University of Arkansas – CSCE Department
Capstone I – Preliminary Proposal – Fall 2017

Implementing Proper Hand Washing with the Help of Persuasive Technology

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Abstract (Cole Woods and Adan Rutiaga)

Throughout history, one of the biggest issues that humanity has faced is combating illnesses. Even with many medical advances, illnesses are still one of the major weaknesses of humanity. This is especially true when it comes to Nosocomial infections and foodborne illnesses. The World Health Organization defines Nosocomial infections as "*an infection acquired in hospital by a patient who was admitted for a reason other than that infection*." (8) By definition, these are infections that are preventable since a patient would not have obtained them had they not visited a hospital. Patients at a hospital are most likely at an already vulnerable state. Acquiring another illness can be detrimental to their weakened health. Furthermore, this can result in complications when trying to relieve them of multiple illnesses.

One of the best ways to prevent Nosocomial infections and foodborne illnesses is to focus on proper and thorough hand washing practices. Although this may sound like a simple task with a simple solution, improper hand washing techniques have been a recurring issue both in hospital settings and in food service. An understudied approach to resolving this issue is encouraging proper hygiene via habit forming technology. Habits have been proven to be difficult to form, but also difficult to break. If proper hygiene can become a habit, specifically hand washing, many illnesses can be prevented in a very simple and economical way. One approach is to use habit forming technology to create acceptable hand washing practices. This is being done by creating a videogame that, coupled with hardware, will allow staff members to learn and maintain appropriate levels of sanitation.

Problem (Natalia Baker)

The human body is a complex and a mysterious entity that is capable of doing remarkable things as well as things that many of us would consider as, well, less-than-remarkable, such as the fact that the human body can provide a place for disease-causing germs and bacteria to grow and multiply (2). Research shows that many of these disease-causing germs and bacteria are directly associated with poor hand washing hygiene habits of food service employees and healthcare professionals, which in turn bring about food borne illnesses and Nosocomial infections. According to the CDC, an estimate of 48 million people get sick, 128,000 are hospitalized, and 3000 people die each year from different foodborne infections such as E-Coli and Salmonella (1). The CDC also estimates that, each year, 1 in 6 Americans get sick from foodborne illnesses caused by foods that are contaminated with germs or toxic substances before they reach the kitchen, or by other foods that are contaminated by food handlers (6). Not washing hands with

soap and clean running water is one of the main causes for spreading germs and contaminating food (7). Nosocomial infections on the other hand, also known as Hospital Acquired Infections (HAI), are infections that are spread by various means to susceptible patients in hospitals and other healthcare facilities (3). The CDC estimates that 1 in 25 hospital patients being treated in a medical facility gets an HAI (5). In addition to their devastating effects on the physical and the mental health of people, Nosocomial infections cost billions of dollars in added expenses to the healthcare system due to the prolongation of hospital stay (5). The most common way Nosocomial infections are spread is by staff members not washing their hands between patient contacts. And despite the fact that the CDC mandates healthcare professionals to clean their hands as they enter and as they leave a patient's room, compliance with the recommended hand washing practices remains in the range of 30% to 50%, which is unacceptably low (4). When accounting for the high mortality rates and increased economic expenses that result from foodborne illnesses and Nosocomial infections, any efforts to create policies and procedures to control the spread of infections and to make the food service facilities and healthcare facilities safer, are justified and encouraged.

Objective (Natalia Baker)

The deadliest recorded outbreak of foodborne illness in the U.S. since the 1970s is a 2011 outbreak of Listeria from contaminated cantaloupes (9). The outbreak sickened 147 people from different states and resulted in 33 deaths (9). In the U.S., the medical expenses, decreased productivity, and premature deaths associated with Listeria amount to an estimated cost of $2.6 billion annually (9). Nosocomial infections on the other hand, account for 1 to 3 million infections and 380,000 deaths each year in long-term care facilities (10). In today's society, cleaning hands is virtually effortless, and despite the hygiene standards and health codes available, clean hands in the food industry remain an issue (12). Some of the factors that hinder hand hygiene compliance in the food industry are: lack of availability of supplies and accessibility of sinks, inadequate food handling training, time pressure in high volume businesses, and lack of accountability (12). Similarly with healthcare workers, some of the factors that contribute to low hand hygiene compliance are: insufficient number of sinks, ignorance of guidelines and/or forgetfulness, high work-load and understaffing, interference with worker-patient interaction (4). The above factors, combined with the statistics mentioned earlier, establish the basis for the objective of this proposal, which is to incorporate persuasive technology, technology designed to change behaviors and attitudes of users through persuasion but not coercion (11), to help alleviate the health and financial cost associated with foodborne illnesses and Nosocomial infections.

Approach (Alec Winebrenner)

As stated in the above sections, there is compelling information that suggests the lack of hand washing in the food industry is the main cause of foodborne illnesses and the spread of harmful bacteria. In an effort to solve this issue of poor hygiene, we will use an incentivized approach. If an employee is rewarded every time they wash their hands thoroughly, it should become second nature in just a short time. Therefore, our approach to this problem is through rewarding a quick 30 second video game to be played while washing hands. In order to play as well as wash your hands there are several pieces of technology we must implement. The first, and most important, is the technology in which to play the game. We will be searching for an inexpensive Android tablet to display the game which will be mounted above the sink. Secondly, to have a hands-free

game such as this, we will be implementing a foot pedal to be used as the one and only control to the game. As the game is a platformer, the pedal will be a way for the character to jump and hence, maximize points. At this point the game should be fully operational and testable. However, there is still an issue of making sure the employee actually washes their hands. We will then implement a sensor within the soap dispenser, causing the game to start once the soap is dispensed. The game will last for exactly 30 seconds as this is ample time to thoroughly wash your hands. These are the main tasks we plan to implement to solve this critical problem we are facing. There are, however, several things we must consider while implementing the technology. There is the obvious issue of theft or vandalism, along with issues of abusing the game without washing your hands. These are things we will investigate once we get further into implementation and testing. The main tasks to be implemented in the project are listed below.

Related Work (Alec Winebrenner and Adan Rutiaga)

Although the food industry is very aware of the excessive lack of compliance when it comes to proper hand washing routines, nobody in the industry has implemented anything similar to what we wish to create. However, there are numerous experiments of using gamification to bring about helpful change in other aspects of life (13). These experiments were conducted in hospitals, an industry which also struggles with lack of proper hand washing (14). These experiments were carried out in an intensive care unit of a Portuguese hospital. Using location, data, and monitoring systems, they were able to track if and for how long a nurse or doctor washed their hands. Although they could not fully implement the system in these first tests, limiting the amount of tangible data, the findings were found to be very promising.

The company Vitalacy(15) has a product that works similar to ours. They have created the Vitalacy wristband, a wristband used to keep track of hand washing practices. This is a wristband that is worn by employees at all times. Once an employee approaches a hand washing station, a sensor connects with the wristband to keep track of hand washing statistics like duration and hand movement. Although this is very similar to what we are doing, it differs in that the wristband does not provide any incentive for hand washing. We are trying to include a gaming aspect to hand washing to encourage proper procedures whereas this wristband only tracks it. For the wristband, encouragement for thorough hand washing will come from those that monitor the data. We are trying to increase proper hand washing procedures by providing internal rewards for an individual. This can make handwashing a fun habit instead of an activity forced upon an individual. Furthermore, our approach does not require the user to walk around with a gadget at all times.

Design Requirements (Cole Woods)

1. The game that was created last year must now be taken a step further:
    - Adding more levels to the game.
    - Adding 30 second trivia.
    - Adding 30 second videos.
        - With all these different things, we want to make sure that every Nth time, it will be something different, kind of like a slot machine.
2. Get the hardware side to connect and work:
    - Hooking up the Soap Sensor and allowing it to start the game.

- Getting the foot pedal to interact with the game when the pedal is pushed on.

3. The Android tablet that we will be using must have a security mechanism to shut off if the tablet is ever unplugged. It should also be protected inside of the security tablet holder.
4. For all the different things that we may implement, the tablet and code must be able to record the frequency and duration of the person washing their hands.
5. For each of the things we may create, they all must last for just 30 seconds and then shut off.

Design Tasks (Andrew Beers)

1. Buy an inexpensive Android tablet, foot pedal, and some sort of sensor for inside a soap dispenser (this will probably be what we use our budget for)
2. Integrate previous year's project into an Android app. It appears to be a game built in the Unity engine, which is compatible with Android. The code doesn't seem overly complex so this shouldn't take more than two weeks.
3. The game is a platformer that only requires the player to jump, so we will buy a wired foot pedal online that will be used to control the game character. Android is compatible with keyboards and mice, so it is safe to assume that the foot pedal will just be recognized as a left mouse button that can be connected to a method to jump in the unity game.
4. Use a sensor inside the soap dispenser to determine when someone dispenses soap, and to start the game. Hopefully forcing the employee to dispense soap before starting will keep them from just playing the game without washing their hands. This may take a little longer because the sensor will need to have its data interpreted as more than just a mouse click.
5. Integrate analytics into the game to determine how long people play the game. This can be done with Google Firebase analytics so that it can all be accessible remotely
6. Build a mount of some sort to hold and charge the tablet over the sink.
7. Preventing theft will be more difficult, but our current plan is that if the tablet is disconnected from the foot pedal it will lock with a passcode until the foot pedal is plugged back in. The people using this will also be under camera surveillance in the kitchen, so if anything does happen, the managers can discipline the employee.
8. Testing the project could be done in a bathroom on campus, probably in the biology building where the research is being done that way our sponsor can quickly identify any bugs in the design. If the bugs are software based, we can quickly push out updates that will be installed wirelessly and automatically.
9. The documentation will be split up into a couple parts:
    - Setting up the tablet and enabling automatic updates for the hand washing app.
    - Mounting the tablet, foot pedal, and hand soap dispenser.
    - Viewing analytics in Google Firebase.

Design Schedule (Natalia Baker)

This is a tentative table that reflects the tasks that will be required and implemented by Capstone-Group5 members. Some aspects of the table may change as the project progresses during the Spring 2018 semester.

Schedule

Task completed **Task in progress**

Task	*January*	*February*	*March*	*April*	*May*
Understand the Background Information					
Outline Ideas					
Project Implementation					
Testing and Debugging					
Run Progress					
Finalize Project					
Documentation					

Project Demonstration					

Design Deliverables (Cole Woods)

All C# code is from the last year's team and will be expanded on, and more levels will be added into the game as was discussed during the meeting with our sponsor. There will also be some type of a video system that last for thirty seconds while the employees wash their hands. We want to further improve the app and make it how our sponsor, Jeffrey, has envisioned it to look and run.

1. **All scripts:**

    - **Player.cs**: Player controls the speed and force of our sprite (game character); also detects collisions between itself and other obstacles.
    - **CameraFollow.cs**: This script is used to have the camera follow the character as the character is moving during the game.
    - **LoadSceneOnClick.cs**: Loads the scene on startup of game. It plays and pauses music on setting menu.
    - **mainLoop.cs**: This script has the sole purpose of acting as a timer for our game. It gives the user 30 seconds to play the game, since that is the minimum amount of time someone should spend washing their hands.
    - **MenuCtrl.cs**: This script serves as our menu controller where the user will be able to select between a limited version of the time (time gated), or a continuous run (non-time gated).
    - **Obstacle.cs**: This script detects collisions when the character hits the obstacle (i.e. the character should be able to land on obstacle and not fall through)..
    - **Rotator.cs**: This script has the sole purpose of rotating the coins while the game is in progress
    - **PressAnywhere.cs**: This script takes you back to the main menu if the right shift key is hit. We will have that input assigned to the right side of the foot pedal, while the left side will be used for jumping.
2. A **Design Document** which will list the main hardware and software components that are used for this project.

    - **Software**
        - **Unity 3D** cross-platform engine which serves as the developing software for the game developed.
        - **Android Studio's** will be used to further develop the app if needed.
    - **Hardware**

- **USB Pedal** will be used sometime this year for the project to control the character.
- **Android tablet** used for testing and debugging the game.
- **Soap Dispenser Sensor** will be used to activate the game whenever the employees stick their hands under the soap.
- **Other:**
    - **GroupMe** will be our main form of communication for this project.
    - **Google Docs** is what we will use to do our papers and reports.
    - **OneDrive** Word is what we will use to better format our paper.
    - **Excel** is what we will use to make all our graphs.

Technical Steps (Andrew Beers)

As it stands, we don't have much to rebuild last year's project. We only have the code for the game, but not image assets, project files, nor instructions on how to run it.

1. set up git repository.
2. Get the previous project running in Unity.
    - Create image assets.
    - Create project files.
    - Link image assets to code.
    - Import Code from previous year.
3. Push the base project to GitHub.
4. Install Android studio on our laptops.
5. Build the sample Android studio project onto the tablet, just to verify everything works correctly.
6. Build the Unity game for Android using the built-in build tools in the Unity Dev Kit
7. Install the game onto the tablet.
8. Check for performance optimization opportunities using Android Studio monitor.
9. Modify code to allow input from foot pedal to be passed through to the game as input.
10. Do some durability testing to make sure the game doesn't crash from memory leaks or other long-running operations.
11. Connect soap dispenser to tablet and figure out how to route input through the app to start our game when the sensor is triggered.
12. Mount the tablet in anti-theft case.
13. Test optimized release build with code obfuscation.
14. Deploy signed build on Google Play Store in private alpha to make it easier for researchers to install the app.

Key Personnel

Natalia Baker – Baker is a senior Computer Engineering major in the Computer Science and Computer Engineering Department at the University of Arkansas. She has completed Computer Organization, Programming Paradigms, System Synthesis, Software Engineering, and Operating Systems.

Adan Rutiaga - Rutiaga is a senior Computer Science major in the Computer Science and Computer Engineering Department at the University of Arkansas. He has completed Digital Design, Programming Paradigms, Operating Systems, and Programming Challenges.

Alec Winebrenner - Winebrenner is a senior Computer Science major in the Computer Science and Computer Engineering Department at the University of Arkansas. He has completed Digital Design, Programming Paradigms, Operating Systems, Software Engineering, and Database Management Systems.

K.C. Cole Woods - Woods is a senior Computer Engineering major in the Computer Science and Computer Engineering Department at the University of Arkansas. He has completed courses such as: Computer Organization, Programming Paradigms, Operating Systems, Software Engineering, Embedded Systems, Computer Networks, and Vector GIS.

Andrew Beers - Beers is a senior Computer Engineering major at the University of Arkansas. He has held multiple positions with teams at Metova, University of Arkansas Networking and virtualization, and Wal-Mart Information Security. He also develops mobile applications in his free time for iPhone and Android. He is also leading the CCDC (collegiate cyber defense competition) team at the U of A and is on the student board for the computer science department at Fayetteville High School.

Jeffrey Clark - Jeffrey is studying to get his PhD in Food Science at the University of Arkansas. He is interested in promoting hand washing as it is a key leader in preventing foodborne diseases. He is also interested in studying how a mobile game may or may not change the attitude of adults towards wanting to wash their hands inside kitchens of restaurants.

Facilities and Equipment (Cole Woods)

1. **Android SDK**: The app which was already programmed in C#, will be using Unity.
    - **Unity:** Is a 3D cross-platform engine which is used to make games and applications.
    - **UofA Kitchen:** This is the main facility which the testing will be held to see if they should continue to work on this idea.
    - **USB foot pedal:** This will allow the potential handwasher to be able to play the game while washing their hands. All the employees will have to do is push the foot pedal whenever they want their character to jump or go under a certain object.
    - **Soap Dispenser Sensor:** This will be attached to the Soap Dispenser so that when the employee puts their hands under the soap dispenser, it will start up the game.
2. **Android tablet:** A tablet will be used for debugging and running our application. This will allow us to quickly detect any problems in the code, along with being used to run the game on, and it will also be used to extend the ideas of the app.

Security Tablet Holder: Is what will protect the tablet from theft and will be fastened on the wall to hold the tablet.

References

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