Title: Personalizing Student Learning and Enhancing Peer-to-Peer Networks through Pen-Based MyEduDecks Application

Short Title: Personalizing Learning through MyEduDecks Application

Author Names: Parv Shrivastava, Prateek Jukalkar, Aileen Owens

Short Author List: Shrivastava, Jukalkar, Owens

Author Affiliations:

Parv Shrivastava: South Fayette High School, 3640 Old Oakdale Road, McDonald, Pennsylvania, 15057-3599, USA, e-mail: parvshrivastava@gmail.com
Prateek Jukalkar: South Fayette High School, 3640 Old Oakdale Road, McDonald, Pennsylvania, 15057-3599, USA, e-mail: psjukalkar@gmail.com
Aileen Owens: South Fayette High School, 3640 Old Oakdale Road, McDonald, Pennsylvania, 15057-3599, USA, e-mail: amowens@southfayette.org

Contact Author: Parv Shrivastava

Abstract

MyEduDecks is a pen-based flashcard application that has been in development at South Fayette High School since 2013. The project initially began as a South Fayette student project under the supervision of computer science professor Ananda Gunawardena of Carnegie Mellon University. The MyEduDecks team has extended the first iteration of the application to meet the user needs at South Fayette. This application intends to personalize student's learning and build collaborative networks in the classroom by leveraging pen-based technologies and their benefits. The application encourages the user to use a stylus to input questions and answers in an electronic flashcard format. MyEduDecks uses the Microsoft Ink API to integrate digital ink into the app. This research paper highlights the application, its continued development, impact on a K-12 learning institution, and both qualitative and quantitative data analyzing the impact of an application reliant on pen and touch technology.

1. Introduction

The emergence of classroom technology has provided educators with the tools to facilitate personalized learning for students in K-12. Research has found a correlation between being successful and personalizing a student's learning [1]. Additionally, digital learning in K-12 education has increased tremendously in traditional school settings with digital instruction models and techniques implemented more than ever before [10]. Digital pen-based technologies can assist in this process in five main ways: (1) offer the ability for students to personalize their learning experience, (2) provide teachers and students tools to connect to further explore learning opportunities, (3) promote peer-to-peer networking to reap the benefits of collaborative learning, (4) explore the use of pen-based technology as an alternative to pen and paper, (5) and enhance knowledge retention.

1.1 Problem Statement

Educational institutions are inclining towards personalized learning to assess strengths and challenges at an individual level to tailor the curriculum and teaching models to be more effective. Furthermore, studies have indicated that peer-to-peer and student-teacher collaboration motivates the students to perform better [8]. The challenge is to come up with the most effective way to achieve a personalized learning approach along with collaboration in the classroom.

Flashcards have long been an effective method for students to memorize and retain information. Paper-based flashcards have shown to be effective in helping people learn in discrete chunks of information [3]. Electronic flashcards allow for more user interaction from the student and provide avenues to retain the same information. A key component of electronic flashcards is the opportunity for collaboration. However, beyond competing for scores, existing flashcard applications do not emphasize sharing and collaboration. Most electronic flashcard applications also have their main input through typing. This is problematic when trying to represent sketches or diagrams as answers. Additionally, students whose typing skills have not been fully developed find pen-based applications easier to use [6, 7, 9]. The application provides an easy to use interface for flexible input.

1.2 Context

The context of the research project is K-12 learning institutions that stand to benefit from a study tool that utilizes a pen-based modality. The intent of the MyEduDecks research project is to personalize learning, increase collaboration, promote peer-to-peer and student-teacher interaction, and explore benefits of a pen-based application. Through this paper, we aim to reveal the changes the application has undergone, the results of a pilot being conducted at South Fayette School District, and the qualitative and quantitative data being collected.

1.2.1. MyEduDecks Application

MyEduDecks is a pen-based electronic flashcards application built by South Fayette High School students. When the program development started in 2013, the MyEduDecks team was comprised of several high school students. When team members graduate from high school each year, new members are added to create a new channel of talent. This process provides invaluable software developmental skills that are transferrable to the workplace. All of this happens while improving a product that has the potential to become a study tool for educational institutions across the country.

The defining feature of the MyEduDecks application is its pen-based interface. The ability to write on the cards allows for more complex and unorthodox information, like mathematical equations and formulas, to be easily expressed. Students can create and play decks using the Microsoft Ink API. The current iteration of the app has added support for foreign languages, expanding the usability of the application to more classroom environments. Additionally, collaboration is becoming a vital skill in today's world, and the application now contains features for more interconnected experiences. Students can create and share decks with their peers across their class. This allows for the integration of healthy competition and motivates students to learn more through sharable decks. Each student now has a personal profile with basic information and the badge system. After procuring a certain amount of points, students earn various badges. Teachers have access to an Excel spreadsheet containing all the student's results, including accuracy and time of completion, for each student. Currently, we are working to incentivize students to use MyEduDecks through a virtual currency system which is now under development. Students will receive points for each deck completed based on accuracy.

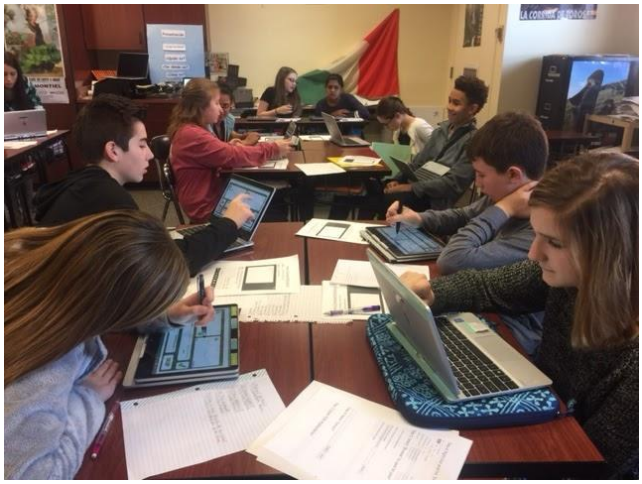


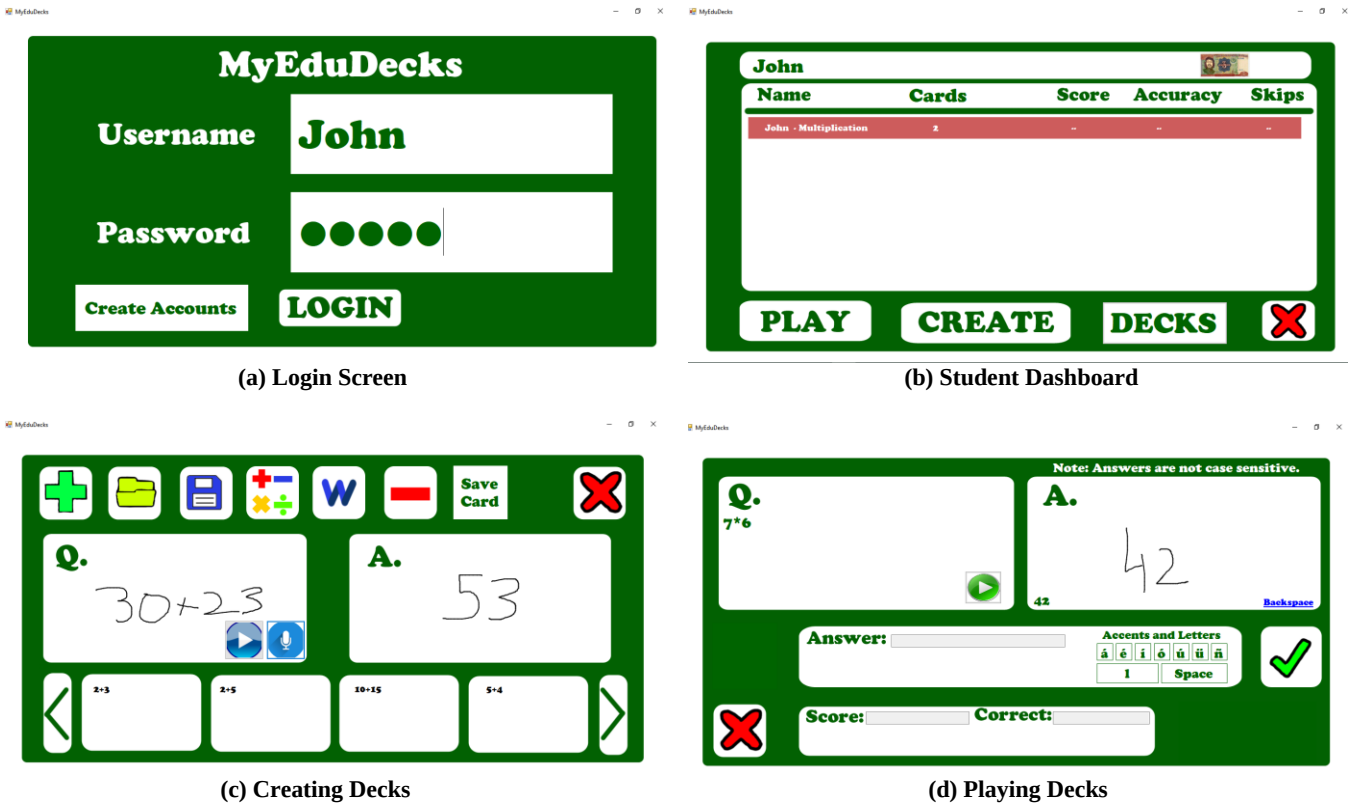
Figure 1: Students using the MyEduDecks application during the beta test.

2. Previous Work

MyEduDecks started five years ago as the Flashcards application [4, 5]. It was inspired by the Table Flashcard projects being explored at CMU [2]. The first working iteration of the app was built three years ago and was tested in grades K-2 in the district. Students had to solve basic math facts with the application in the beta test. The potential to personalize learning for students was evident, but bugs and design flaws persisted. The project was renamed to MyEduDecks to reflect the new functionality and direction of the product, which is to offer a more personalized approach to learning. The next year, the application was beta-tested with ten third grade students and received positive feedback. The team has since completely rebuilt the application, making it run more smoothly, and overhauling the outdated graphics. The interface was redesigned to make it more user-friendly and intuitive. The application has been tested at younger grade levels in the past, and educators found it to be beneficial in the classroom, expressing interest in incorporating the final version of MyEduDecks into their lesson plans. The feedback and suggestions of the educators and students have been invaluable and driven much of the change in the application since. This continued educational research has tracked the impact of personalized learning and student collaboration.

3. System Details

The MyEduDecks application contains three main modules which include creating, playing, and sharing decks. Each deck contains multiple electronic flashcards for students to answer. Through its various features, the MyEduDecks application intends to enhance student interactions and personalize learning.



(a) Login Screen

(b) Student Dashboard

(c) Creating Decks

(d) Playing Decks

Figure 2: Screenshots of the MyEduDecks application

3.1 Student Interface

There are two main interfaces which are comprised of the student and teacher interfaces in the application. Students arrive at the login screen when they launch the MyEduDecks application as shown in Figure 2. The student can input their username and password to progress to the dashboard. When arriving at the dashboard, students will see decks they have completed, decks that have been shared with them, and decks that need to be completed. The three types of decks are denoted in specific colors. From the dashboard, students can create, play, or share decks. In the create deck screen, the student has three ways to create a deck: handwriting, importing a Word file, and the Automath feature. In the handwriting feature, students can write the question and answer for each card in the electronic panels. An audio feature has also been implemented which allows students to record audio and embed it into the cards. Furthermore, students can create decks using formatted Word documents. Students can import these Word documents into the application to automatically create decks. The last way to create decks is by the Automath feature which randomly generates math problems based on the parameters the user selects. Students can also play decks that they created or ones that were shared with them using the digital ink interface to write the answers to the questions. The play deck screen tracks the percentage of questions the student got correct which is easily accessible by teachers. Students can share decks with other students in the MyEduDecks app. This allows for more peer-to-peer collaboration and helps build student networks.

3.2 Teacher Interface

From a teacher's perspective, the flow of the application is similar to the student interface. In addition to having all the features the students have, teachers can assign decks to their class and view the class's scores in a spreadsheet. Furthermore, teachers can easily interact with students and see their progress. This allows for teachers to tailor to individual student needs by creating decks to help students build proficiency in areas where they need more assistance in meeting their learning goals.

3.3 Digital Ink through Microsoft Ink API

The pen-based interface built into the app is only possible through the Microsoft Ink API. The Ink API had recently been updated with the release of Windows 10. This updated API allows for better recognition of the user's input. In the application, there are many ink panels where the user can utilize the pen-based input when interacting with the app. The ink recognizer built into the API translates the ink to text. There are text labels that update every time the ink is used which allows for instant feedback about what is written. There are errors with the ink recognizer sometimes, but the real-time feedback allows for users to fix these errors.

4. Methods Employed

MyEduDecks was tested in a classroom setting by Mr. Miguel Hernandez, a Spanish teacher at South Fayette. Due to the nature of a language, vocabulary is an integral part of becoming proficient. The teacher felt MyEduDecks might be a way to incentivize learning vocabulary. He piloted the MyEduDecks program with sixty-three seventh-grade students to encourage them to practice Spanish vocabulary, grammar, and listening interpretation skills, and to give students the opportunity to personalize their learning. Mr. Hernandez felt that providing his students with a more interactive study tool could benefit their learning in the classroom. In addition, he felt that being able to easily and conveniently create and assign skill-building activities, and view student performance on the assignments, would provide him with a better understanding of the comfort level of each individual student. The MyEduDecks team trained Mr. Hernandez on how to use MyEduDecks prior to the start of beta testing.

In previous beta tests with the application, the tests only spanned for a few days. A pilot was run for a month with MyEduDecks in Mr. Hernandez's Spanish classroom. This allowed us to test MyEduDecks for a longer duration and see how it benefits students. In the beta test, Mr. Hernandez assigned decks related to the material he was teaching to help reinforce and practice the concepts they learned in class. He was easily able to see the scores the students received on their practice decks. For students who struggled with the practice, Mr. Hernandez could easily identify students who were not grasping the material well and reassigned the practice decks to them. The students were given a total of three practice decks through the beta test and three assessments covering material on a specific deck. The three assessment scores in Mr. Hernandez's class were compared to another classroom's test scores studying the same curriculum without using MyEduDecks. In addition, a 2-tailed Pearson Correlation test with the statistical program SPSS was used to determine the effectiveness of MyEduDecks based on the assessment data. In addition, students provided their feedback and input regarding MyEduDecks through a post-survey administered after completion of MyEduDecks.

5. Results

The 63 students participating in the pilot filled out a survey based on their thoughts and perception about MyEduDecks and general learning technologies. Table 1 shows the survey results that were collected from the students.

Post Survey Questions	Agree	Disagree
Learning independently is important to me.	90.6%	9.4%
Based on what I know about MyEduDecks, I think using MyEduDecks could enhance my ability to learn independently.	74.6%	25.4%
Based on what I know about MyEduDecks, I think using MyEduDecks could enhance my ability to work collaboratively with teammates.	60.3%	39.7%
I like to have the ability to pre-learn concepts before they are introduced in class.	84.1%	15.9%
Based on what I know about MyEduDecks, I believe that using MyEduDecks could enhance my ability to pre-learn concepts before my teachers teach the material.	73%	27%
I like to be in control of my own learning.	85.7%	14.3%
Based on what I know about MyEduDecks, I believe that using MyEduDecks could enhance my ability to be in control of my own learning.	69.8%	30.2%

I like to personalize my own learning.	81%	19%
Based on what I know about using MyEduDecks, I believe I could personalize the way I learn by designing and creating unique cards or decks that align to the concepts I most need and want to learn.	73%	27%
I enjoy creating my own study guides and help guides.	57.1%	42.9%
Based on what I know about MyEduDecks, I believe I could create my own personalized assessments to help me learn concepts that I find difficult.	74.6%	25.4%
I believe I would like answering questions on MyEduDecks using digital ink and a stylus rather than simply typing answers on the cards.	40%	60%
I would like to be able to add my own graphics and pictures on the MyEduDecks digital flashcards system rather than using plain white paper based flashcards with print.	63.5%	36.5%
I can think of important reasons to include audio when creating MyEduDecks flashcard quizzes.	58.7%	41.3%
I think using the MyEduDecks flashcards would help me learn things that were hard because I could test myself and practice what I do not know.	81%	19%
I think being able to add pictures on the Flashcards would be very helpful.	81%	19%
Hearing a person's voice reading, or having sound on the flashcards, would be very helpful.	66.7%	33.3%
If I could make my own online flashcard deck using MyEduDecks, I believe I could make my own questions and could help improve my learning.	69.8%	30.2%

Table 1: Survey Results

In Figure 3, the test scores of two different classes are shown. The class with orange bars used MyEduDecks to study for tests, and the class with the blue bars did not use MyEduDecks to study for tests. For the first two assessments, the students who used MyEduDecks had a higher class average by 0.7 and 4.1 percent, respectively. In the last assessment, the students who did not use MyEduDecks had a higher class average by 1.9 percent.

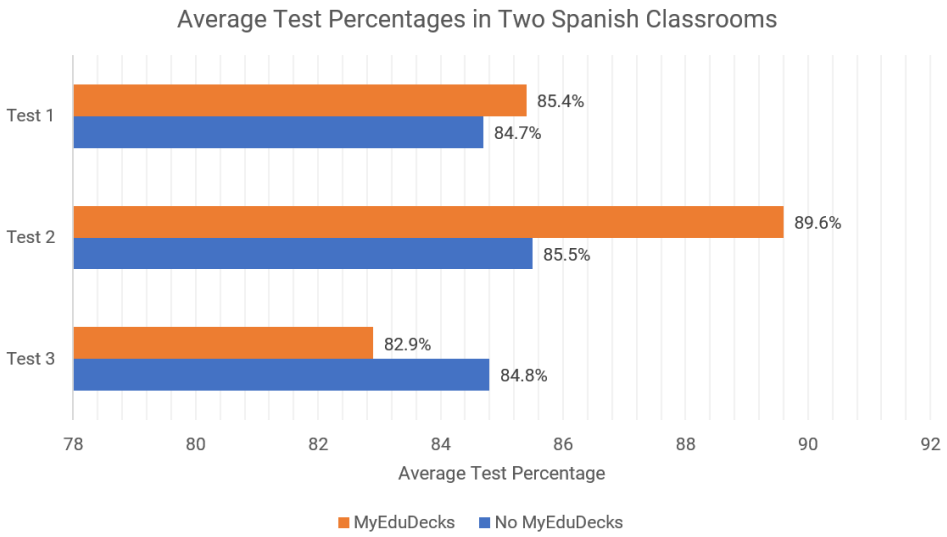


Figure 3: Clustered bar graph depicting average test scores for both classes.

We also did a 2-tailed Pearson correlation test between the students' MyEduDecks practice scores and their assessment scores. For the AR quiz and the AR verb practice on MyEduDecks, the correlation coefficient was 0.39 and it was significant at the .01 level. Furthermore, the correlation coefficient for the preposition quiz and the preposition practice on MyEduDecks was 0.3 and it was significant at the .05 level. Finally, the correlation coefficient for the chapter test and the AR verb practice on MyEduDecks was 0.434 and it was significant at the .01 level. The correlation coefficients ranged from 0.3 to 0.434 and were all positively related.

Correlations

		MyEduDecks Test 1 Practice	Test 1
MyEduDecks Test 1 Practice	Pearson Correlation	1	.390**
	Sig. (2-tailed)		.004
	N	52	52
Test 1	Pearson Correlation	.390**	1
	Sig. (2-tailed)	.004	
	N	52	52

**. Correlation is significant at the 0.01 level (2-tailed).

		MyEduDecks Test 2 Practice	Test 2
MyEduDecks Test 2 Practice	Pearson Correlation	1	.300*
	Sig. (2-tailed)		.022
	N	58	58
Test 2	Pearson Correlation	.300*	1
	Sig. (2-tailed)	.022	
	N	58	58

*. Correlation is significant at the 0.05 level (2-tailed).

		MyEduDecks Test 3 Practice	Test 3
MyEduDecks Test 3 Practice	Pearson Correlation	1	.434**
	Sig. (2-tailed)		.003
	N	46	46
Test 3	Pearson Correlation	.434**	1
	Sig. (2-tailed)	.003	
	N	46	46

**. Correlation is significant at the 0.01 level (2-tailed).

Figure 4: 2-tailed Pearson Correlation test between practice decks and test scores.

6. Discussion

The survey results indicate that most students found MyEduDecks to be a beneficial learning tool. The initial data collected gauges the interest of students and how they think MyEduDecks can be used to supplement their learning. The beta test results above indicate that a majority of students believe it can enhance their learning of concepts. The findings are discussed below.

Being able to take control of your own learning is an important skill to being successful, and one that can be enhanced by technology. Over ninety percent of respondents agreed that learning independently is important to them over the previous two years, proving its importance to students. Over seventy percent of these same students indicated that MyEduDecks helps them achieve this. The application does this by allowing students to create their own decks, attempt them multiple times, and clearly indicating their progress over time on their personal dashboard. Pre-learning concepts give students an opportunity to understand some of the material in advance so they can better understand what is being taught the first time. Nearly eighty-five percent of students agreed with this based on the survey results. MyEduDecks enables students to look ahead by allowing teachers to create decks with future material, giving students the chance to get familiar with the concepts in advance. Seventy-three percent agreed that MyEduDecks helped them do this. Being able to personalize learning has been important to students participating in beta tests, with over eighty percent indicating as such. Personalizing learning is also one of the goals of the MyEduDecks application. This is achieved by allowing students to create their own decks to master information they consider relevant. Additionally, each student has their own dashboard that displays the results of the decks attempted to track their progress. Furthermore, a student profile feature is currently being developed to be added to the application. This will give students access to some basic statistics regarding their performance and give each of them something unique. Seventy-three percent of the participating students agreed that MyEduDecks helps them personalize their learning.

A main focus of the MyEduDecks application was to encourage collaboration between teachers and students as well as among students and their peers. Educators now receive an Excel spreadsheet with each student's statistics which allows them to track their progress and identify high achieving and low achieving students. To increase peer-to-peer collaboration, students now have the option to create and share decks with peers. In addition, a virtual currency system is being developed to promote healthy competition and active learning for students. Reaching certain amounts of currency will unlock badges that can be viewed in the aforementioned student profile screen. These features will provide students with immediate gratification after completing a deck and encourage positive competition. The ultimate goal of any educational product is to improve student performance on assessments. Based on three student assessments, a positive correlation between using MyEduDecks and increased test scores exists.

One interesting data point from the survey was that 60 percent of students would rather type out their answers than use the digital ink to write the answers on the cards. This is likely because most seventh graders are generally proficient in typing their answers, and it would be slower for them to write out their answers with the ink. This aversion to ink-based input was very different from the results we collected from the first two beta tests with students from grades K-3. They preferred the ink-based input rather than typing. Usually, students in younger grades have not developed proper typing skills, which makes

writing a more attractive option. With results over the past three years consistently supporting this notion, the team will consider toggling the mode of input depending on the age group being tested to ensure that the students are most comfortable.

The students' assessment average scores were also compared between the class that used MyEduDecks and the class that did not use MyEduDecks. The first two assessments did show that MyEduDecks helped the students score better on the tests. However, in the third assessment, students who did not use MyEduDecks scored marginally higher than students who used MyEduDecks. Overall, MyEduDecks seems to have an impact with students getting higher scores on the tests.

In regards to the correlation test, the strength of the correlation between the scores of the practice decks and assessments is modest. The correlations ranged from 0.3 to 0.434 from a scale from -1 to 1. Also, the correlations were significant at the 0.01 and 0.05 level. There is a clear positive correlation between both scores, and it does show that people who score well on the practice in MyEduDecks score well on the tests.

7. Future Work

With the results and feedback offered from students and through ongoing collaboration and support from Mr. Hernandez, we will continue to improve the application in the future. A few key features that will be added include the ability to view a student's profile from the teacher interface, the ability for students and teachers to add graphics to the cards, and the implementation of a leaderboard system. By allowing teachers to view student profiles through the review sets, the teacher can better determine each individual student's learning needs and how to address them. In the same way, students will be able to determine their own individual areas of improvement. Students will be able to take control of their learning by creating practice decks that are designed to improve areas of weakness. In the future, we hope to fulfill the great potential the MyEduDecks application possesses in helping students to improve their learning through increased collaboration with peers and with greater connections to the teacher. We plan to develop the features in MyEduDecks that will allow for more peer to peer network. For example, instead of completing tasks individually, students can compete in team challenges and collaborate with other students. Supporting a team approach to learning builds on the peer-to-peer networks these students have established through MyEduDecks. We will continue to gather input from students and work towards improving the user experience by making the app more responsive and easier to use.

8. Conclusion

Through another year of development and research, we have gained valuable insight on the current capabilities of MyEduDecks in addition to taking significant steps to address issues identified in past years. While developing the current iteration, we focused on expanding the boundaries of the application into foreign languages by adding Spanish capabilities. This addition broadened potential user base while making the app more versatile. Furthermore, we have added another avenue for collaboration through the sharing of decks. This enables students to create their own decks and share them with their peers. The app has also undergone an overhaul from the teacher's perspective. Teachers and educators can quickly and easily assign decks to their students to be completed. The ability to incorporate sound and audio recordings has also been added to decks. This allows for teachers to assess their students' listening comprehension skills in an efficient manner. The results of completed decks can then be downloaded as an Excel spreadsheet with statistics beneficial in gauging the progress of students. MyEduDecks has shown that it can be a useful tool in many classrooms through the personalizing learning for students and promoting collaboration.

Acknowledgements

We would like to give special thanks to an instructor, Miguel Hernandez, who piloted the application in his classroom and to Dr. Ananda Gunawardena, professor of computer science at Princeton University, who began the project with us and continues to support and guide each new team. We would also like to thank Vinay Pedapati, Zoe Koutavas, and Priya Matreja for helping program the application and the support they provided to the middle school students during the pilot of this program. We would also like to thank former members of the team who have graduated and are pursuing their careers. Furthermore, we would like to thank the students taking part in the beta test and answering all of the survey questions. Finally, we would like to thank Superintendent Dr. Bille Rondinelli and the South Fayette School District Board of Education for their generous support for this project which has allowed us to present at conferences and to continue ongoing research.

References

1. Cathy Cavanaugh, Dorit Maor, and Aidan McCarthy. 2014. K-12 mobile learning. In Handbook of Research on K-12 Online and Blended Learning, Richard E. Ferdig and Kathryn Kennedy (Eds.). ETC Press, Pittsburgh, PA, USA 391-413.

2. Jeong, Y., Gunawardena, A., Koedinger, K.R.: Designing a pen-based flashcard application to support classroom learning environment. In: CHI '10 Extended Abstracts on Human Factors in Computing Systems, CHI EA'10, pp. 4695–4698. ACM, New York (2010). DOI 10.1145/1753846.1754214.

3. Kornell, N.: Optimising learning using flashcards: spacing is more effective than cramming. Appl. Cogn. Psychol. 23(9), 1297–1317 (2009).

4. Kothuri R., Cohen S., Wilke N., Owens A. (2016) Personalizing Student Learning Using the MyEduDecks Application Through Teacher Supervision and Peer-to-Peer Networks. In: Hammond T., Valentine S., Adler A. (eds) Revolutionizing Education with Digital Ink. Human–Computer Interaction Series. Springer, Cham

5. Kothuri R., Kenawell B., Hertzler S., Babatunde M., Wilke N., Cohen S. (2015) Analyzing Trends in Pen Computing among K-2 Students Through Flashcards Application. In: Hammond T., Valentine S., Adler A., Payton M. (eds) The Impact of Pen and Touch Technology on Education. Human–Computer Interaction Series. Springer, Cham

6. Li, J.T., Fan, Y.N.: Using iPad to Make E-flashcards and Sharing the E-cards Through Doceri. In: T. Hammond, S. Valentine, A. Adler, M. Payton (eds.) The Impact of Pen and Touch Technology on Education., pp. 249–257. Springer (2015)

7. Raymond, D., Liew, J., Hammond, T.A.: A vision for education: Transforming how formal systems are taught within mass lectures by using pen technology to create a personalized learning environment. In: T. Hammond, S. Valentine, A. Adler, M. Payton (eds.) The Impact of Pen and Touch Technology on Education., pp. 355–363. Springer (2015)

8. Roshan, S.: The flipped classroom: touch enabled, academically proven. In: The Impact of Pen and Touch Technology on Education, pp. 215–222. Springer, Cham (2015)

9. Solberg, V.S., Phelps, L.A., Haakenson, K.A., Durham, J.F., Timmons, J.: The nature and use of individualized learning plans as a promising career intervention strategy. Journal of Career Development 39(6), 500–514 (2012). DOI 10.1177/0894845311414571

10. Watson J., Murin A., Vashaw L., Gemin B., Rapp C. (2011). Keeping pace with K-12 online learning: An annual review of policy and practice. Evergreen, CO: Evergreen Education Group.