Abstract  It’s not diabetes; it’s Live-A-Betes.

The current insulin pump systems available to type 1 diabetics are outdated and unpleasant to use as a result of clunky interfaces, short-lasting batteries, and the multiplicity of devices often necessary to maintain proper control of blood glucoses. The devices themselves are cumbersome to carry and wear and aesthetically unbecoming. Using one of the currently available devices is neither elegant nor discreet, and when all of these aspects are combined, it affects the ease and quality of the lives of young people with type 1 diabetes by contributing to poor management of this autoimmune disease. Diabetics are unfamiliar with the capabilities their devices or uncomfortable using them in public environments. Blending information science, design thinking, mechanical engineering, and available technology like Bluetooth and options for better interfaces creates an opportunity to modernize assistive wearable medical technology in order to develop new, and hopefully better, experiences for users.

Audience  Young adults with type 1 diabetes.

Because most type 1 diabetics are diagnosed as children, adolescents, or young adults, Live-A-Betes is intended for young, technologically-minded adults who are interested in improving the maintenance of their diabetes. Because Live-A-Betes functions with preexisting systems that young adults typically already use, such as Smartwatches and Smartphones, we believe that our system will be easier to fit into users’ lives with less hassle and more impact. Live-A-Betes is accompanied by education materials to promote skills for a healthy lifestyle and strong management of diabetes.
Problem  The state of the insulin pump.

The value in improving the insulin pump experience for type 1 diabetics is more than just aesthetic; better management of diabetes decreases long term health complications which not only improve the quality and span of the user’s life but would also reduce costs in the healthcare industry, where about $14.9 billion dollars is spent on diabetic related issues each year. Poor control of blood glucose leads to long term complications that could be mitigated by an improved insulin regimen. This is a chance to not only use empathy to design an improved device and system of care but also an opportunity to explore the possibility of how such devices can also inspire empathy in others and contribute to effectively communicating users’ issues in a way that developers often forget or disregard.

In designing Live-A-Betes, we sought to design wearable medical technology (a redesigned insulin pump, interface, and compatible monitoring application that will work with existing Smartwatch and Smartphone technology as well as on a small, discreet nano square) that fits the needs of young adult type 1 diabetic users while showcasing the value of an empathetic approach to information studies and product design. Our devices address the shortcomings of current devices on the market, such as size, battery life, tubing, interface accessibility, data input and retrieval, and aesthetics, and combine other technologies in order to create a more positive and easy to use system to improve the overall experience with an insulin pump for everyone who interacts with it.

Proposal  Reinventing the insulin regimen.

We are designing a system that modernizes the insulin pump (interface and design) for greater accessibility with a mobile application connected through Bluetooth enabled devices and creates a system of improved diabetes management. We are also focused upon addressing security concerns for when data is shared with healthcare professionals remotely. By improving insulin regimens, we hope to assist in better diabetic control and a more positive experience with the disease, thus making diabetes into live-a-betes for over 3 million people worldwide. This includes an educational component that teaches users’ about their diabetics. We are providing not only a device, application, and system, but the skills necessary to better use and understand these tools.
**Bodystorming** A study in binder clips & string.

In order to grasp exactly what having an insulin pump is like, Andrea built a simple prototype out of binder clips and string for the rest of the team to wear for a week. While Andrea is actually a type 1 diabetic, the rest of the team used these binder clips to represent real insulin pumps in a process called bodystorming, which is a tangible form of brainstorming, in order to experience the problems that diabetics encounter while trying to use insulin pumps and simultaneously maintain normal, comfortable, and healthy lifestyles. The team learned how difficult it was to perform everyday tasks such as bathing, changing outfits, navigating curious pets and children, dealing with tubing getting caught on doorknobs, and more. Herein lies why we are different; we are learning the science of empathy and to better communicate and understand the needs of others. Empathy helps us to understand frustrations that are not empirical without trying the device (or something similar) ourselves, and these lessons in empathy can be channeled into an iterative process of redesign. Using observations as information scientists, real experience as a type 1 diabetic, and empathetic bodystorming, the team learned firsthand what worked, what did not, and where to go from there, and as entrepreneurs, we learned to utilize a dataset of past emotions, reactions, and experiences in order to continuously develop new, and hopefully better, experiences for users.

**Prototyping** Designing, testing, & iterating.

Live-A-Betes began with paper prototyping and sketches. The team imagined what a more flexible system would look like and began to design not only new ideas for the shapes of the pump and its internal components but accessories that would fit into a variety of lifestyles and solve some of the issues determined through bodystorming.

We 3D printed a sample prototype of a device that could be used to control the insulin pump, mapped out a system of circuits to imagine what the inner pump technology would look like, built paper prototypes of different insulin pumps to play around with the spacing and size of the device itself, and developed an application that could be used on multiple Bluetooth devices by our different personas: a child, an elderly person, a young adult, a doctor, and anyone experiencing a hypoglycemic reaction.
Our goal was to create a pump that is easy to use, tubeless, and touchscreen, along with a corresponding mobile application that works with existing technology, in order to develop a product model that has yet to be created. Live-A-Betes will lead to greater flexibility in lifestyle and more precision in diabetic control for users and their support systems. Live-A-Betes has not filed any claims or patents nor have we published any information about our ideas and devices, but we do intend to file for a patent and potentially buy a website domain as well. These are our own ideas and coursework for a graduate school course at the University of Illinois at Urbana-Champaign.

**Process** A story of sketches & renderings.

We determined that the insulin can come in either a square or a circular container, though circular would save on manufacturing costs by utilizing existing vials. There is a motor attached to the base of the vial that pushes the fluid through a dam and tube that dispenses directly into the adipose tissue of the user. The dam and increased capacity to 300ml are inspired by a current pump the T-slim.

We envisioned that a watch could be a main interface that could communicate with both the pump and the computer, while also serving as a medical bracelet. The interface will be easy to use, control timers, settings, reminders, checks, and boluses, and will have aides for users.

Using Bluetooth, we wanted a secure and easy way of transferring data for downloading blood glucoses, meal information, and settings for either the user or a medical professional.

These sketches matured into renderings in InDesign, which helped us develop a more robust vision of Live-A-Betes and its capabilities.
The pump itself consists of a rechargeable Lithium Ion battery, the insulin vial, motor, Bluetooth, and reservoir contained in a hard plastic shell. This plastic shell slips into a soft rubber sheath attached to an elastic strap that can fit around the waist or thigh and tightened. The soft rubber sheath is designed to smooth the shape of the pump against the body under the clothes.

Our needs analysis helped us determine what functions to put into our final design. Several things that users from various formats (online comments, video blogs, and in person observations) mentioned were the following:

**Aesthetics**  more aesthetically pleasing in terms of bulk and visibility

**Multiplicity**  less devices but more flexibility

**Quality**  ease of application use in terms of the menus themselves as well as when the user is experiencing a hypoglycemic reaction

**Communication**  better communication between pump, glucose monitors, and computers when downloading data logs

We envisioned multiple accessories that could fit a diverse range of lifestyles and potentially lead to new lines of wearable diabetic technology, thus making healthy diabetes management more fashionable and approachable in a way that was neither scary nor intrusive. We also thought that costs could be reduced by a simple retrofitting of preexisting devices with an eye toward security and flexibility that has previously not really been seen in the diabetic technology market.
Hardware  The internal mechanics.

Battery  Lithium ion (color: black-grey, finish metallic but not a shiny surface, basically like the batteries in cellular phones)

Circuit  Plastic (Green shade circuit board and Black color for the rectangular components, and the 'slot' like components can be any color (shiny finish). There is a micro SD slot close to the pump on the board.

Pump and reservoir  Created as single part and revolved to make the 3D; Ideally the reservoir (longer cylinder) is made of transparent plastic material, and the pump (is stainless steel for the bottom cylinder and black carbon steel for the top cylinder). The slender rod which connects the reservoir and pump is plastic or acrylic (black or white color).


The Live-A-Betes application features four simple and distinct categories and large menu options that can be accessed under imprecise conditions, such as during a hypoglycemic reaction or in the middle of night.

Glucose  For adding blood glucose entries, checking glucose history, calculating glucose corrections, and setting monitoring alerts

Menu  For rewinding and loading the insulin cartridge, priming the tubing, and filling up the user’s cannula when refilling the pump

Bolus  For dosing for meals, low or high blood glucoses, and setting insulin to carbohydrate ratios, insulin sensitivity factors, and basal rates

Settings  For syncing Bluetooth, setting time and date, changing sound options, and advanced features, such as airplane mode

http://1g3l2k.axshare.com
password  Twidale
There are six major brands of insulin pumps that are compared on a number of sites; they fall into two major groups: with tubing or without tubing. Interface options include touch screens or digital screen with buttons as varying input options. In each of major brands, there are advantages and disadvantages but selection is often based on personal user preference and needs rather than one clear winning product.

There is a wide variety in the amount of time that each competitor has been in the insulin pump market, but it is all within the last 30 years. The Tandem T-Slim is the newest device, and it would be our main competitor because it has an increased insulin capacity to 300ml (from standard 200ml), alerts and timers that can be manually set or automatically initiated after meals, and a clear, large interface that is multi-touch, and tubing. The Roche Accu-Chek Combo, Medtronic 530G with Enlite, and Asanta Snap are competitive pump and glucose monitor systems with tubing. The Insulet Omnipod does not have tubing, but it is bulky and looks like a leech when worn by users. The Animas Ping features an LED screen and corresponding glucose meter, but also has tubing, looks like a pager, and does not contain a reservoir for the insulin, only a main cartridge. In January 2015, Animas is also introducing the Animas Vibe, which features the same device but new interface options, such as full color, and compatibility with a Dexcom glucose sensor which can be used to constantly monitor blood glucoses in real time, reducing the need for a separate glucose monitoring system.

<table>
<thead>
<tr>
<th>Feature</th>
<th>Revel</th>
<th>Omnipod</th>
<th>T-Slim</th>
<th>Medtronic 530G</th>
<th>Asanta Snap</th>
<th>Tandem T-Slim</th>
<th>Roche Accu-Chek Combo</th>
<th>Animas Ping</th>
<th>Animas Vibe</th>
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</tr>
</tbody>
</table>
Future Plans  Envisioning a live-a-betic future.

We would like to continue prototyping our insulin pump device and application, perform plenty of user testing, and build various Bluetooth capable devices to partner with the pump to give users lots of options for controlling their pumps. We are also looking into incorporating blood glucose monitoring technology to see if we could condense the number of devices that diabetics have to keep track of, either by creating a multifunctional device or by utilizing what users’ already have, such as phones and watches. Further, we would like to build a device like Square that can securely plug into a user’s phone and act as a glucose monitor. The user would apply the usual drop of blood to a tester strip, and the device would potentially read the user’s blood glucose, store the data, and then calculate the appropriate course of action in the application, whether that entails giving a bolus or advising the user to perhaps eat carbohydrates or test for ketones.

Acknowledgements  To those who helped.

The team would like to extend our thanks to Dr. Michael Twidale and Christopher Nixon for their assistance and continued efforts in supporting our project.

Appendix  More photos of our process.
Literature Review  Resources we utilized.

GENERAL RESOURCES

About type one diabetes (diabetes mellitus) http://jdrf.org/about-jdrf/fact-sheets/type-1-diabetes-facts/


History of the insulin pump http://www.wpi.edu/about/history/pump.html


T-slim insulin device http://www.tandemdiabetes.com/default.aspx

Specs on pumps http://integrateddiabetes.com/insulin-pump-comparisons/#tandem

NEWS AND BLOGS


Diabetes hacking (everything that goes into managing diabetes) http://www.hanselman.com/blog/HackingDiabetes.aspx

The problem with the "bionic pancreas" http://www.hanselman.com/blog/CategoryView.aspx?category=Diabetes

Development in insulin pumps capabilities http://www.onetouch.com/professional/products/onetouch-zoom-pro-software

Reddit polling of what diabetics might want in an insulin pump: http://www.reddit.com/r/diabetes/comments/z0ugz/the_sad_state_of_diabetes_technology_in_2012/

Diabetes blog: http://asweetlife.org/author/karmel/

HUMAN FACTORS AND USABILITY ISSUES WHILE DESIGNING MEDICAL DEVICES


Regulations Part I http://www.fda.gov/medicaldevices/deviceregulationandguidance/guidancedocuments/ucm259748.htm

Regulations Part II http://www.fda.gov/medicaldevices/deviceregulationandguidance/guidancedocuments/ucm094957.htm

Design rules for “disabilities” https://medium.com/backchannel/all-technology-is-assistive-ac9f183c8cd
doi: 10.1109/PERCOM.2011.5767594
http://ieeexplore.ieee.org.proxy2.library.illinois.edu/stamp/stamp.jsp?tp=&arnumber=5767594&isnumber=5767569

doi:10.1145/2557977.2558020
http://doi.acm.org.proxy2.library.illinois.edu/10.1145/2557977.2558020

DOI=10.1145/1028480.1028483
http://doi.acm.org.proxy2.library.illinois.edu/10.1145/1028480.1028483

http://dx.doi.org/10.1016/j.ijmedinf.2011.05.001

Maria Lluch, Healthcare professionals’ organisational barriers to health information technologies—A literature review, International Journal of Medical Informatics, Volume 80, Issue 12, December 2011, Pages 849-862, ISSN 1386-5056,
http://dx.doi.org/10.1016/j.ijmedinf.2011.09.005

http://search.ebscohost.com.proxy2.library.illinois.edu/login.aspx?direct=true&db=a9h&AN=85134122&site=ehost-live

http://doi.acm.org.proxy2.library.illinois.edu/10.1145/1031607.1031639


Team Live-A-Betes
Andrea, Liz, Chandra, and Jerrod