individual evaluators only found half of the problems. The evaluators disagreed in their judgment of which problems were the most severe ones. This study gave me an idea that measuring how many students were needed to cover, and whether or not studying from the decks that other students created would be beneficial in learning. In John's research, the evaluators were asked to find as many usability problems as they could find (Jacobsen, 1998). However, in this research, the students may or may not include all

the material for several of reasons. For example, they may know the material sufficient enough that they feel that they do not need to study more or they may not understand the material enough to be able to create a card on it.

This study is related to Bonnie John's study in that we are measuring the correlation between the number of people and the coverage of the material; however, it is still a worthwhile study to have done because the participants were novice learners in this study, whereas in Bonnie John's study, the participants were experts. Also, in Bonnie John's study, the participants were finding usability problems - merely detecting problems - whereas in this study the participants created flash cards for the material that they were trying to learn. Furthermore, in this study by observing the users behavior in creating the flash cards for the learning material, we can learn how best to create a collaborative learning environment to maximize learning.

Research Question

Do multiple students cover a study material more extensively and thoroughly than a single student? If so, what is the optimal number of students to cover the materials fully? How do students decide what material to include in their study material?

Procedure

There are nine students enrolled in the geometry course in Ellis School. They individually created one deck for the material that they learned already and another deck for the material that they have not learned yet. The first deck is used as a review material and the second deck is used as a preview of the material before they learn it in their class. They uploaded their deck files on a Google group to which only the participants, their teacher, my advisors and I have an access. Their teacher also created decks for each of these materials. The teacher's decks were used as the control group from which I created the list of topics covered in the material. I measured the coverage of the material on the students' decks against these topics. From nine students, only five decks for each material were analyzable due to a few problems from the participants – some did not create the cards, and some faced technical difficulty uploading or emailing the deck files. So, total of twelve decks were collected and analyzed including two decks from the teacher. For each material, I randomly chose groupings of 2, 3, 4, and 5 decks in a group to measure whether more students collectively cover a wider range of materials, and if so what would be the optimal

number of students needed to cover most of the material. After students created the decks, a follow-up survey was used to determine the inclusion and exclusion criteria that they had when creating the deck. Furthermore, the survey was used to determine how the participants felt about collaboration in learning. The following is the list of the questions asked in the survey (with the exception of question #10, all the others were given multiple choices with the ability to choose more than one answer):

1. How do you learn best
2. How do you prefer to work
3. How comfortable are you in sharing your flash card deck files with your peers?
4. Have you used Tablet PC Flash Cards Application for other use than geometry?
5. Which types of collaboration methods (working with groups, sharing files, etc) in learning do you like?
6. What do you like about collaboration in learning?
7. What do you dislike about collaboration in learning?
8. How did you create flashcards for the things that you learned in the class?
9. How did you create flashcards for the material that you learned in the class?
10. What would you change about the Tablet PC Flash Cards Application?

Results

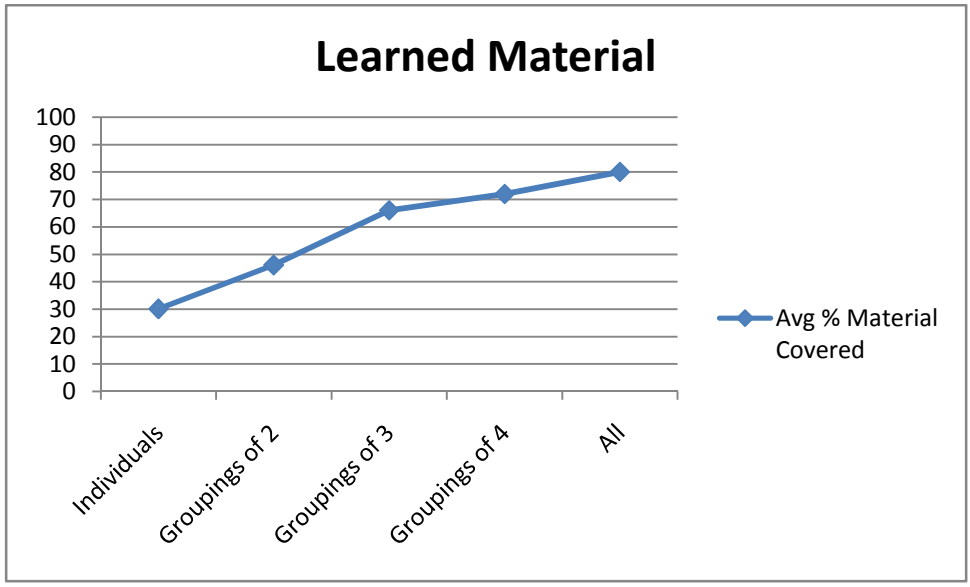
There were ten topics for the learned material and only three topics for the new material. The list of the topics and their difficulty levels were generated by analyzing the teacher's decks. Then each of the students' cards was analyzed to see which of the topics the card covered.

Out of nine students, only five students submitted analyzable deck files for the learned and the new materials.

The following is the result from analyzing five decks for the learned material:

Learned Material:

	Individuals	Groupings of 2	Groupings of 3	Groupings of 4	All
Avg % Material Covered	30	46	66	72	80



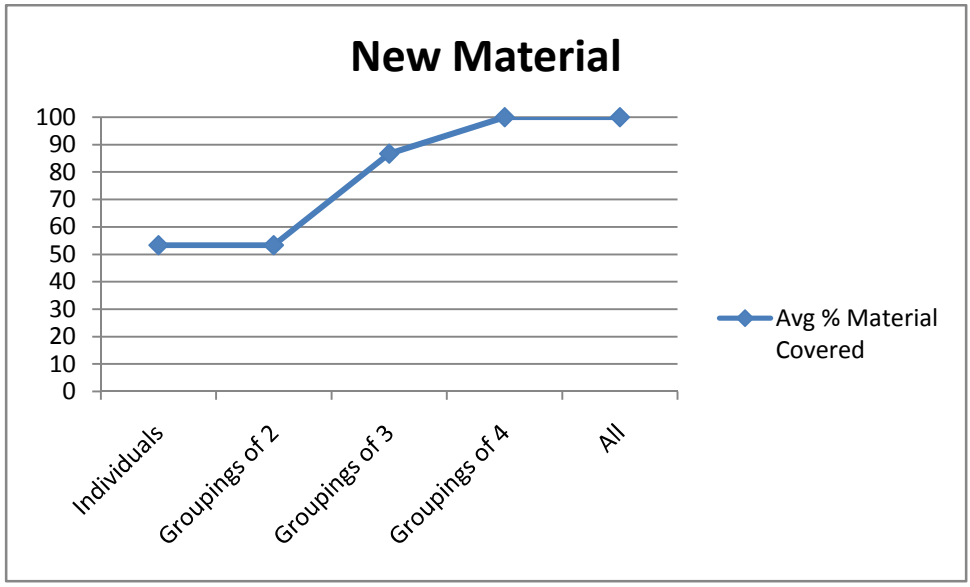
Even when all five decks were consolidated, only 80% of the material was covered.

The amount of material covered for the groupings of 4 was greater by only 6% than the groupings of 3.

The following is the result from analyzing five decks for the new material (some of these decks are from different students from the ones for the learned material):

New Material

	Individuals	Groupings of 2	Groupings of 3	Groupings of 4	All
Avg % Material Covered	53	53	87	100	100



Four students were enough to cover all the topics for the new material. In average, groupings of three students covered 87% of the topics which was greater than the percentage of material covered for all students combined for the learned material case.

Survey Results

Out of eight respondents, half preferred to study alone where the other half preferred to study in a small group (two to three people). All of the respondents felt comfortable sharing their deck files with their peers. 7 students used the application for science classes, 3 students used it for language courses, 3 students used it social science classes, 1 student used it for music and art related courses, and 1 used it for other math courses. 5 students like that in a collaborative learning environment they feel safe that others can correct them in case they were wrong. Half of the students also responded that they like that they get to learn about different ideas and opinions from others in a collaborative learning environment. However, only 1 student felt that she could accomplish more in a group than on her own. On the other hand, 7 students indicated that the biggest problem in collaboration in learning was that there are “free riders” who do not do their part in a group. The next biggest complaints (5 students each) were that when collaborating with others the organization of the work is inefficient and that there are conflicts of opinions and ideas. Furthermore, it was interesting that for both the learned material and the new material, half of the students created some of the cards for the topics that they didn’t know well enough so that they can review it more;

and half of the students created some of the cards for the materials they knew they would answer them correctly. These students are not mutually exclusive as 1 student also honestly indicated that she created the cards without giving it much thought.

Conclusions

It may seem contradictory that the students had greater coverage for the new material than for the learned material. It may be due to the fact that some students create the cards for the material that they know they will answer correctly when they know the material. Therefore, for the new material, since they do not know the material well enough yet, they may not merely include only the material that they know they would answer correctly. However, it could also be due to the fact that number of topics to be covered for the new material was considerably less than those for the learned material. To be able to more accurately understand the different behaviors in creating the cards for the learned material vs. new material, we should further collect and analyze the decks on the new material with a comparable number of topics as with the learned material.

We saw how Tablet PC Flash Cards application could be extended as a collaborative learning tool to benefit students in a classroom. Since the vast majority of the students were concerned about the “free riders” problem that in traditional group settings some members of the group do not contribute to the rest of the group, instead of encouraging the collaboration in creation of the cards, we can encourage collaboration in sharing of the cards. We can effectively share the cards by merging the decks of three to four students randomly and cover most of the topics for the material. In this way the cards would be independently created by the users, thus avoiding biasing each other as well as the “free riders” problem. Also, we can satisfy both types of people: people who prefer to study alone and people who prefer to study in small groups. By merging the cards and sharing them, the users can benefit from both individual learning and collaborative learning.

Limitations of the Study

The sample size of this study was small as there were only nine students in the class and not everyone’s deck files were usable for this study. Also, the new material only had three topics whereas the learned material had ten topics. Having a greater number of topics for the new material would give us a better comparable data with the learned material.

Future Work

Further research can be done to find the optimal number of cards - not just the number of students - that we should collect to create the best topic coverage. Also, we can further study the ideal size of the deck in relation to the users' performance in the "game" mode. Then we can further measure the optimal number of repetitions of the cards in the "game" mode to learn the material by heart.

Furthermore, we can also study how we should choose the cards to merge with other cards. In this study all of the cards were merged hence we ended up having multiple cards that covered the same topic in groupings of the decks. Therefore, as also shown from this study, sharing all the cards from everyone may not increase topic coverage after three or four decks were merged. So it shall be interesting to study the effect of choosing the cards based on a few criteria such as the students' grades and students' topic coverage in previous cards to see if we can have less number of users' deck to create better topic coverage.

Though it may take years of research, measuring the memory retention rate or the learning outcome of the material studied using the application would also be interesting. In addition, we should also investigate whether students learn better or remember for a longer period of time the material for which that they created the cards than the material that their peers created and they merely played in the "game" mode. Even if the students remember better when they actually create the cards than when they just study their friends' cards, it may still benefit them to study the cards that their peers created because that way they could get greater topic coverage of the material.

One may ask why the students shall bother creating the cards when their teachers would create the deck with a better coverage of the material. It is because the students could benefit from going through the cognitive process of understanding, analyzing, and selecting the material in order to create the cards. The real answer to this question, however, shall be answered by a further research on the cognitive benefits of creation of the cards.

References and Works Consulted

Jacobsen, N.E., Hertzum, M., & John, B.E. (1998). The evaluator effect in usability studies: problem detection and severity judgments. Proceedings of the Human Factors and Ergonomics Society 42nd Annual Meeting: Santa Monica, CA: Human Factors and Ergonomics Society.

Pavlik Jr., P. I., Presson, N., & Hora, D. (2008). *Using the FaCT System (Fact and Concept Training System) for Classroom and Laboratory Experiments*. Workshop presented at the Inter-Science of Learning Center Conference, Pittsburgh, PA.

Pavlik, P. I., Jr., Presson, N., Dozzi, G., Wu, S.-M., MacWhinney, B., & Koedinger, K. (2007). The FaCT (fact and concept) system: A new tool linking cognitive science with educators. In *proceedings of the 29th Annual Conference of the Cognitive Science Society*. Nashville, TN, USA.

Frishkoff, G., Levin, L., Pavlik, P., Idemaru, K., & de Jong, N. (2008). A Model-based Approach to Second-Language Learning of Grammatical Constructions. In V. Sloutsky, B. Love & K. McRae (Eds.), *Proceedings of the 30th Conference of the Cognitive Science Society* (pp. 916-921). Washington, D.C.