Diabetes Tracking

Challenge Problems and Resources

Developed by:
The teachers, students, and mentors in the
Gaming Research Integration for Learning Laboratory® (GRILL®) Summer 2015

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1. THE CHALLENGE

To effectively manage health conditions such as diabetes, monitoring information like blood glucose is critical. Having the capability to see visual representation of trends can be more meaningful than individual data points—allowing one to make adjustments to improve their lifestyle. The Challenge is to develop prototypes that will successfully collect and present visual representations of data. The prototypes should be able to record blood glucose, food, medications, mood, and activity, as well as provide visual displays for these parameters. This Challenge can be adapted to monitor any health condition or lifestyle factor.

1.1. KEY QUESTIONS

- *What is diabetes?*
- *What challenges do people with diabetes face?*
- *What data is important to track and/or correlate to facilitate effective diabetes management?*
- *How do people with diabetes currently track and visualize data? Are these methods effective? How might these methods be improved?*
- *What are the demographics of this population—how does that influence the design or mode of delivery?*
- *How can the display of data, or types of graphics, influence interpretation of the data and even lifestyle modifications?*
- *How can predictive modeling be applied?*

1.2. BACKGROUND AND APPLICATION

Diabetes is a condition in which the body cannot regulate blood glucose levels: either by not producing insulin or not responding to insulin. Consequently, blood glucose must be closely monitored to prevent severe spikes (hyperglycemia) or drops (hypoglycemia) in blood glucose. Regular monitoring affords better management, but only temporarily. Visualizing trends of data over time, correlated with other lifestyle factors such as diet or activity, is difficult but can reveal underlying patterns, increase engagement, and provide meaningful information for health care providers or coaches. Ultimately, these trends can be used to make lifestyle adjustments towards easier management and overall better health.

1.3. POTENTIAL TOOLS

Data collection and analysis software such as Excel, MatLab (FreeMat), R, etc.; computer coding and app design tools could be used to complete this Challenge.

2. ASPECTS OF A SOLUTION

A solution was created during the summer of 2015 by participants in the Wright Scholar program in collaboration with the Gaming Research Integration Learning Laboratory® (GRILL®). The solution that follows was arrived at by the program participants during their nine week experience, so this is not the only way, nor is it intended to be the best way to solve the problem. The solution is given to provide guidance for future use. This section details the technology used in the solution and some of the issues encountered on the way to a solution, accompanied by documentation on how each issue was resolved.

Over the summer a research team at the GRILL® partnered with the insurance company Humana®. Humana® challenged the team to create visuals which would be used in Humana®'s health program *Sweet Spot*, which educates those with Type 2 diabetes, aged 65 to 80 years old, about their health. The visuals were to include representations for blood glucose levels, food and medication intake, mood, and exercise levels.

2.1. TECHNOLOGY RESOURCES

Your students will likely choose different hardware and software to complete this Challenge Problem. Better hardware at a cheaper price, a newer version of the software, or free open-source technology may be available when your students tackle this problem. Detailed below are the tools used in the construction of this solution at the GRILL® during the summer of 2015. Do not limit your students to the specific technology mentioned in this document. Encourage students to search for a resource that allows them to continue making progress toward their solution.

2.1.1. HARDWARE

- N/A

2.1.2. SOFTWARE

- N/A

2.2. POTENTIAL ISSUES

While working on the solution for this Challenge Problem at the GRILL® summer 2015 program, participating students encountered a number of different issues along the way. Included in this document are those issues that teachers or students who tackle this problem in the future would also likely encounter. If your students approached the Challenge Problem using different tools, they may not experience these exact issues. Issues are ordered based on when they arose in the process. Participating students did not document every single issue they

encountered; this document includes issues that could be potential hurdles others might need to be able to resolve.

2.2.1. HOW CAN DIABETES TRACKING BE IMPROVED?

People with diabetes already have access to numerous diabetes apps on the market. Each app has a different style and different features, but the intention remains the same: to give people with diabetes a way to log and visualize their data. Every app has its pros and cons, but ultimately, most are missing key features. Many are complex and some are not informative enough (Figure 1). The purpose of this Challenge Problem was to develop a better way to track and visualize information. Therefore, the first issue was to research which aspects of each app were most helpful in presenting the data given.

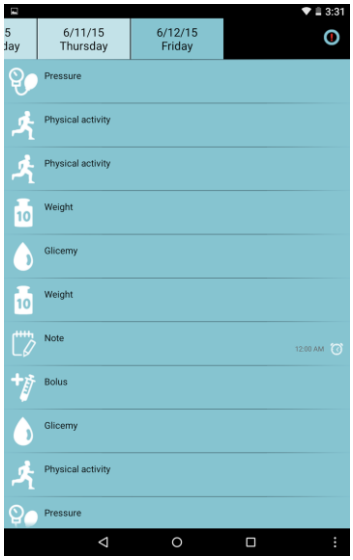


Figure 1: This app design can be overwhelming as the log data accumulates.

2.2.1.1. RESEARCH CONDUCTED

The two key questions were: *what features do current apps lack and how can the way people with diabetes visualize data be improved?*

The first goal of the research team was to review a multitude of apps, including those from both the Apple and Android stores, in order to properly understand key features. The team reviewed each app thoroughly and created a chart based on what features they did and did not have (Figure 2).

	Free	Records Weight	Reminders	Records Glucose	A1c Percents	Records Insulin	Records Food,Carbs	Shares/Syncs Data
AgaMatrix	✓	✓	✗	✓	✗	✓	✗	✓
dbees.com	✓	✓	✓	✓	✗	✓	✓	✓
DiabetesConnect	✓	✓	✗	✓	✓	✓	✓	✓
Glucose Buddy	✓	✓	✓	✓	✓	✓	✓	✓
mySugr	✗	✓	✓	✓	✓	✓	✓	✓
OnTrack	✓	✓	✗	✓	✓	✓	✓	✓

Figure 2: Multichotomous chart created based on app features

To determine the needs of the target audience, a meeting with a person with Type 1 diabetes was conducted early on. In the interview, the research team received very useful information on the daily problems of those with diabetes and what they would want in an ideal app. She said a person with diabetes would rather have a weekly update in terms of blood glucose levels rather than daily updates which can seem boring and time consuming. She also noted that she uses her mood, such as high level of irritation, as a signal that her blood glucose may be too high. Designs from previous apps proved too complicated and maintained the idea that readings should be done consistently and that logs should be reviewed daily. The team then shifted efforts by focusing on more weekly updates and tracking another aspect: mood, as it can be indicative of low or high blood glucose levels.

To determine how to improve visualization of the data, the team focused on the end product, and compared charts and graphs—listing the advantages and disadvantages of each. Progress came from comparing what would be most useful, yet also simple. After researching certain graphs, three types stood out based on simplicity and effectiveness: line graphs, box and whisker charts, and bar graphs. For example, line graphs are useful because they connect data points. The people with diabetes in the Humana® *Sweet Spot* program record six blood sugar readings per day, so using a line graph to show trends that correlate high and low glucose levels with time is beneficial.

In addition to simple graphs, analogous designs were also constructed, such as a dartboard pie graph, a speedometer chart (Figure 3), a thermometer chart, and a specialized line graph (Figure 4). These were created to make the designs easier to interpret and more user-friendly, especially for the older audience.

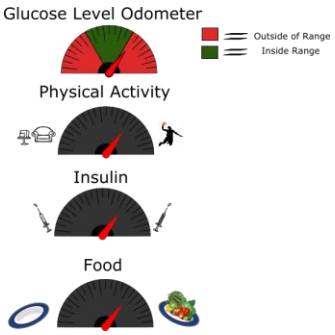


Figure 3: Speedometer chart for four different data types

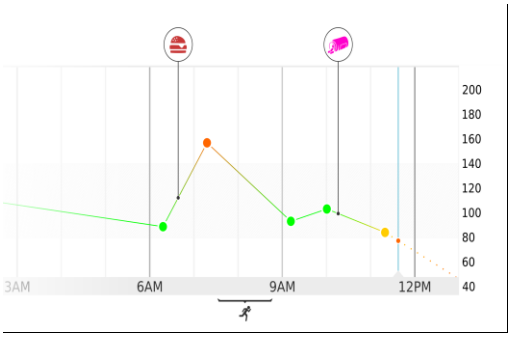


Figure 4: Line graph displaying influences for glucose fluctuations

2.2.1.2. RESOURCES

Resources included apps, websites, videos, and articles on data visualization:

- Living with Type 1 Diabetes (*Living with Type 1 Diabetes: Krisha / Type 1 Diabetes / Spoonful*): https://www.youtube.com/watch?v=b7rJaopJjuM
- Living with Type 2 Diabetes (*Living with Type 2 Diabetes A Teens Journey.mp4*): https://www.youtube.com/watch?v=eKnZ6X37K4M
- Interactive graph with diabetes incorporation (*Level For Diabetes Web Site Line Graph With Events and Numerics*)*:* https://www.youtube.com/watch?v=hKbxGJhAFjQ
- Ted Talk showing interactive graphs with different customizable settings (*The best stats you've ever seen*): http://www.ted.com/talks/hans_rosling_shows_the_best_stats_you_ve_ever_seen?language=en#t-334797
- Ted Talk showing interactive graphs with different customizable (*The beauty of data visualization*): http://www.ted.com/talks/david_mccandless_the_beauty_of_data_visualization?language=en

- CNN reviewing diabetes apps (*Apps you can download to manage your diabetes*): https://www.youtube.com/watch?v=MXUprfEzZkg

2.2.1.3. IMPORTANT CODE

N/A

2.2.1.4. RESOLUTION

The issue was how to display data in a way that was both effective and appealing. Resolutions were achieved in meetings where group members discussed issues and chose which were the most effective. After conducting research on the best applicable graph designs, one person would input a good idea and the rest would throw the idea around until someone came up with something that everyone agreed upon. Afterwards, we produced the design in Inkscape and tweaked it until everyone agreed that it was finished.

After researching and choosing the best features of the apps that were reviewed, and further discussing with the diabetes expert, a solution evolved. So far three different areas of importance have been catalogued: chart driven, analogy driven, and expert input driven.

2.2.1.5. STUDENT REFLECTION

Resolving this issue included many conflicting opinions. Everyone's ideas over the best displays clashed until the final product was created. We resolved our differences by keeping the objectives in mind, and choosing designs which met the objectives the best. For example, a journal layout can be overwhelming, so designs featuring that layout were not often used. Throughout the challenge, we collaborated with Humana® extensively, by meeting with them on a weekly basis for advice on how to proceed with our project. Our collaborations with them were quite helpful because of their professional opinions. The chance to work professionally on research proved very helpful to my learning experience. I learned various research and presentation skills that I will most definitely use in the future.

2.2.2. CREATING VISUALS BASED ON SCIENCE, NOT PERSONAL PREFERENCE

The Challenge was to "develop innovative ways to visualize blood sugar readings, food, activity, and medication data for Humana®'s *Sweet Spot* participants." This process began with the creation of app designs, graphs, and visuals, but soon an issue was encountered. All of the creations were based on personal preferences, not scientific data. The designs required support by science to be as effective as possible. In order to solve this problem of creating unbiased, effective designs, research was required on the science of feedback.

2.2.2.1. RESEARCH CONDUCTED

To begin learning about feedback, a subject-matter mentor was contacted to provide useful information to the problem-solving team. A PhD candidate in Industrial Operations Psychology from the University of Akron created a presentation titled "Feedback & Display Design" on the basics of feedback. During close examination of the presentation slide by slide, unfamiliar material was further researched on the internet. While Googling unfamiliar terms, many of the resources Google returned did not contain feedback definitions. Time was necessary to sift through the search results and find the few sites that provided useful information and then exhausting those resources. The few sources that were found to be valuable had multiple feedback terms. Helpful excerpts came from the book *Interactive Instruction and Feedback* by John V. Dempsey, detailing **immediate** and **delayed** feedback, **KR** and **KCR** feedback, and **affective** feedback. Also, excerpts from the article "Focus on Formative Feedback" by Valerie J. Shute, pertaining to **directive, facilitative, specific,** and **elaborative** feedback were helpful. Other worthwhile excerpts came from the book *Social Cognitive Psychology: History and Current Domains* by David F. Barone, which covered **negative** feedback, while the article "What is Positive Feedback?" from the website *Psychology Dictionary*, defined **positive** feedback. Another source was "Augmented Feedback: How Giving Feedback Influences Learning" by R.R. Danielson, which covered **inherent** and **augmented** feedback. As can be seen, many types of feedback come in pairs, such as delayed and immediate feedback. One type of feedback was chosen over the other based on Humana®'s requirements and the input of the subject matter expert. For example, of the two feedback types delayed and immediate, immediate is most useful in the designs because the program participants need immediate results to effectively change their health behavior. From this, the research team created visuals featuring immediate rather than delayed feedback, displaying data from the day or week view, as opposed to the month view.

2.2.2.2. RESOURCES

- PhD candidate's presentation, "Feedback & Display Design"
  - Overview of Feedback
- Dempsey, J. V., & Sales, G.C. (Eds.). (1993). *Interactive Instruction and Feedback*. Englewood Cliffs, NJ: Educational Technology Publications.
  - Immediate and Delayed (pg. 23, 25), Affective (pg. 281)
- Shute, V. J., (2007). Focus on Formative Feedback. *Educational Testing Service*. Retrieved from https://www.ets.org/Media/Research/pdf/RR-07-11.pdf
  - Directive, Facilitative (pg. 6), Specific (pg. 7), Elaborative (pg. 9)
- Snyder, C. R., (1997). *Social Cognitive Psychology: History and Current Domains*. New York, NY: Plenum Press.

  - Negative (pg. 225)
- Positive Feedback. (n.d.). In *Psychology Dictionary*. Retrieved from http://psychologydictionary.org/positive-feedback/
  - Positive
- Danielson, R. R., (2015). Augmented Feedback: How Giving Feedback Influences Learning. Retrieved from http://danielson.laurentian.ca/drdnotes/2206-5_schmidt_ch11.html
  - Inherent, Augmented

2.2.2.3. IMPORTANT CODE

N/A

2.2.2.4. RESOLUTION

The problem was resolved through an in-depth examination of the science of feedback. In order to determine which types of feedback would be useful, the definitions of all the terms were learned. For example, the meanings of KR/KOR and KCR feedback were researched. However, those types of feedback were removed because they applied more to test taking, rather than healthy decision-making. Delayed versus immediate, negative, positive, and other types of feedback were also researched. The types of feedback applied in the project included immediate, delayed, and visual-based.

2.2.2.5. STUDENT REFLECTION

Finding the definitions of many feedback types was difficult. I was lucky to find literature such as Dempsey's which included definitions for many of the terms. What information I found was very helpful and informative, especially when considering the impact it had on the types of feedback we used in our designs. I was glad to get the chance to do scientific research, and discover the process of doing research that helped us make decisions in our solution.

2.2.3. INTEGRATING MULTIPLE SOURCES INTO ONE SOLUTION

To receive input from the target audience for whom the visuals were being created, a person with diabetes was interviewed. Meeting with the subject matter expert gave good insights into the problems people with diabetes face when logging and understanding their data, such as when and how many times blood glucose values are recorded and the amount of time and effort required for analyzing that data. Based on this information, visual designs were created with data points and were organized based on the period of the day—morning, midday, and evening. However, during a meeting with Humana®, the Humana® representative reiterated

that their program focuses on blood glucose readings collected pre- and post-meals, not times of day. This was an issue, because the visuals initially created did not match the data that was provided by Humana® in the sample log books.

In hindsight, one potential issue noted was that the subject matter expert interviewed had type 1 diabetes, in which the body does not produce insulin and requires the use of a continuous insulin pump and numerous blood glucose readings; whereas most participants in Humana®'s program have type 2 diabetes, in which the body does not efficiently respond to insulin and can usually be managed with medication and lifestyle management. As such, to better manage their diabetes, people with type 2 diabetes focus blood glucose readings before and after meals.

2.2.3.1. RESEARCH CONDUCTED

During the meeting with Humana®, the representative reviewed the initial designs and explained changes that needed to be made, such as changing the focus to pre- and post-meal data. Humana® also provided information on acceptable blood glucose level ranges for pre- and post-meals.

2.2.3.2. RESOURCES

- A person with Type 1 diabetes (subject matter expert)
- Humana® representative
- Logging data provided by Humana®

2.2.3.3. IMPORTANT CODE

N/A

2.2.3.4. RESOLUTION

The Humana® representative helped get the project back on track, by offering advice on each of the designs presented. The meeting provided an opportunity for the diabetes research team to explain the current designs and hear from the representative what needed changing and why. Using both the input from the person with diabetes and the Humana® representative, the team focused on reworking the initial design to change from displaying data based on time periods to data based on pre- and post-meal data to create the most effective visuals.

2.2.3.5. STUDENT REFLECTION

I took away a couple of lessons from this issue. One was to build and use effective communication skills. Communicating effectively is key, not only in the workplace, but in any relationship. Another thing I learned was to ask good questions and care about the project. Really thinking about the project's problems and possible solutions and asking pertinent questions facilitate solving the problem. For example, in order to create effective visuals, my team had to care about the problem. I tried to put ourselves in the place of the program's participants to understand their challenges. As far as asking good questions, I made sure to think about what the Humana® representative was saying in our meetings and asked clarifying questions.

2.3. PROBLEM SOLVING TIMELINE

Diabetes Design Development Timeline

The Challenge

In this Challenge Problem students will be expected to use a variety of skills in order to create the most effective visuals for motivating the healthy behavior of people with diabetes aged 65 to 80.

Data Visualization Improvement

During this process we mostly had problems coming up with designs which incorporated all four parameters given by Humana®. The parameters were blood glucose, exercise, medication, and food.

Backing Visuals with Science

The visuals we created were based on our personal preferences concerning layout, color, etc. We needed to find scientific data which would guide us to make the most effective visuals.

Finding Focus Areas

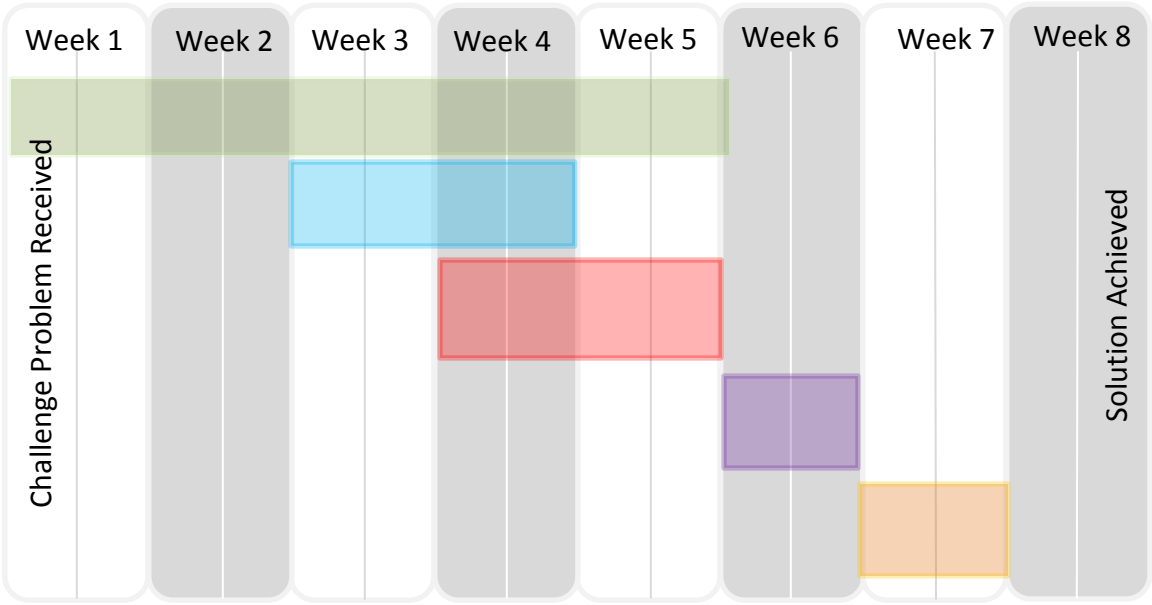
After meeting with the diabetes expert, we centered our graph designs on the time periods of morning, midday, and evening. However, the people with diabetes participating in Humana®'s program focus on pre- and post-meals.

Revising Graphs

After finishing data visualization improvement, we still had to make high quality visuals of our graphs. Week 6 was centered on creating final products of our graphs, and overcoming related obstacles such as design issues in Inkscape.

Revising Analogies

Following the completion of our revised graphs we began the analogy design aspect of the project.



Week 1
- Received summer assignment
- Researched basics of diabetes
- Began investigation into current mobile applications

Week 2
- Created a presentation for Humana ®
- Met with Humana ® and learned project focus: data visualization
- Continued research

Week 3
- Heard presentation on feedback types, began research on unfamiliar terms
- Interviewed diabetes subject matter expert

Week 4
- Continued and finished feedback research
- Met with Humana ®
- Began side programming

Week 5
- Brainstormed graph ideas
- Continued visual design, focused on graphs
- Revised student solution templates
- Met with Humana ®

Week 6
- Improved old graphs and began a series of new graphs
- Graph driven visuals finalized

Week 7
- Analogy driven visuals finalized
- Revised some of the old graphs
- Presented graphs to Humana ®

Week 8
- Met with diabetes subject matter expert for feedback on final designs
- Prepared presentations for end of the project out briefings

This timeline does not depict all of the issues students encountered as they developed the solution during the GRILL® summer program 2015. Other issues arose during the problem solving process and were resolved within the given timeline.