The Effect of a Mobile Application on Fire Safety Education

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The lack of knowledge about fire safety is a growing concern in our country. The National Fire Protection Agency surveys have shown that about 75% of Americans claim to have a home evacuation plan. However, more than half of those families cannot attest to practicing by means of a home fire drill. To better inform families of this important issue, the implementation of a fire safety application is proposed. This research was aimed at the creation of a mobile application to aid families in forming a fire escape plan, and informing them of the dangers of house fires, and focused on the creation of the first "Flash cards" section. It was hypothesized that the in-app flash cards would prove more beneficial in helping students to learn than traditional paper flash cards. The app was first developed through Apple's XCode platform. Students were then tested with the digital flashcards and paper flashcards to see which was more effective. A two-sample t-test showed that the difference in quiz scores between the control group (n = 15, M = 1.40, SD = 1.12) and the experimental group (n = 15, M = 0.8, SD = 1.37) were not statistically significant, (t(6) = -1.31, p = 0.89). This concludes that the null hypothesis is supported, and it is suggested that there was no significant difference between the use of the app and the cards.

Introduction

Since the launch of the App Store® in 2008, there have been a total of 130 billion downloads from over 2 million applications. The proliferation of apps available to smartphone users helping make simple tasks in life easier. However, there are still issues which could be easily remedied with the implementation of a mobile app. Apps for emergency and natural disaster planning are abundant, but in terms of fire safety and home escape planning, applications for that purpose have yet to surface in the App Store. While a tool for this purpose may seem extrinsic, collected statistics prove otherwise. Surveys by The National Fire Protection Agency show that about 75% of Americans claim to have a home evacuation plan. However, more than half of those families cannot attest to practicing by means of a home fire drill.[1] A similar survey by the American Red Cross resulted in comparable result to those of the NFPA, while also ascertaining that only 10% of families have rehearsed fire drills, and only 24% have a safe, outside meeting spot.[1]

The world of application development has spread to a very diverse group, and with thousands of touchscreen device users, mobile apps have the ability to make an impact on large groups of people. Mobile applications can range in function from entertainment to education. As one of the leading software platforms, the iOS operating system has always been coded in *Objective-C*, a language exclusive to Apple.[2] In June of 2014, Apple released a new language by the name of *Swift*, as well as the beta testing program TestFlight. The TestFlight program allows developers to share their app prototypes with fellow iOS users. The users who partake in the prototype testing can send crash reports and other feedback to the developer. The information provided by the testers helps developers to make their apps more user-friendly.

The goal of bug fixing and beta testing is to repair the flaws of the app, which can include developer error, technical issues, and bad interface design. When surveyed about what they would do in the case of an app malfunction, 44% of the users reported that they would delete the app immediately, 38% would delete the app if it froze for 30+ seconds, 32% would speak negatively of the app, 21% would post their negative comments on social media, and 18% said they would delete the app if it froze for 5 seconds.[3] In spite of an app's poor performance, 27% of people said they would keep a paid app a little longer, as they cannot be refunded, but they would not buy apps from the same developer again.[3] These statistics adduce the importance of having a well-polished the final product.

Apps are effective tools for teaching and helping students, especially younger ones, to comprehend information.[4] As a part of student-led learning, technological advancements enable creativity, collaboration, and critical thinking skills in children.[4] Apps can be used with learners at different levels, and from this, they should be designed for the intended user. If the app is targeted towards families, especially ones with small children, then there should be features that are engaging for younger audiences as well as being informative for adolescents and adults.

To collect information on how well students have comprehended fire safety lessons, the American Red Cross has prepared a short online assessment for educators to understand the class information retention.[5] Using information from the survey statistics conducted in 2014, the assessment is 9 questions. The NFPA also has a "Fire Safety Week" quiz that is 15 questions.[5] By combining the two assessments, with slight modifications, an understanding of the newly comprehended information by students can be analyzed.

Baker and Cormier explored differences in two populations of families of children with special health care needs. Initially, the two locations were studied to find differences in their levels of disaster preparedness.[6] The idea of a brief education intervention was hoped to prove successful in increasing baseline preparedness for natural disasters, and the data from both populations were compared to see if the information retention differed between the groups. A brief education was delivered by trained community of health educators to 210 families of children with special health care needs. A test was given before and after the experiment. Although there was no difference in preparedness levels based on geographic location, both populations increased greatly in preparedness levels after they were educated. This study provides additional evidence that a brief education intervention helps to increase disaster preparedness levels.

In this experiment, Mack, Spotts, Hayes, and Rains Warner aimed to help prepare low-income and low-resource families for disastrous situations.[7] Sessions were held to inform families about preparing disaster kits on a small budget, and they aimed to increase awareness about disaster preparation by providing resources. The participants were families enrolled at the Children's Relief Nursery in Portland, Oregon's St. John's District. Follow-up assessments were used to test the effectiveness of the sessions and to follow-up on kit assemblies. A replicable teaching tool was successfully developed, and the community was interested in securing the program. These families then possessed the skills, knowledge, and resources to carry out a disaster survival plan successfully.

Stevenson, Hedberg, Highfield, and Diao explored how using apps enables the learning process to be meaningful and student-centered.[4] The authors discuss recent developments in technology, mobile learning, and using apps as part of student-led learning processes to enable creativity, collaboration, and critical thinking. They addressed the idea that apps can be used with learners at different levels. Exploring the connections between mobile apps and media and visual literacy, the paper also discusses the collaborative features of many current apps. The authors argue the

need for schools and education systems to move away from infrastructure-led developments towards more learner-led solutions. They also mentioned that apps should be designed with the intended user in mind so that the features available effectively engage the appropriate user.

Nilson, Bonander, and Jonsson found that statistics about household fires and resulting fatalities were abundant, but statistics about types of people the statistics are about are often overlooked.[8] A survey was sent to Swedish households, taking note of whether the participants had experienced a house fire, as well as their sociodemographics. Numbers of children, percentages of fires, age, gender, education, income, nationality, and housing type were documented based on the responses. An unevenly distributed risk for fires was noted; However, they did find that highly educated households had a greater risk for house fires, but lower educated households had a higher risk for fire fatalities. Also, for houses with children, the 6-12 year age range was the highest risk for house fires. People between the ages 0-5 years as well as those over 65 years were at the highest risk for fire fatality.

This project was chosen because it explores an idea relevant to the computer science field and has a possibility to benefit the community. The mobile application will aim to help many families become better prepared for house fires and help teach others about planning for fires. Many families have never officially created a plan, and the goal of this experiment is to develop an app that will allow families to plan for house fires. Currently, there is no mobile application like this, but the one to be developed will compile resources, provide emergency planning within, and have special features to assist families.

It was hypothesized that if students studied paper flash cards and the flash cards within the app, then the digital flashcards will help them to learn more information. The app was first developed through Apple's XCode platform. Students were then tested with the digital flash cards and paper flash cards to see which was more effective.

Materials and Methods

2014 Macbook Air running macOS™ Sierra   Human participants
iPad® running iOS 10   Swift™ 3 language
XCode® 8 platform   Proto.io© software

The application was prototyped using the Pro.io software (Figure 3), and the prototype was used as an outline for creating the app using XCode®. From the prototype, the "flash cards" section was developed. This code is located in Figure 4. After development, 30 participants (ages 8-9) were gathered from an elementary school. Minimal risks existed for participants, although the discussion of fires may have been frightening to younger participants. However, informed consent documents were sent home to the parents/guardians of each student mentioning this possibility. The students were split into two groups, A and B, corresponding to the use of the application or the paper flash cards. They were divided by randomly assigning each student a number, 1 through 30, and assigning each set of three to group A or B. A set of 12 question and answer pairs were developed (Figure 5), and random sampling was used to select question/answer pairs from the set and design "before" and "after" surveys. Students first took the 5 question "before" survey on their existing knowledge of fire safety. They then had 4 minutes to explore the assigned app or go through the set of flashcards, in groups of 3. Both the flash cards and the app included a set of 12 questions and answer pairs. After all students had been exposed to either the digital or paper flash cards, the students were given the "after" survey to analyze what was learned from the application.

Results

The raw data tables can be found in Table 5. The "before" and "after" scores from each student were collected, and the differences from each student's score were calculated (Table 5). As seen in Table 1, the mean difference for paper flash card scores was 1.4. However, the average difference for the app scores was 0.8. A two-sample t-test showed that the difference in quiz scores between the control group (n = 15, M = 1.40, SD = 1.12) and the experimental group (n = 15, M = 0.8, SD = 1.37) were not statistically significant (t(6) = -1.31, p = 0.89). This concludes that the null hypothesis is accepted, and it is suggested that there was no significant difference between the use of the app and the cards.

Discussion

The purpose of this study was to develop a mobile application that allows families to plan for safe fire evacuation, and to help educate families on the dangers of fires and how to prepare for worst-case scenarios. For the first stage of development, the "flash cards" section was the primary focus, and it was found that the use of the digital flash cards within the app had an equal impact on educating as the tried and true paper flash card method. The hypothesis, however, was not supported, as the mobile flash cards were not more effective than the paper ones.

Overall this research demonstrates several main points. Firstly, it was found that there was no significant difference between paper and digital flashcards. Paper flash cards have been used by students for decades, and they have become a method for helping students to learn and study information. However, the results show that digital flash cards may be just as helpful. This is in accordance with the findings of Colbran, Gilding, Marinac, and Saeed, who found that digital and paper flash cards had relatively the same impact on student learning.[9] Ebersbach, Schiller, Hege, Holzer, and Fischer had similar findings, showing that digital flashcards were equally as helpful as traditional study methods.[10] Lastly, Hung found that digital flashcards were practical learning tools.[11]

While the collected data corresponded with the findings in previous research, there were still possibilities for sources of error to arise. For example, some of the student participants were not able to read as well as others, limiting their take away from either type of flash card. Also, the digital flash cards did not include a "back" button to allow students to view previous cards without completely starting the set over, which differed from the paper cards in the sense that they could be read over and over again without cycling through a continuous loop. These sources of error will be taken into consideration for future expansions on the project.

For future studies, the app itself will be further developed. In the initial prototype stage, the app had 4 sections: "Flash Cards", "Reminders", "Game", and "MyHome". The reminders section will aim to help families keep track of when to change smoke detector batteries and other important routine checks to keep their homes safe and prepared. The game feature will aim to help younger family members learn to identify unsafe fire hazards within the home, and help to keep family members safe. Lastly, the MyHome section will aim to help families map out an escape route, and make note of where smoke detectors, fire extinguishers, and first aid kits are located. Each of these sections will be tested with real-world

application studies, as the flash card section was in this experimental process.

Acknowledgements

Notes and References

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Title: The effect of a mobile application on fire safety education		
Hypothesis: If students study paper flash cards and the flash cards within the app, then the digital flashcards will help them to learn more information.		
Independent Variable: Presence of game		
Levels	Paper cards	App
# of trials	15	15
Dependent: Survey score (difference in points)		
Control: Paper flash cards		
Constants: Device used, number of students per group		

Figure 1: Experimental design diagram. All data collected from participants remained anonymous, and data was analyzed at alpha equal to 0.05 with a two-sample t-test.
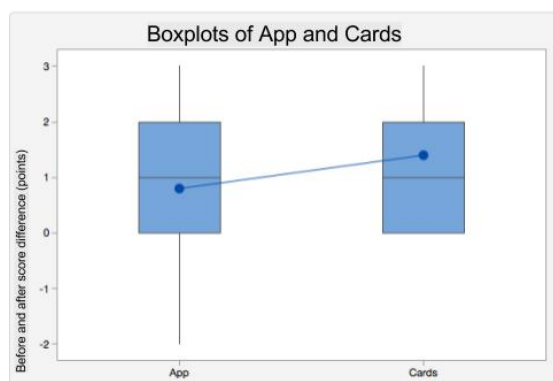
Figure 2 shows the graphs of both groups in terms of mean comparisons. The group that was tested with the app had a wide range of scores, with several scores falling far below the mean. The group that tested with the paper cards had much more consistency in score differences. The paper card group also had a higher mean, but there was not a large enough difference between the two to prove statistically significant.

Figure 3 initial map of the application, which was then directly transferred to A Storyboard layout in XCode.

Figure 4. The entire code for the "Flash Cards" section ViewController.

```swift
import UIKit

let q1 = "How often should smoke alarms be replaced?"
let q2 = "Where can the smoke alarm date of manufacture be found?"
let q3 = "Will closed doors slow the spread of fire, smoke, or heat?"
let q4  = "Why are interconnected smoke alarms best?"
let q5 = "A smoke alarm should be installed:"
let q6 = "How often should smoke alarms be tested?"
let q7 = "If a smoke alarm sounds,"
let q8 = "What is an important tool for families to have?"
let q9 = "If your smoke alarm makes a chirping sound:"
let q10 = "How often should you replace alarm batteries?"
let q11 = "How many escape routes should household members have?"
let q12 = "How many times should you practice your escape plan each year?"


let a1 = "Every 10 years"
let a2 = "On the back of the alarm"
let a3 = "It will slow the spread of all of them"
let a4 = "If one sounds, they all sound"
let a5 = "In every room"
let a6 = "Once a month"
let a7 = "Get out and stay out"
let a8 = "An escape plan"
let a9 = "Replace the battery and then test the alarm"
let a10 = "Once a year"
let a11 = "2"
let a12 = "2 times a year"


var questionNumber = 1

class ViewController: UIViewController {
    @IBOutlet weak var questionLabel: UILabel!
    @IBOutlet weak var answerLabel: UILabel!

    override func viewDidLoad() {
        super.viewDidLoad()
        questionLabel.text = q1
        answerLabel.text = "???"
        // Do any additional setup after loading the view, typically from a nib.
    }

    override func didReceiveMemoryWarning() {
     super.didReceiveMemoryWarning()
        // Dispose of any resources that can be recreated.
    }

    @IBAction func updateLabelsQ() {
        questionNumber = questionNumber + 1
        if questionNumber > 12{
            questionNumber = 1
        }
        if questionNumber == 1{
            questionLabel.text = q1
            answerLabel.text = "???"
        }
        if questionNumber == 2{
            questionLabel.text = q2
            answerLabel.text = "???"
        }
        if questionNumber == 3{
            questionLabel.text = q3
```

Figure 4. The entire code for the "Flash Cards" section ViewController.

```
                answerLabel.text = "???"
            }
            if questionNumber == 4{
                questionLabel.text = q4
                answerLabel.text = "???"
            }
            if questionNumber == 5{
                questionLabel.text = q5
                answerLabel.text = "???"
            }
            if questionNumber == 6{
                questionLabel.text = q6
                answerLabel.text = "???"
            }
            if questionNumber == 7{
                questionLabel.text = q7
                answerLabel.text = "???"
            }
            if questionNumber == 8{
                questionLabel.text = q8
                answerLabel.text = "???"
            }
            if questionNumber == 9{
                questionLabel.text = q9
                answerLabel.text = "???"
            }
            if questionNumber == 10{
                questionLabel.text = q10
                answerLabel.text = "???"
            }
            if questionNumber == 11{
                questionLabel.text = q11
                answerLabel.text = "???
}
            if questionNumber == 12{
                questionLabel.text = q12
                answerLabel.text = "???"
            }
            }
    @IBAction func updateLabelsA() {
            if questionNumber == 1{
                answerLabel.text = a1
            }
            if questionNumber == 2{
                answerLabel.text = a2
            }
            if questionNumber == 3{
                answerLabel.text = a3
            }
            if questionNumber == 4{
                answerLabel.text = a4
            }
            if questionNumber == 5{
                answerLabel.text = a5
            }
            if questionNumber == 6{
                answerLabel.text = a6
            }
            if questionNumber == 7{
                answerLabel.text = a7
            }
            if questionNumber == 8{
```

Figure 4. The entire code for the "Flash Cards" section ViewController.

```
            answerLabel.text = a8
        }
        if questionNumber == 9{
            answerLabel.text = a9
        }
        if questionNumber == 10{
            answerLabel.text = a10
        }
        if questionNumber == 11{
            answerLabel.text = a11
        }
        if questionNumber == 12{
            answerLabel.text = a12
        }
    }
    // Preferred status bar style lightContent to use on dark background.
    // Swift 3
    override var preferredStatusBarStyle: UIStatusBarStyle {
        return .lightContent
    }
}
```

Figure 5. The questions and answers that were included in the flash card sets.

How often should smoke alarms be replaced? Every 10 years

Where can the smoke alarm date of manufacture be found? On the back of the alarm

Will closed doors slow the spread of fire, smoke, or heat? It will slow the spread of all of them

Why are interconnected smoke alarms best? If one sounds, they all sound

A smoke alarm should be installed: In every room

How often should smoke alarms be tested? Once a month

If a smoke alarm sounds, Get out and stay out

What is an important tool for families to have? An escape plan

If your smoke alarm makes a chirping sound: Replace the battery and then test the alarm

How often should you replace alarm batteries? Once a year

How many escape routes should household members have? 2

Table 1. Paper cards descriptive statistics. Shows a summary of the data collected from the students who used paper flash cards during experimentation. On average, student scores increased by about 1.4 points.

Variable	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Cards	15	1.4000	1.1212	0.0000	0.0000	1.0000	2.0000	3.0000

Table 2. App descriptive statistics. Shows a summary of the data collected from the students who used the app's flash cards during experimentation. Student scores increased by about 0.8 of a point on average.

Variable	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Cards	15	0.8000	1.3732	-2.0000	0.0000	1.0000	2.0000	3.0000

Table 3: Descriptive Statistics. Shows a summary of the statistics from data collected in each of the groups. Both groups contained 15 participants, and the control group, being the cards, had a mean of 1.4 and a standard deviation of 1.12. The app group had a mean of 0.08 and a standard deviation of 1.37.

Sample	N	Mean	StDev
App	15	0.8	1.3732
Cards	15	1.4	1.1212

Table 4: T-Test Summary. Shows a summary of the two-sample t-test that was run, with H_0: $\mu_1 - \mu_2 = 0$, and H_1: $\mu_1 - \mu_2 > 0$. Since the test was run at alpha = 0.05, and the P-Value of 0.8993 > alpha, there was no

T-Value	DF	P-Value
-1.31	26	0.8993

Table 5: Raw data that was collected during experimentation.

#	Before	After	Difference	#	Before	After	Difference
1	2	3	1	4	2	4	2
2	4	4	0	5	0	3	3
3	2	5	3	6	2	3	1
7	1	4	3	10	2	3	1
8	1	3	2	11	1	3	2
9	2	4	2	12	1	2	1
13	3	3	0	16	2	1	-1
14	0	2	2	17	2	2	0
15	2	2	0	18	0	2	2
19	0	2	2	22	0	2	2
20	2	3	1	23	3	1	-2
21	2	2	0	24	3	2	-1
25	0	3	3	28	2	3	1
26	3	4	1	29	1	2	1
27	2	3	1	30	3	3	0