# AirCycle Proof-Of-Concept: Work towards Using Gamification and IoT to Fight the Global Obesity Crisis

Laurie Butgereit
[1]Nelson Mandela Metropolitan University
Blue Label Telecoms
South Africa
laurie.butgereit@nmmu.ac.za

Laura Martinus
Meraka Institute, CSIR
South Africa
martinus.laura@gmail.com

***Abstract*—The world is becoming overweight and obese. A multitude of health organisations provide dire statistics about the prevalance of obesity in modern society. It is a problem which spans both the first world and the third world. To counter this problem, there is a growing number of apps for smart devices and wearable devices which encourage people to exercise. These apps and wearables, however, are often not focused on the poor, the aged, and the infirm who can not afford such devices. This paper looks at the possibility of installing exercise equipment in public places which provide real-world value for exercising. The participant would not need to purchase any devices.**

***Keywords—Obesity, IoT, gamification***

## I. Introduction

According to a World Health Organisation (WHO) fact sheet, 1.9 billion adults over the age of 18 years were overweight in 2014. Of those 1.9 billion adults, 600 million can be considered to be obese. This amounts to 39% of the world adult population being overweight and 13% being obese. In 2014, 42 million children under the age of 5 were considered to be obese. According to WHO, the majority of the world's population live in countries where more people now die of problems related to obesity and being overweight than die of problems related to being underweight. WHO also considers obesity to be preventable [1].

Researchers are now documenting the effect of this obesity epidemic has on both the individuals and greater society. According to the the Harvard TH Chan School of Public Health, obesity has certain similarities to tobacco usage in that both cause a wide range of health conditions including heart disease, stroke, diabetes, high blood pressure, unhealthy cholesterol, asthma, sleep apnea, gall stones, kidney stones, infertility and as many as 11 types of cancers including leukemia, breast cancer and colon cancer [2].

Although one may first assume that obesity is a problem of the wealthy developed world, the changes in diet and lifestyles in the developing world spreads the epidemic. According to research published by the US National Library of Medicine, some developing counries have obesity rates as high as 50% in certain sub-populations such as men in Tonga, women in Kuwait, Kiribati, Libya, Qatar, and Somoa [3].

Studies in sub-Saharan Africa shows that the region is not immune despite still battling malnutrition. This is especially true of growing urban populations [4]. The 2014 WHO report on Non-communicable Diseases by country indicates that South Africa's obesity rate (taken from 2008 data) is 21.0% for men and 41.0% for women with a total of 31.3%. Only one African country had obesity rates higher than South Africa. Egypt's obesity rate for men is 21.4%, for women is 44.5% and overall 33.1%.

Medical researchers have found that obesity and sedentary lifestyles co-exist [5]. Modern, urban lifestyles have conspired to interfere with the population getting enough daily exercise. Public transportation, office jobs, living areas where it is not safe to take a walk, elevators/lifts, and delivery services all conspire to stop people from getting enough exercise, whether obesity causes the sedentary lifestyle or whether the sedentary lifestyle causes the obesity is beyond the scope of this paper.

This paper, however, looks at how Gamification combined with the Internet of Things can encourage people to get more exercise. This paper does not attempt to solve the world obesity crisis. This paper does, however, describe a proof-of-concept project which merges both Gamification and Internet of Things into a tangible artifact which could be used to combat obesity by providing real world rewards for exercise.

## II. Previous Work with Gamification and the Internet of Things

Gamification is the use of game mechanics in a non-gaming environment in order to engage people and solve problems [6, 7]. Game mechanics such as points, leaderboards, badges, and leveling can be found in business applications, health applications, and education applications. People have been playing games for thousands of years [8-11]. Gamification is taking the mechanics which make a game a compelling and often addictive activity and then inserting these mechanics into other situations or environments.

The Internet of Things is the growing phenomenon of more and more physical objects being connected to the

978-1-5090-2576-3/16/$31.00 ©2016 IEEE

Internet [12, 13]. The participants in the Internet of Things range from trivial devices which tweet when a house plant needs water to self driving cars which download maps and routes from the Internet.

Over the past few years, there has been a growing number of examples of merging gamification and the Internet of Things in an effort to fight overweight and obesity and/or encourage people to live healthier lives.

The simplest of these mergers are smart phone applications which allow people to measure how far they walk or run using the GPS facilities of the smart device. Applications such as JogTracker [14] allow participants to measure the physical distances covered. These distances can then be uploaded to social media such as Facebook and Twitter. In addition, however, Jogtracker supports its own gamification website where participants can track each others progress, earn points and badges for meeting goals, and communicate with friends with similar fitness goals.

The next level in complexity could be wearable devices such as the Fitbit [15]. Fitbits (and wearables in general) can monitor physical activity and transmit these measurements to servers via the Internet. In addition, these devices can measure activity which is not based on distance traveled such as climbing stairs, traditional exercise, and using a treadmill.

Some facilties use both apps on smart devices combined with wearables. In 2015, a new cryptocurrency entitled *Bitwalking Dollars* was launched [16, 17]. Although strictly speaking Bitwalking is not a reward system, the end result is the same. Bitwalking allows participants to *mine* Bitwalking Dollars by walking in the same way that Bitcoins allow participants to *mine* Bitcoins by executing certain algorithms on their computers. One Bitwalking Dollar is approximately equivalent to 10,000 steps. These steps are measured and verified by a combination of cell phone app and a wearable device. Currently, the maximum number of steps a person can claim in one day is approximately 30,000 giving an equivalent of 3 BW$. It is possible that Bitwalking Dollars may become more popular in the developing world than in the developed world. According to [17], in Malawi there are two Bitwalking centers where Bitwalking Dollars can be exchanged for both US Dollars and Malawian Kwacha.

There has been much research on the use of wearables in xfighting obesity and overweight and associated diseases. A new research project was started in October, 2015, where children in the 11-18 age group with a BMI (Body Mass Index) greater than 85% would be provided with Fitbits and smart phone applications. The study hopes to answer the research question "will the intervention show the ability of technology to create positive health impacts on children and their families?"

Having said that, however, a recent op-ed article by JC Herz at Wired magazine entitled "Wearables are Totally Failing the People who Need Them Most" argued that "...young, healthy, highly educated, mostly male entrepreneurs are developing marginally useful apps and gadgets for people just like themselves" [18]. Herz argues "...the people who could most benefit from this technology – the old, the chronically ill, the poor – are being ignored. Indeed, companies seem more interested in helping the affluent and tech-savvy sculpt their abs and run 5Ks than navigating the labyrinthine world of [bureaucracies]." Herz continues "After all, regulation is yucky. Clinical trials are a drag. Integration with legacy systems is boring."

A recent study research proposal [19] attempts to look at exactly this problem. Their objects is to evaluate the effectiveness of weight loss programs based on standard diet recommendations plus a free smartphone application with a wearable device compared to just diet recommendations alone.

It is important to note, that both the smart phone applications and the wearable applications requires certain self-motivation in order to start on an exercise regime. Recently, another type of gamification-Internet of Things merger has been seen which provides external motivation.

In 2013, the Moscow subway system implemented a program entitled "Squat a 30, Ride for Free" [20]. Participants could do 30 squat exercises and then be entitled to ride the Moscow subway for free. The participants did not need to purchase any devices or download any software onto their smart phones. The devices and connectivity were all provided at the subway entrance ironically near the vending machines selling sweets. Following suit, in 2015, the Mexico City subway system and metropolitan buses started to offer a similar program but requiring only 10 squats for a free ride on the subway or bus system [21].

This research described in this paper builds on this idea of impulse-exercise (as opposed to impulse-buying) by providing exercise equipment to the public which provides some type of gamified reward by accessing a legacy system.

## III. RESEARCH METHODOLOGY

There are two research questions for this project. The first research question is with respect to the hardware devices involved.

> How can common exercise devices be augmented to monitor exercise and communicate via the Internet?

The second research question is

> How can rewards be given via legacy systems to encourage people to exercise?

Design Science Research was used to guide this project.

Design Science Research attempts to create artifacts or things which serve human purposes [22]. Design Science Research supports three cycles: a Relevance Cycle, a Design Cycle, and a Rigor Cycle [23] as can be seen in Figure 1 [23]. The Rigor Cycle ensures that the artifact is based on good scientific theories and methods. The Relevance Cycle ensures that the artifact is useful in the environment for which it is created. The Design Cycle is a cycle of design-build-evaluate repeated until the artifact is complete.

Of primary interest in this research project is the Design Cycle. Two separate evaluations were done on the evolving artifact over the course of the project.

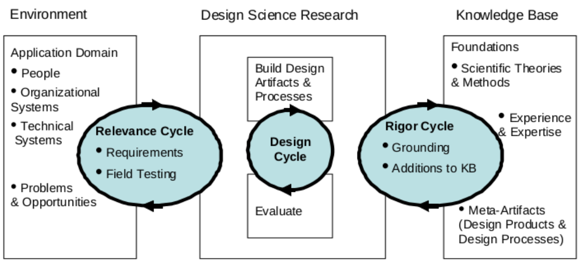

Fig. 1: Cycles of Design Science Research

The first evaluation was done by colleagues of the first author. These participants were employees of company providing the legacy system (AEON) which would provide the real-world rewards. AEON is a proprietary commercial platform which allows merchants to sell a wide variety of non-tangible products such as cell phone airtime, electricity, event tickets, etc. This evaluation was done on the AEON test platform and no actual airtime was dispensed although test vouchers were printed through the AEON test platform. The second evaluation was done by students at the University of Pretoria. Again, for the second evaluation, no actual airtime was dispensed however complete connectivity to the cell service provider was tested and sample vouchers were printed.

## IV. ARCHITECTURE

The AirCycle project uses the Moscow and Mexico City subway system as inspiration. From a participant's point of view, AirCycle interacts as follows:

I. At the beginning of a session, the AirCycle would ask the participant for their cell phone carrier (MTN, Vodacom, Cell C, and Telkom Mobile were supported).

II. The participant would need to exercise on the stationary bicycle for a certain required distance or period of time.

III. When the participant was finished, a voucher worth a varying amount of cell phone airtime would be printed on a small bluetooth printer.

In order to implement this, AirCycle consists of three major subsystems. Each of these subsystems will be explained in detail in following sections but a brief overview follows:

1. A Wi-fi G demo board from Microchip, consisting of a PIC32MX695F512H 32-bit microcontroller and a MRF24WG0MA IEEE 802.11 Wi-Fi Transceiver Module. The board creates its own wifi-hotspot and hosts a small webserver. A sensor on the microcontroller detects whether a revolution has been made and updates a webpage

2. An Android application running on a smart device. This Android application polls the website created on the Wi-fi G board. When the user has bicycled for the required distance or time, then a request is made to the AEON platform in order to award an airtime voucher. The tablet would be accompanied by a small low cost blue tooth printer which would print the voucher

3. The AEON platform is a proprietary commercial platform which is owned and operated by Blue Label Telecoms. The AEON platform itself is not part of this research. It was the legacy system which provided rewards. Commercial entities can contact Blue Label Telecoms and become a registered vendor. A registered vendor is then able to sell many non-tangible objects such as airtime, data bundles, wifi connectivity, event tickets, etc, through the AEON platform.

Each of these three subsystems will be described in detail and can be seen in Figure 2.

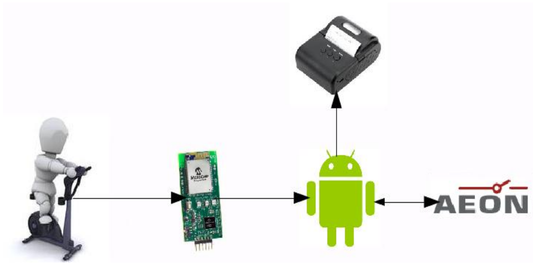

Fig. 2: Overview of architecture

## V. DEVICE SENSORS

A Wi-Fi® (Registered trademark of Microchip Technologies) G Demo Board by Microchip Technologies was used for quick prototyping. The Wi-Fi® G Demo Board is a compact demonstration platform including Microchip's new MRF24WG0MA Wi-Fi module. The demo board hosts a fully-functional standalone web server. It is powered by 2 AAA batteries and creates a surrounding wifi hotspot. It comes with a PIC32 pre-programmed with the Microchip TCP/IP stack, connected to an onboard, fully-certified MRF24WG0MA Wi-Fi module [24]. The fact that it is powered by 2 AAA batteries made the board easy to mount on exercise machinery for the prototype.


Fig. 3: Wi-Fi board and sensors mounted

A photodiode was connected to an Analog-to-Digital (ADC) port on the PIC32 microcontroller and was used to detect the light from an LED mounted on the pedal of the bicycle. At every revolution of the pedal, the sensor detects the change in light intensity and increases a counter on the microcontroller. This can be seen in Figure 3.

The photodiode connection can be easily modified for other types of exercise devices. Very minor modifications needed to be done to the provided firmware to detect the light changes and publish the changes on the hosted webpage.

## VI. Android Software

Software was developed for an Android device which would periodically poll the Wi-fi G board. The Android software went through a number of different configurations during the research cycles. In some instances, the participant could pedal for a given period or time. In other instances, the participant could pedal for a specific distance. And yet in other instances, the participant could pedal for as long as desired (above a certain minimum) and the Android software measured the distance and/or time utilised by the participant.

When the Android software determined that a voucher must be issued to the user, a conversation of 4 request/response messages were sent to/from the AEON platform. The voucher is then printed in a bluetooth printer.

## VII. AEON Platform

The AEON Platform is proprietray software of Blue Label Telecoms. For the scope of this research, AEON represented the legacy system to which devices needed to connect. This legacy system also provided the gamificiation rewards. At the time of writing, the AEON platform supports airtime and data sales for eight cell providers in South Africa, electricity sales, event ticketing, bill payments, traffic fine payments, and some miscellaneous wi-fi hotspot sales. For the scope of this research, only airtime sales were used as rewards.

This research connected to the test AEON platform which, in turn, connected to test platforms of the various cell phone carriers in South Africa. Although this research was a proof-of-concept, it would only take the change of an IP address to start issuing valid airtime vouchers.

## VIII. Results

The first evaluation was done by colleagues of the first author. These evaluators were well acquainted with the facilities of the AEON platform. They were also, obviously, employed. It is acknowledged that any responses from these employees may not be indicative of the wider population which would include the unemployed population. There were seven opened ended questions on the questionnaire of which three are of primary importance. Those three were

1. Do you think rewards should be measured in time cycled? Or distance cycled?
2. Do you think there should be a fixed amount of time or distance or should a participant be able to cycle as long as he/she wants?
3. What value of airtime/distance or airtime/time should be rewarded?

In response to the first question, it was almost unanimous that rewards should be based on distance traveled and not on time cycled.

In response to the second question, there was a mixed replies. Approximately one third of the respondents said that there should be a fixed distance required. Approximately one third said that participants should be able to cycle as long as they want. And approximately one third said that participants should be able to cycle as long as they want with an upper limit to time.

In response to the third question, the range in rewards varied between one Rand per kilometer travel to five Rand per kilometer traveled. It is again important to note that the respondents to the first evaluation were fully employed in the IT industry and that these responses do not necessarily reflect the responses of unemployed people.

A second evaluation was done at the University of Pretoria.

The two research questions were clearly answered. The first research question was:

> How can common exercise devices be augmented to monitor exercise and communicate via the Internet?

The physical device created for this research project can be easily mounted on exercise devices which have moving pieces. The device itself is small and powered by 2 AAA batteries.

The second research question was:

> How can rewards be given via legacy systems to encourage people to exercise?

This research clearly demonstrated how rewards can be obtained from legacy system. In this specific case, vouchers for airtime were given to the participants.

Although the two research questions were answered, other important questions came to light which were not answered.

## IX. Unanswered Questions

The most difficult part of this project was to determine the best ratio for exercise to reward. This appears to be a common problem. A comparison of the Moscow subway system exercise incentive program and the Mexico City subway system exercise incentive program highlights this problem. In Moscow, participants were required to do 30 squat exercises in order to ride the subway. In Mexico City, only 10 squat exercises were required for a subway ride. There are currently no published research papers explaining this wide gap. It could be the fact that the weather is different between to the two countries, or that the obesity rates are different, or that the length of the subway rides are different.

In discussing this problem with the people evaluating the AirCycle, it was pointed out that if the AirCycle was installed in a commercial gym which catered for middle class, urban, employed people who are reasonably fit, the rewards would need to be very different than if the AirCycle was installed in the hostel or residential building of a high school in a rural area. This prompted one commerce graduate from the University of Pretoria to comment that perhaps the Android application needed to have a flexible formula system where the owner of a specific AirCycle installation could configure such details. In addition, the commerce graduate suggested that the rewards could also be a function of the total amount of funding that the AirCycle installation had acquired.

## X. CONCLUSIONS

The world is facing an obesity problem which affects both the first and third worlds. Modern lifestyles including the use of public transportation, private cars, delivery services, elevators/lifts, and convenience foods conspire against the population making it difficult to stay active and healthy.

This project investigated the use of game mechanics (gamification) combined with physical devices (Internet of Things) to encourage people to be less sedentary. In addition, this project provided real life rewards by interacting with a legacy system to provide airtime rewards for exercise. This project confirms that this is all possible.

The unanswered question, however, is how to calculate the ratio of exercise to reward. Additional research is invited on this topic.

## REFERENCES


[1] World Health Organisation, "Obesity and overweight, fact sheet no 311," WHO, Tech. Rep. 311, January 2015. 2015.

[2] Obesity Consequencesm, Harvard TH Chan School of Public Health, Retrieved November 22, 2015, 2015, from http://www.hsph.harvard.edu/obesity-prevention-source/obesity-consequences/

[3] Global, regional and national prevalence of overweight and obesity in children and adults 1980 - 2013: A systematic analysis. Retrieved November 22, 2015, 2015, from http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4624264/

[4] A. Scott, C. S. Ejikeme, E. N. Clottey and J. G. Thomas. Obesity in sub-saharan Africa: Development of an ecological theoretical framework. Health. Promot. Int. 28(1), pp. 4-16. 2013. . DOI: 10.1093/heapro/das038 [doi].

[5] A. S. Barnes, "Obesity and Sedentary Lifestyles," Texas Heart Institute Journal, vol. 39, pp. 224-227, 2012.

[6] S. Deterding, M. Sicart, L. Nacke, K. O'Hara and D. Dixon. Gamification. Using game-design elements in non-gaming contexts. Presented at CHI'11 Extended Abstracts on Human Factors in Computing Systems. 2011.

[7] S. Deterding, D. Dixon, R. Khaled and L. Nacke. From game design elements to gamefulness: Defining gamification. Presented at Proceedings of the 15th International Academic MindTrek Conference: Envisioning Future Media Environments. 2011.

[8] R. C. Bell. Board and Table Games from Many Civilizations 1979, Courier Dover Publications.

[9] W. Decker. Sports and Games of Ancient Egypt.1992, Yale University Press.

[10] N. Purcell. Literate games: Roman urban society and the game of alea. Past and Present pp. 3-37. 1995.

[11] P. Townshend. African mankala in anthropological perspective. Curr. Anthropol. pp. 794-796. 1979.

[12] R. H. Weber and R. Weber. Internet of Things, 2010, Springer.

[13] H. Kopetz. "Internet of things," in Real-Time Systems, pp 307-323, Springer, 2011.

[14] Jogtracker website. http://www.jogtracker.com

[15] Fitbit Corporate Website. https://www.fitbit.com/

[16] Bitwalking Website Website http://www.bitwalking.com

[17] Bitwalking dollars: Digital currency pays people to walk. Retrieved December 15, 2015, 2015, from http://www.bbc.com/news/technology-34872563

[18] Wearables are Totally Failing the People who Need them most. Retrieved December 21, 2015, 2015, from http://www.wired.com/2014/11/where-fitness-trackers-fail/

[19] E. Granado-Font, G. Flores-Mateo, M. Sorli-Aguilar, X. Montana-Carreras, C. Ferre-Grau, M. L. Barrera-Uriarte, E. Oriol-Colominas, C. Rey-Renones, I. Caules, E. M. Satue-Gracia and OBSBIT Study Group. Effectiveness of a smartphone application and wearable device for weight loss in overweight or obese primary care patients: Protocol for a randomised controlled trial. BMC Public Health 15pp. 531-015-1845-8. 2015. DOI: 10.1186/s12889-015-1845-8 [doi].

[20] V. Bojovic. Squat a 30, ride for free. 2013. Retrieved December 14, 2015, from http://www.brandingmagazine.com/2013/11/14/squat-30-ride-free/

[21] Mexico's latest way to beat the obesity epidemic: make commuters do squats for free subway tickets. Retrieved December 3, 2015, 2015, from http://www.theguardian.com/society/shortcuts/2015/jan/27/mexico-beat-obesity-make-commuters-do-squats-for-free-subway-tickets

[22] S. T. March and G. F. Smith. Design and natural science research on information technology. Decision Support Systems 15(4), pp. 251-266. 1995.

[23] A. R. Hevner. The three cycle view of design science research. Scandinavian Journal of Information Systems 19(2), pp. 87-92. 2007.

[24] Microchip Technology website. Retrieved December 20, 2015, 2015, from http://www.microchip.com/Developmenttools/ProductDetails.aspx?PartNO=DV102412