University of Arkansas – CSCE Department
Capstone II – Final Report
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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. 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.

Key Concepts (Natalia Baker)

There aren't any available technologies related to the problem of improper hand washing practices in the food and health industries that our team is aware of, which is why this project is particularly important. There are, however, other games designed for children that revolve around hand washing and other healthy habits, but these games aren't designed to be played at the same time their hands are being washed. This is where our project comes into play, which is to design a game that can run on most Android devices, and can be played at the same time the hands are being washed, in order to promote the importance of proper hand washing practices for workers in the food and health industries.

To implement this project, many software technologies are being utilized, such as **Android Studio** for app development, with Java being the main language, **Github** for version control and source code management (SCM), and **Trello** for project management and planning. These technologies are essential in helping organize our group's collaborative efforts and make our project possible. The game is similar to Flappy Bird which requires only one input from the user. Having said this, the hardware technology piece used as the only control to the game, is a foot pedal used by the user to make the game character jump.

The key concept behind the project is to encourage workers in the food and health industries to adapt to proper hand washing practices by extending the duration of the hand washing process from just a few seconds to 30 seconds. This 30 seconds duration presents a challenge for most people. However, this challenge can be overcome by playing a game that is fun, engaging, and offers a sense of competitiveness and a desire to improve, leading eventually to proper hand washing practices. Averting the lack of interest and boredom that comes with the 30 seconds hand washing duration is a key concept in this project's design.

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:
    - Created a flying version which has 7 different characters and different difficulty.
    - Created a character that starts on the ground with 1 jump capability to beat the tubes.
    - 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:
    - Getting the foot pedal to interact with the game when the pedal is pushed on.

3. The Windows 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.

High Level / Detailed Architecture (Andrew Beers)

- Logging is done using Keen.io that stores data in JSON in the cloud and can be used to find user interaction patterns.
- Currently, the game logs play time, background image, pipe image, and game end time.

- Various game graphics are randomized at the start of each level. The assets used are logged to determine what users like the most.
- LibGDX Java graphics library is being used so it runs on Android and PC.
- Wifi connection must be used to transmit event logs.

Risks (Andrew Beers, Cole woods, Adan Rutiaga, Natalia Baker)

Risk	Risk Reduction
Foot Pedal Connection/Stuck	Integration must be precise, close proximity helps. Routine light cleaning of pedal.
Android Game Freezing	Regular Monitoring of the Android Device.
Tablet Being Stolen	Making sure it is always in the Wall Mount.
Tablet Can Get Wet	The tablet should only receive a few droplets of water. If it occurs often then protector can be purchased.
Tablet running out of Power	Making sure that it is always plugged in.
Tablet getting struck by Lightning	Making sure it is plugged into a power surge protector to ensure the Android device isn't ruined if the building was ever to be struck by lightning.
Diagnostics Failing	Checking the numbers daily and making sure they're on course with how many times. The amount of time is what is averaged for each day.

Design Tasks (Andrew Beers)

1. Buy an inexpensive Windows tablet, foot pedal, which should be all within the allotted budget.
   The code doesn't seem overly complex, so this shouldn't take more than 2 weeks.
2. 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 game.
3. By using the foot pedal, the game starts immediately, making it easier for users to enjoy a little game while washing their hands and, hopefully, without realizing that they just spent 30 seconds washing their hands, which is the goal of this project.
4. Integrate analytics into the game to determine how long users play the game. This can be done with Keen analytics so that it can all be accessible remotely
5. Build a mounting platform of some sort to hold and charge the tablet over the sink.
6. 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. Users utilizing the game will also be under camera surveillance in the kitchen, so if anything does happen, the managers can discipline the employee.
7. 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.
8. The documentation will be split up into the following 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 Keen.

Design Schedule (Alec Winebrenner)

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.

PROJECT SCHEDULE

	Week 1	Week 2	Week 3	Week 4
JANUARY		Create Github Repository	Develop Menu Screen	Build Randomizing Pipes
		Create Game States	Create Play State	Implement Collision Detection
		Implement Game State Manager	Implement Bird Class	Add Music and Sound Effects
	Week 1	Week 2	Week 3	Week 4
FEBRUARY	Receive Hardware	Game Testing & Bug Fixes	Make game easier to play	Send Demo to Sponser
	Export Game onto Tablet		Randomize background graphics	
	Week 1	Week 2	Week 3	Week 4
MARCH	Keen.io Analytics Implemented	Finalize Preliminary Report	Configure Foot Pedal to Left Mouse Click Input	Find Graphics for Pipes
		Prelimenary Design Presentations	Attach Foot Pedal to Computer	Add Different Character Images (Bubbles, soap bar, poop emoji)
	Week 1	Week 2	Week 3	Week 4
APRIL	Implement Platformer Gameplay Option	Randomize Difficulty (Gravity, Pipe Gaps, etc.)	Final Testing	Poster Session
	Randomize Gameplay Options (Platformer vs. Flappy Bird)	Implement 30 Second Timer Shutoff Point	Finalize Game	Complete Final Report
	Week 1	Week 2	Week 3	Week 4
MAY	Final Project Presentations	Final Project Presentations		

Design Deliverables (Cole Woods)

These are all the updated files for the new game we had to create since the last game did not work. They're all created in Android Studios and are all java files.

1. **All scripts:**

- **Animation.java –** Is what is happening on the screen and controlling the frame rate and the texture of the game.
- **Bird.java** – This is where the bird picture is controlled and where the position of the bird starts and the gravity movement and also has the mp3 attached to it to control the sound of the flap.
- **Tube.java –** This controls the top and bottom tube and how they're positioned throughout the levels that we have created.
- **GameStateManager.java –** It manages the play button and starts the game.
- **MenuState.java -** State where the play button is in a pause state.
- **PlayState.java -** You have now hit the pause button and it is in a play state.
- **State.java –** Super class of all of the State parts.
- **FlappyWash.java –** ties together the GameStateManger and the audio and graphics.
- **DesktopLauncher.java –** sets the width and height of the window.
- **TextureLoader.java –** the different background theme.
- **Theme.java –** File paths for the themes.
- **Configurator.java –** used as a Singleton to randomize and control all variables in the game, as well as switch between game mode and handle analytics.
- **Configuration.java –** each configuration stores various hard-coded graphics combinations to introduce variety into the game.

2. **Design Document**

- **Software**
  - **Unity 3D –** the previous project was written in Unity 3D, but we did not receive enough source code to reconstruct the game, so we will be starting from scratch.
  - **LibGDX –** an open source Java game library.
  - **Android Studio's –** JetBrains IDE used to write the Java game and install it on Android.
- **Hardware**
  - **USB Pedal –** is the only control to the game utilized by the users.
  - **Windows tablet –** Will be used to mount and play the game due to compatibility issues with the Android tablet and foot pedal.

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. However, as mentioned before, the previous project was insufficient to work with.
    - 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. Use LibGDX to build the game on Android, using Java.
7. Install the game onto the tablet.
8. Check for performance optimization opportunities using Android Studio monitor.
9. Do some durability testing to make sure the game doesn't crash from memory leaks or other long-running operations..
10. Mount the tablet in anti-theft case.

Facilities and Equipment (Cole Woods)

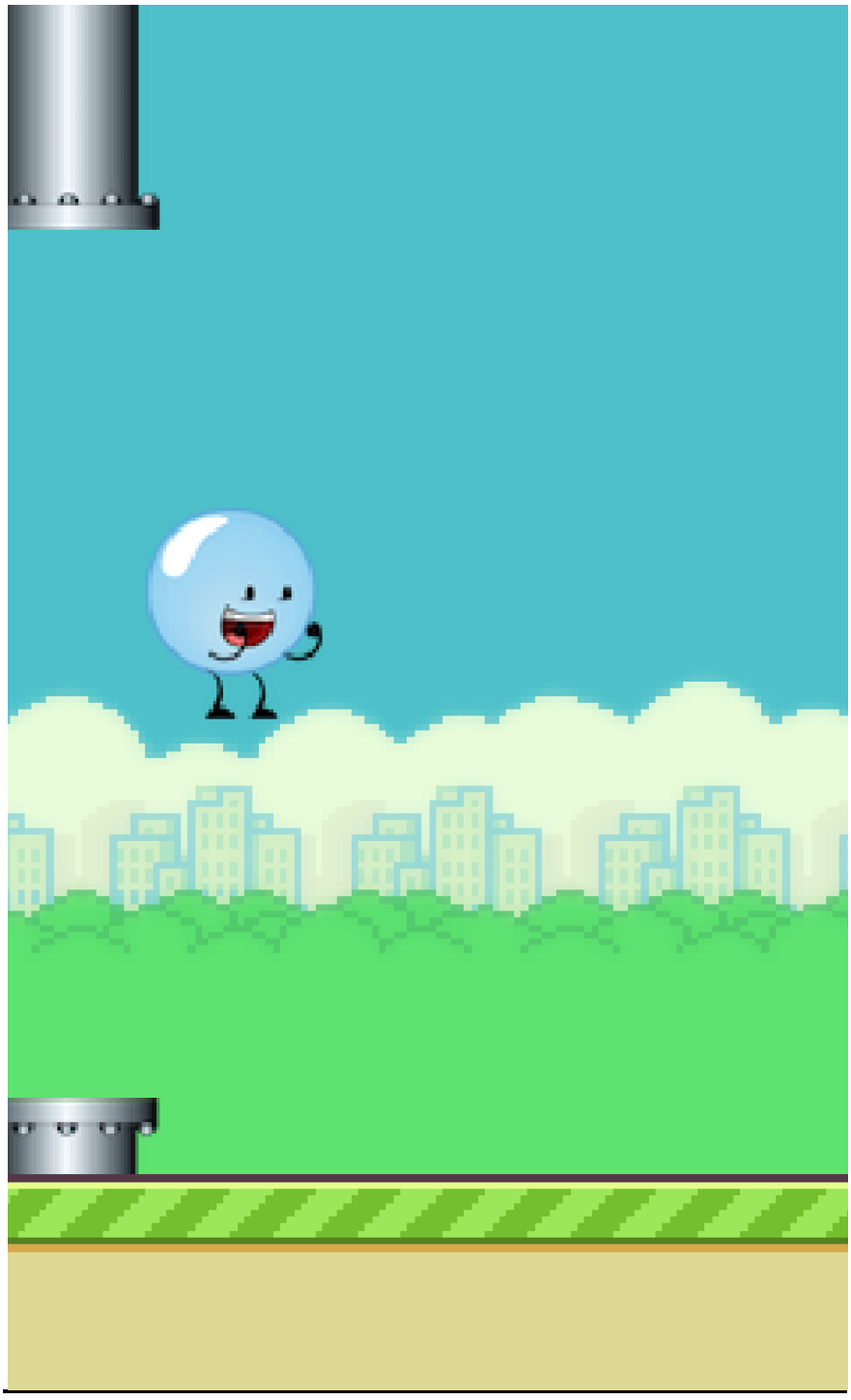
1. **Android SDK**
    - **Android Studio:** for app development, with Java being the main language
    - **U of A Kitchen:** This is the main facility which the testing will be held to see if they should continue to work on this idea.
    - **USB foot pedal:** This will allow the potential user to be 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.
2. **Windows 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: The holder will be mounted on the wall to protect the tablet from theft.

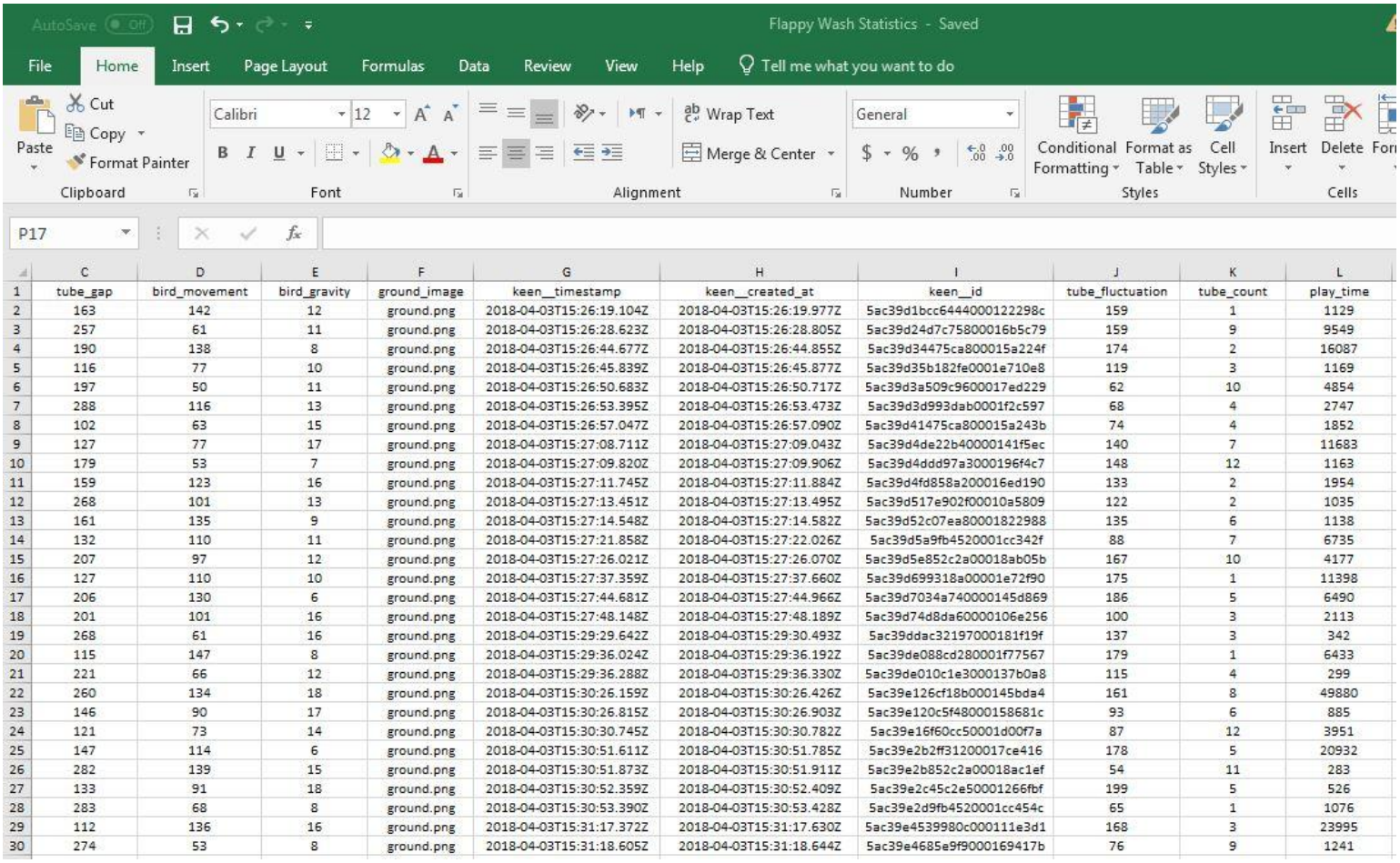
Results

Below are a few images that briefly showcase our project. Many people expressed interest when the project was presented at the Poster Session event, sponsored by U of A's College of Engineering on April 25th 2018.

One of the game characters, which starts form ground and has 1 jump capability



Exported analytics into Excel sheet



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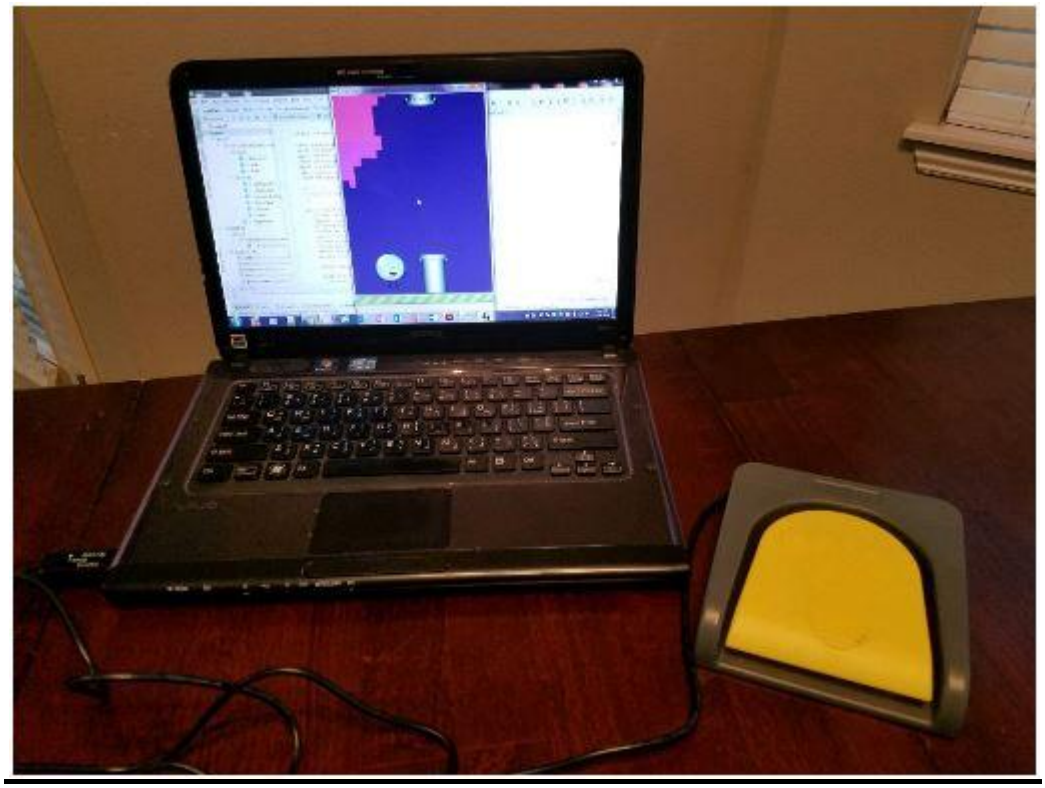
Keen.IO dashboard

Foot pedal wired to a Windows platform



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.

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