GNG2101 Report

PD – D: Detailed Design, Prototype I, BOM

Submitted by

Talk Box, C23

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Date February 6, 2021

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Abstract

This report details the organization of the final detailed design concept, and the first prototype of the final product. The team plan includes identified objectives that should be achieved during the prototyping phase, and modifications that should be made based on the second client meeting with Anthony and Roy. Included in this report are five focused prototypes determined to be the most important from the detailed design. These focused prototypes include diagrams and detailed images supporting their function. Furthermore, the testing summaries and feedback of each focused prototype are analyzed to ultimately determine where each concept needs to be improved or modified in future prototypes, as well as what materials need to be purchased for the second and third rounds of prototyping.

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List of Acronyms

Acronym	Definition
BOM	Bill of Materials
LED	Light Emitting Diode
LCD	Liquid Crystal Display
GUI	Graphical User Interface

1 Introduction

The ability to talk is something that able bodied people take for granted every day. Not often do we realize how difficult it would be if we were not afforded that privilege. Our goal is to create a product that will allow users with low dexterity and no voice, the ability to talk through a "talk box." Not only will this give the user the ability to talk, but it will also give them a sense of freedom and independence. Our design will incorporate specifically designed hardware and customer to give our users a voice. To do this, a prototyping test plan was developed to fulfill the individual needs and subsystems identified in the previous phases of this project. Five focused prototypes were identified, organized, and explored through both testing and analysis. It is important to note that prototyping will be done in stages beginning with the alpha prototype, which is several focused prototypes, then a comprehensive prototype will be developed by combining and integrating the alpha prototypes. Finally, within the last weeks of the design process, the third prototype will be the complete and fully functioning prototype which will be distributed to the clients: Anthony and Roy. The focused prototypes identified were containment of the TalkBox, a joystick for navigation of the LCD Screen, the connection of the various electrical components, the graphical user interface, the text-to-speech program, and the caretaker interaction and phrase/category storage. Also included in this report is a list of the materials required to begin the construction of this product the testing of the individual prototypes, and project management.

2 Summary of Client Feedback

On February 3rd, 2021, the second client meeting with Anthony and Roy took place. This meeting was a time set aside for the clients to view our current design concepts and give feedback on them. Both the clients expressed interest in the first design concept with the joystick and screen elements. They felt this would be the best option for the end users. Their suggestions were that instead of having the talk box mount to the chair, it should be attached to a gooseneck camera holder. That way, if the product gets bumped or needs to be moved it will not break, and instead will just be pushed out of the way. As well the screen would then be adjustable to the user and would take into account the viewing angle. The second suggestion they made was that instead of having an awkwardly placed joystick, it should be able to be moved around according to the end user's needs. They also suggested that there be an easier way to have the caretaker edit the phrases and menus and suggested that perhaps a spreadsheet format would be the ideal way to modify the phrases. Anthony and Roy also emphasized that the device would need to be moved around frequently, so that it is important to consider any sharp corners on the device and making sure it is easy to move. They also agreed that with much more time, an application on a phone for a caretaker to edit the phrases and update it would be desirable but given time constraints that it was not necessary. Going forward, we are going to take all of Anthony and Roy’s suggestions into our first prototype.

3 Detailed Design Concept

3.1 Physical Design

Figure 3.1.1 - Physical Subsystems

#	Subsystem	Solution
1	A way to navigate on-screen options.	A joystick that allows the user to select options and navigate the menu systems.
2	A way to mount the device to a wheelchair.	A gooseneck camera holder that will attach to the wheelchair and the talk box itself.
3	A way to view the content on the screen.	An LCD Screen that will attach to the Raspberry Pi.
4	A way to run the software on the device.	A Raspberry Pi will be used to run the software.
5	A way to hear the text-to-speech.	A speaker compatible with the Raspberry Pi will be incorporated into the system.
6	A way to contain the product.	A 3D printed case will be created to provide an enclosure to the product.
7	A way to power the Raspberry Pi.	The Raspberry Pi will be connected to the wheelchair battery using an XLR cord that attaches through a micro USB charging port.
8	A way to turn the device off and on.	The Raspberry Pi turn on when connected to a power supply and turn off when not connected to a power supply.

3.1.1 Subsystem 1—A Way to Navigate On-Screen Options

In order to interact with the program a joystick will be connected to Raspberry Pi via a USB port. The joystick can select phrases and navigate the menus of the program through left, right, up, and down movements, and can select by holding. The joystick will be independent of the TalkBox for ease of use.

Figure 3.1.2 - Joystick - Credit Digit Space

3.1.2 Subsystem 2—A Way to Mount the Device to the Wheelchair

A gooseneck camera mount will be used as the connection between the device and the wheelchair, it is also necessary for user to adjust the TalkBox into the desired position at the user's will. It will also prevent the product from breaking if the device is bumped, and will allow the device to be easily moved around, especially for caretakers helping someone in and out of their wheel chair.

Figure 3.1.3 - Gooseneck Mount - Credit Walmart

3.1.3 Subsystem 3—A Way to View Content On-Screen

An LCD screen will attach the Raspberry Pi and will provide the user increased navigation abilities and ease of use by showing the menus and on-screen phrase and category choices. The LCD screen will cover the Raspberry Pi and will be held in with the surround case. For a better user's experience, a gooseneck camera holder will hold the TalkBox so that the screen is perfectly angled to the user's specifications. The screen will also play the role of the cover of the top of the TalkBox. The screen is also a touch screen which will allow simple modification to phrases and categories.

Figure 3.1.4 - Digital Touch Screen - Credit Amazon

3.1.4 Subsystem 4 – A Way to Run Software on the Device

In order to run the software, programs, speakers, and the LCD screen, a Raspberry Pi will be used. The Raspberry Pi is a single board computer containing a processor, RAM, USB-C Power Supply, Micro HDMI Ports, USB Ports, A Gigabit Ethernet Port and many features. These features will be used to connect the software and the hardware components, including the LCD screen, the speaker the joystick and power supply.

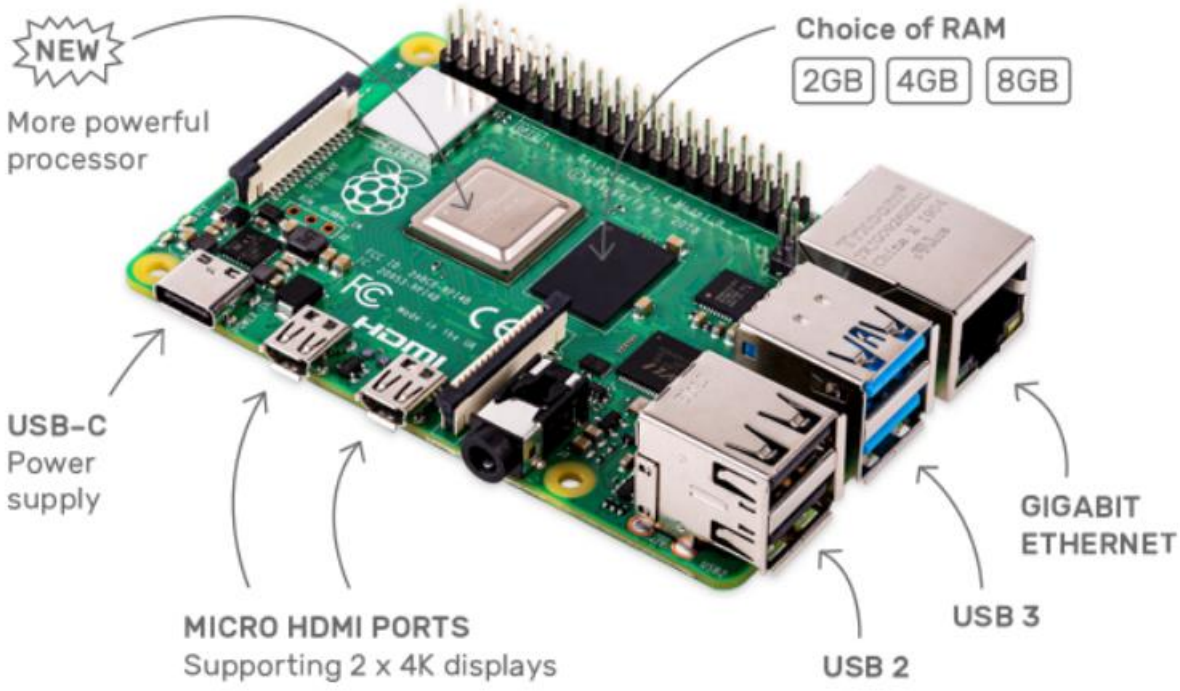


Figure 3.1.5 - Raspberry Pi 4 - Taken by Raspberry Pi

3.1.5 Subsystem 5 – A Way to Hear Text to Speech.

To hear the text-to-speech, a speaker will be attached to the Raspberry Pi in the Microphone Out Plug and will attach to the outside of the enclosure to ensure maximum volume and clarity. The program with the text-to-speech will operate through the Raspberry Pi and play through the speaker.

Figure 3.1.6 - Raspberry Pi Speaker taken by Dexter Industries

Figure 3.1.7 - Raspberry Pi Speaker taken by Dexter Industries

3.1.6 Subsystem 6– A way to contain the product.

A 3D printed case will be produced in order to contain the Hardware of the TalkBox. It will most likely be made of plastic as it is the most common 3D printing material. The exact dimensions of the printed case will be determined as the project progresses. The product of this design will be filed on the corners, as our clients are concerned about sharp edges.

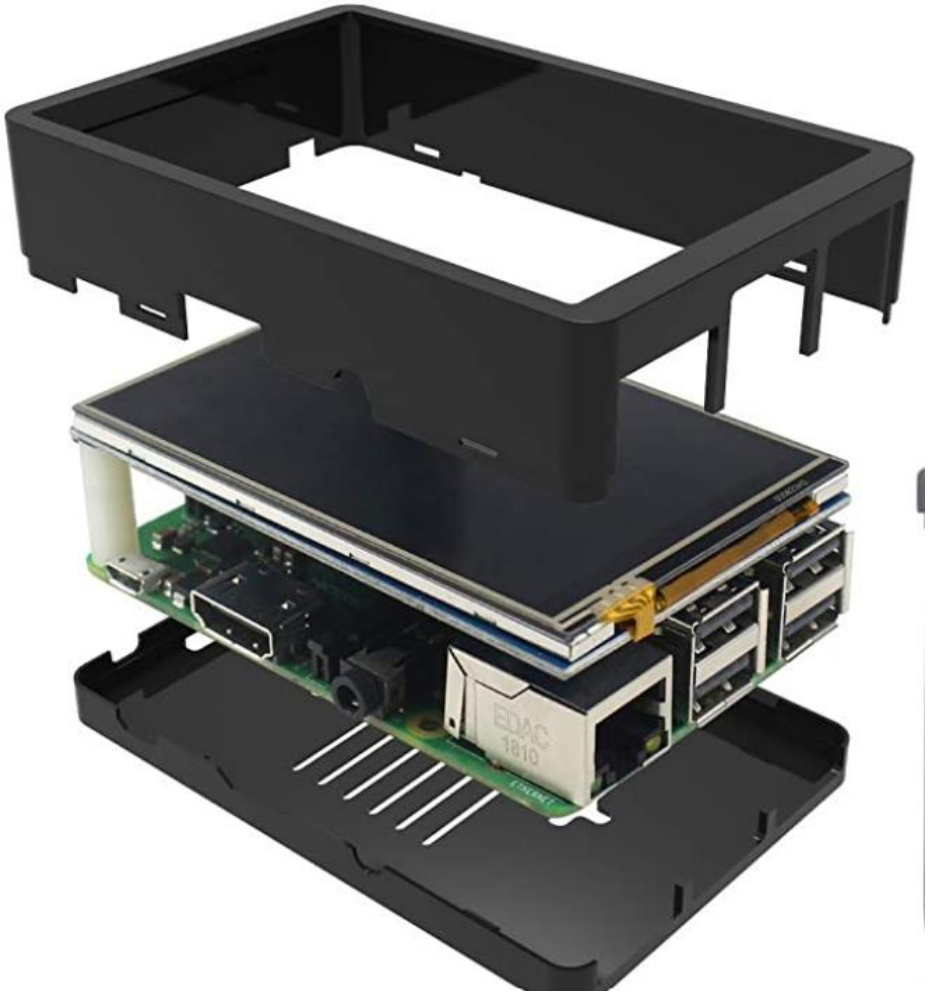


Figure 3.1.8 - Case- Credit Amazon

3.1.7 Subsystem 7 – A Way to Power the Raspberry Pi

A battery pack will be used to power the Pi. A special mount for the battery pack will be placed in the 3D printed enclosure. A USB-C cable will connect the battery to the Rasbery Pi. The enclosure will also have a hole for access to the battery pack charging port. The battery will be charged using wheelchair power through an XLR-USB converter.

Figure 3.1.9 - Battery Power - Credit Amazon

3.1.8 Subsystem 8 – A Way to Turn the Power On and Off

A power button included with the Raspberry Pi will be used. The power button will have a mount in the 3D printed enclosure, through which the user will be able to access it.

3.2 Software Design

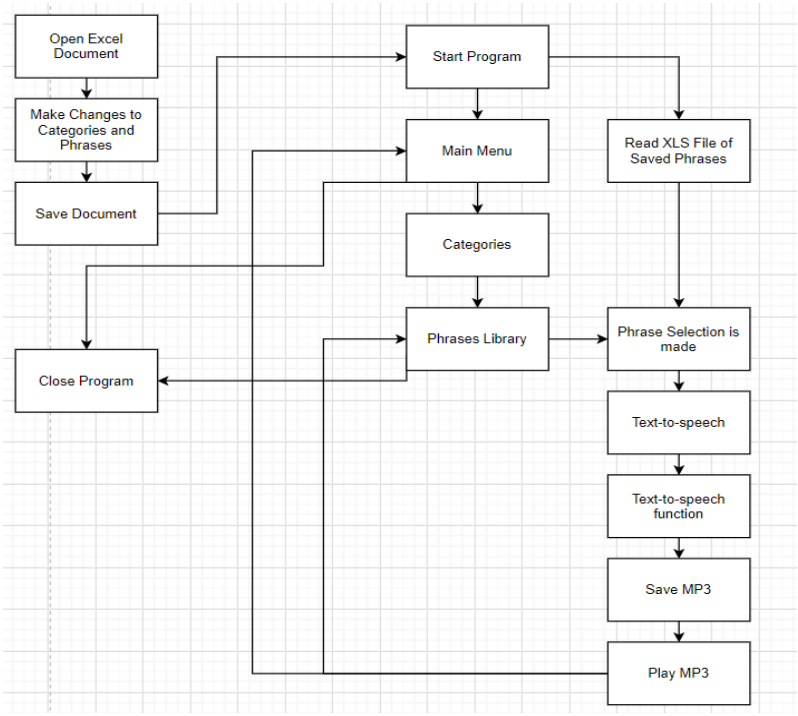


Figure 3.2.1 - Complete Flow Chart of Current Programs

Table 3.1.8.1 - Program Subsystem

#	Subsystem	Solution
1	User Interface	The user interface will include a main menu, which then lead to sub menus that contain phrases to be read out. It will be displayed on the LCD Screen.
2	Text-to-Speech	The text-to-speech will be activated when the phrase the user wants is selected. It will be programmed on the Raspberry Pi and will be head over the speaker.
3	Caretaker Modifications	The caretaker modifications will be made on the Raspberry Pi through the touch screen option of the LCD Screen. They will be able to access the phrase banks and make their own modifications and store them.
4	A keyboard program	The keyboard program will allow the caretaker to type on the LCD screen attached to the Raspberry Pi.

3.2.1 Subsystem 1 – User Interface

Click to go along the arrow, hold to go backward of the arrow, while the main menu to start backward is banned. Instead, user can go to the caretaker mode. Three default menu is settled for user in the beginning. The system will change the pick automatically at the same level. User might have some method to modified the autochanger speed or direction.

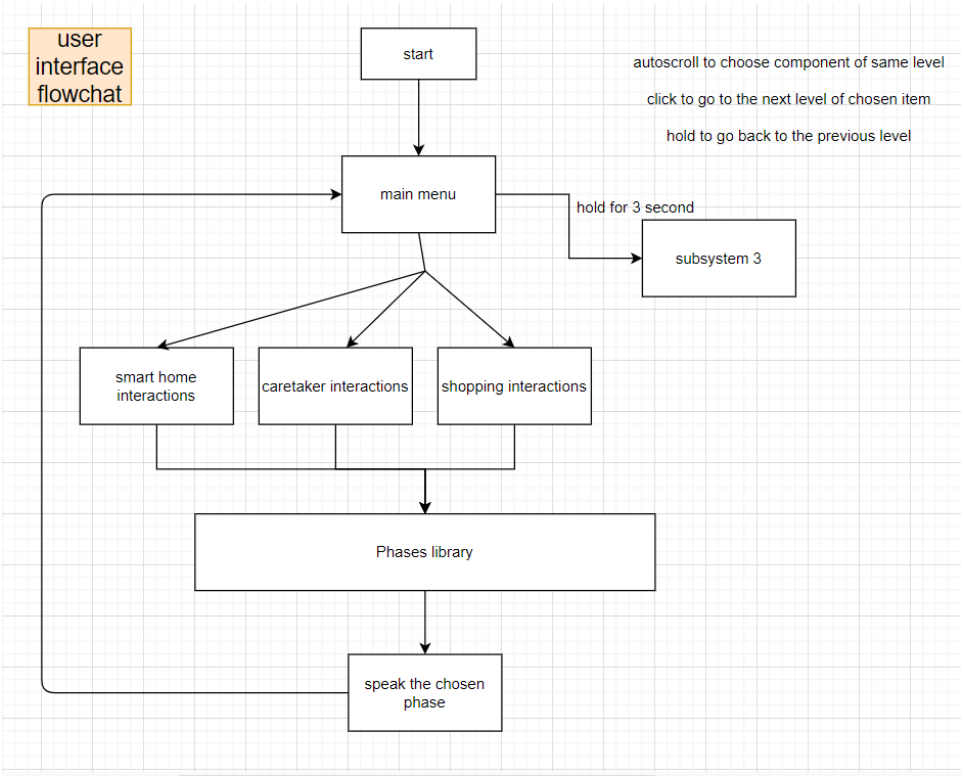


Figure 3.2.2 - User Interface

3.2.2 Subsystem 2 – Text-to-speech

The text-to-speech program will read the phrases from a text file, and once the phrase selection is made it will convert it to an MP3 using a text-to-speech function. Then it can be played

through the speaker connected to the Raspberry Pi when the user makes a choice of a phrase selection using the joystick.

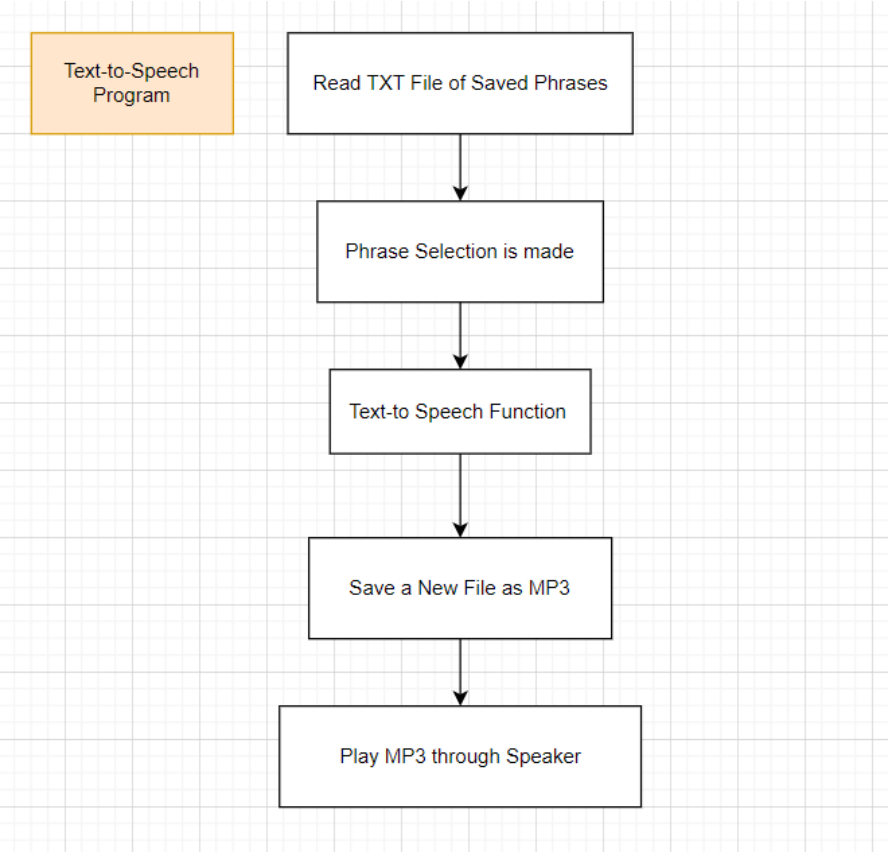


Figure 3.2.3 - Text-to-speech Programming

3.2.3 Subsystem 3—Caretaker modifications

The caretaker will enter the phrases and categories into an excel document. The data from the excel document will be stored in variables that can be called on when the text-to-speech function is engaged by the user with use of the joystick attached to the Raspberry Pi. The User Interface will also display these stored phrases and categories on the screen as well.

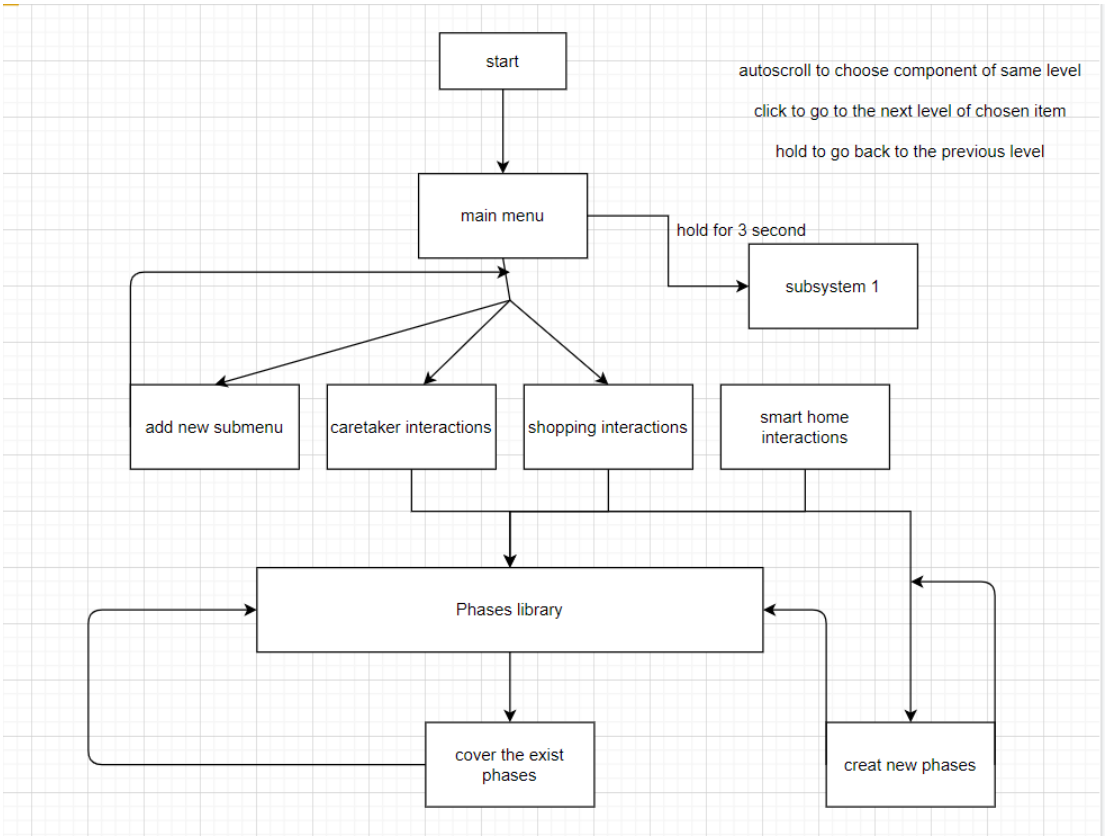


Figure 3.2.4 - Caretaker Modifications

3.2.4 Subsystem 4 - On-Screen Keyboard

There is no need to create any software for the Raspberry Pi keyboard because it already comes with the built-in function of a virtual keyboard. There is also no need for a mouse, as the LCD screen is touch screen. This will allow the caretaker to modify phrases and categories in the excel document. This will most likely be the easiest function to apply to the project.

Figure 3.2.5 - Raspberry Pi Keyboard - Credit PiMyLifeUp

3.3 Critical Product Assumptions

The product assumptions we have made are:

- The user has enough dexterity to use a joystick.
- The caretaker knows how to function Microsoft Excel.
- The user will have a wheelchair battery with an XLR Port
- The user can see a small LCD Screen.
- The main menu will include only six categories of phrases.

4 Prototype I

This report details the five focused prototypes for the subsystems the team deemed most important. These prototypes will provide a working basis for the next prototyping phases and a foundation for further research, benchmarking, and ideation for the duration of the project. These focused prototypes were deemed the most critical to this project.

Table 3.2.4.1-Focused Prototypes

Focused Prototypes	**Subsystem**	**Target Value**	**Actual Value**
Physical Prototypes			
Containment of the TalkBox	6	Contains LCD and Raspberry Pi	Contains LCD and Raspberry Pi
A Joystick for Navigation	1	Joystick and joystick and cover are acquired.	Joystick and Joystick and cover are acquired.
Software Prototypes			
Graphical User Interface for Main Menu	1	Program compiles and functions.	Program compiles and functions.
Text-to-speech Program	2	Program compiles and functions.	Program compiles and functions.
Caretaker Interactions and Phrase/Category Storage	3	Program compiles and functions.	Program compiles and functions.

4.1 Physical Prototypes

So far the physical prototype consists of a 3D model, used to fine tune the ergonomics of the design. The 3D model is a major redesign from the previous concept, utilizing the client's feedback from the last meeting. The new design features adjustable screen and joystick positions, as well as rounded corners.

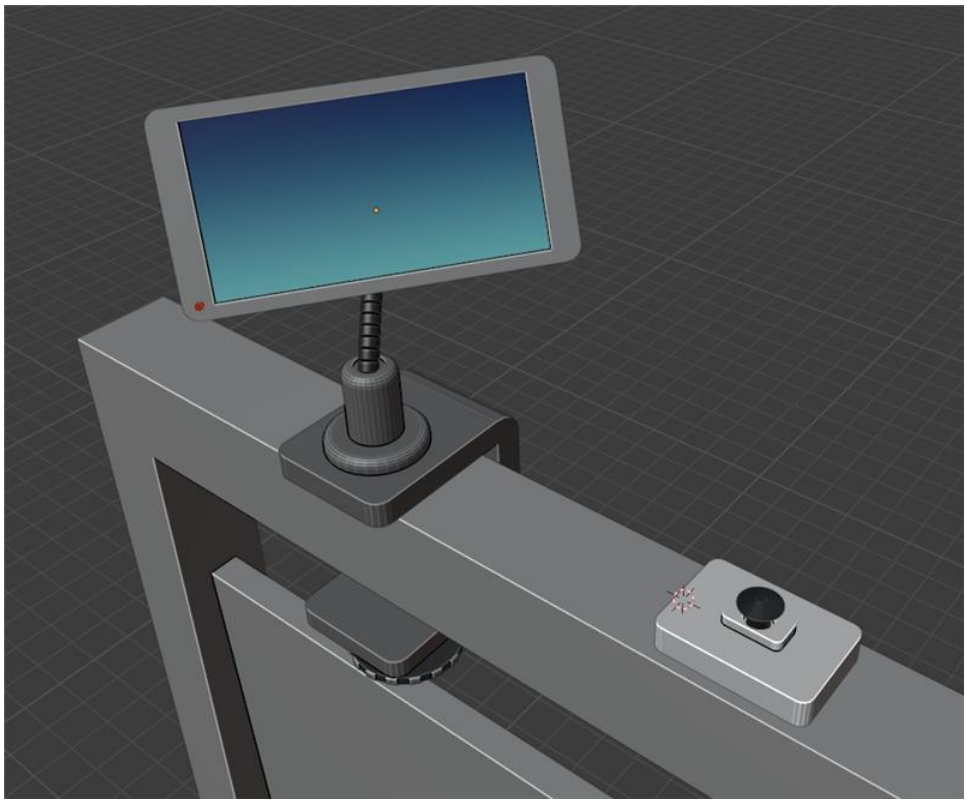


Figure 4.1.1 - 3D model of the latest concept

4.1.1 Subsystem 6 - Containment of TalkBox

The talk box will be contained in a case that will be 3D printed. This case will contain both the LCD screen, the wiring, and the Raspberry Pi. It is important that this case has rounded edges and is durable. This will be necessary for wear and tear of the product and for the safety of the user, respectively. It must also not be too large or clunky in order to not take up too much of the user's personal space.

Figure 4.1.2 - Containment of TalkBox

Figure 4.1.3 - Containment of TalkBox

Figure 4.1.4 - Containment of TalkBox

4.1.2 Subsystem 1 – Joystick

The joystick will be paramount to making choices in the TalkBox program. It will aid the user in both navigation and making selections to the voicing of their selections. The user will be able to pick either a scanning menu mode, or a mode that uses the complete freedom of the joystick. This will be done at the main menu screen. The joystick will be free roaming and independent of the TalkBox but will be connected to the Raspberry Pi using wires that are cable braied and wrapped around the gooseneck of the holder.

Figure 4.1.5 - Joystick Cover

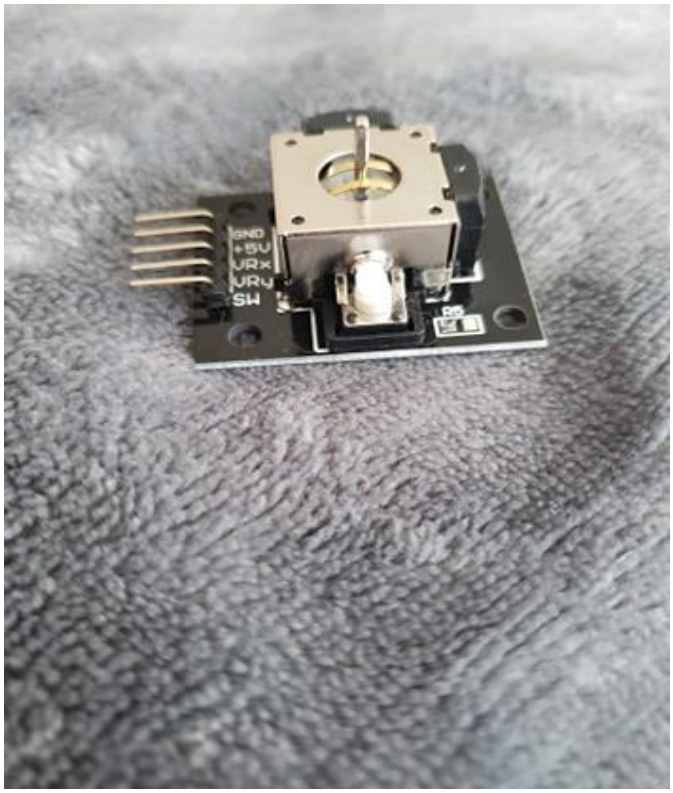


Figure 4.1.6 - Joystick Controller

4.2 Software Prototypes

4.2.1 Graphical User Interface for Main Menu

Below are the photos of the code for the main menu graphical user interface. It imports the categories from the excel document and places them on the screen, so that the user may choose which one they like. There is a max total of six categories for the user to modify and organize. The colors chosen for the menu screen are black and white to create high contrast.

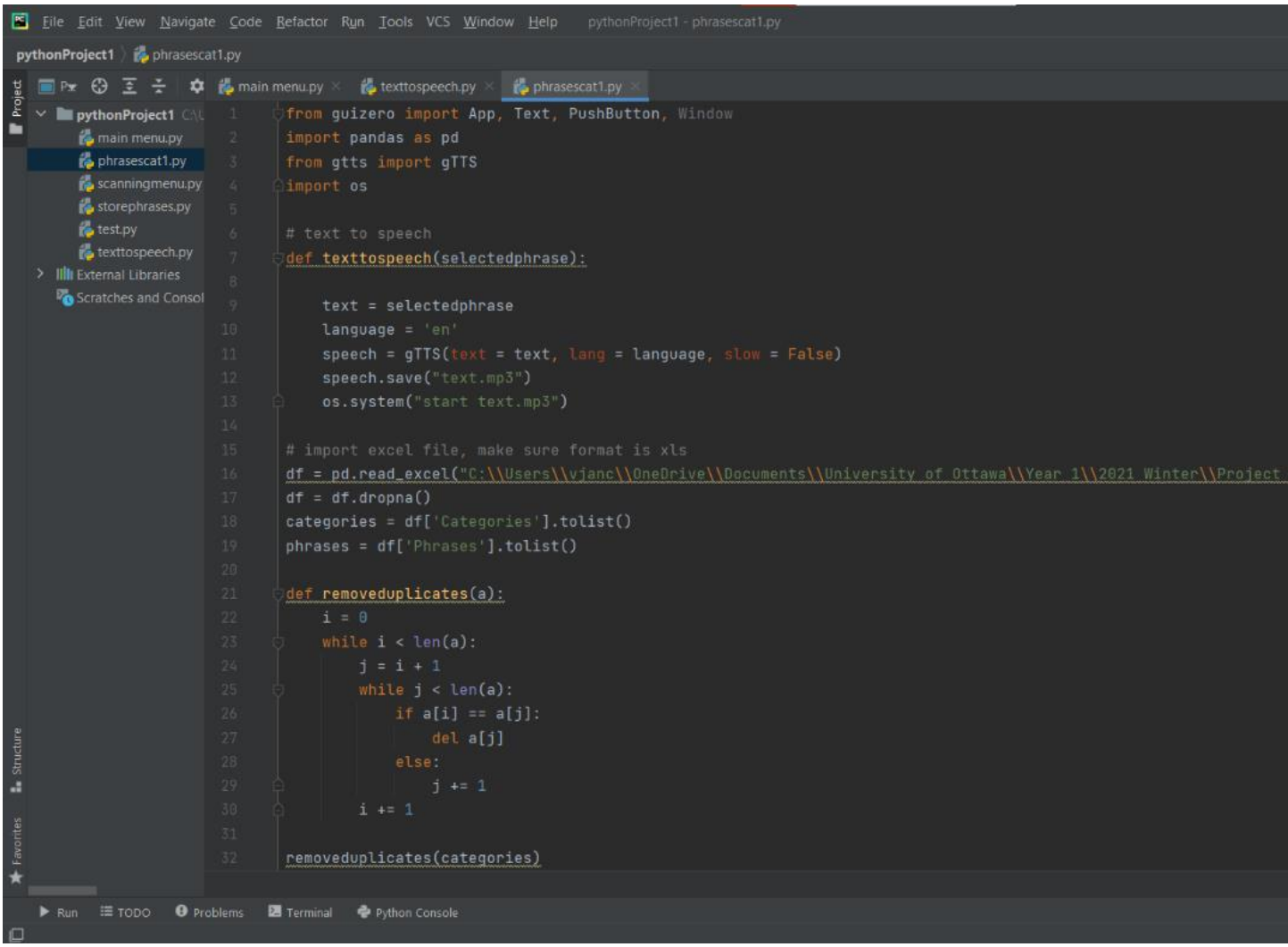


Figure 4.2.1 - Code for GUI

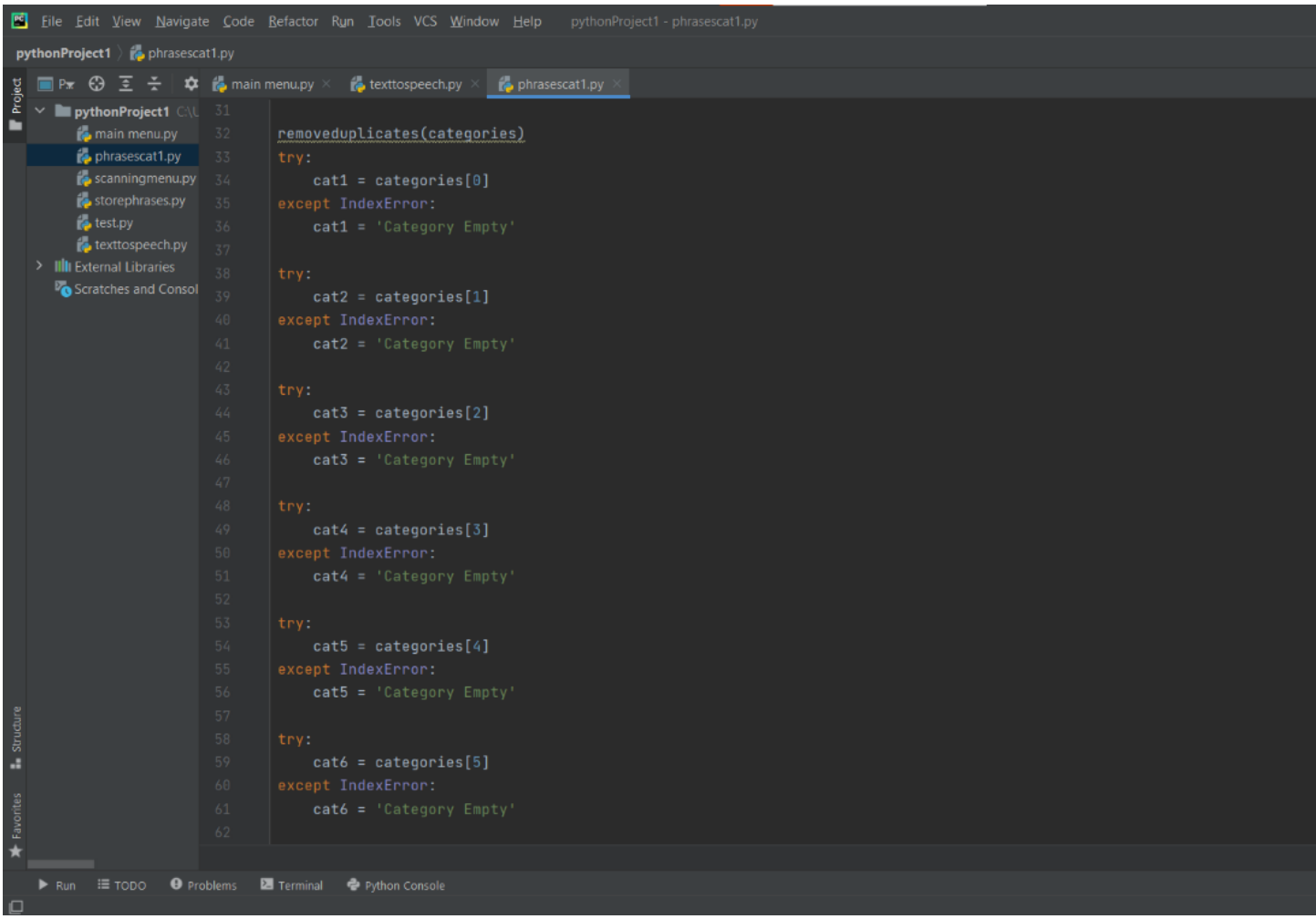


Figure 4.2.2 - Code for GUI

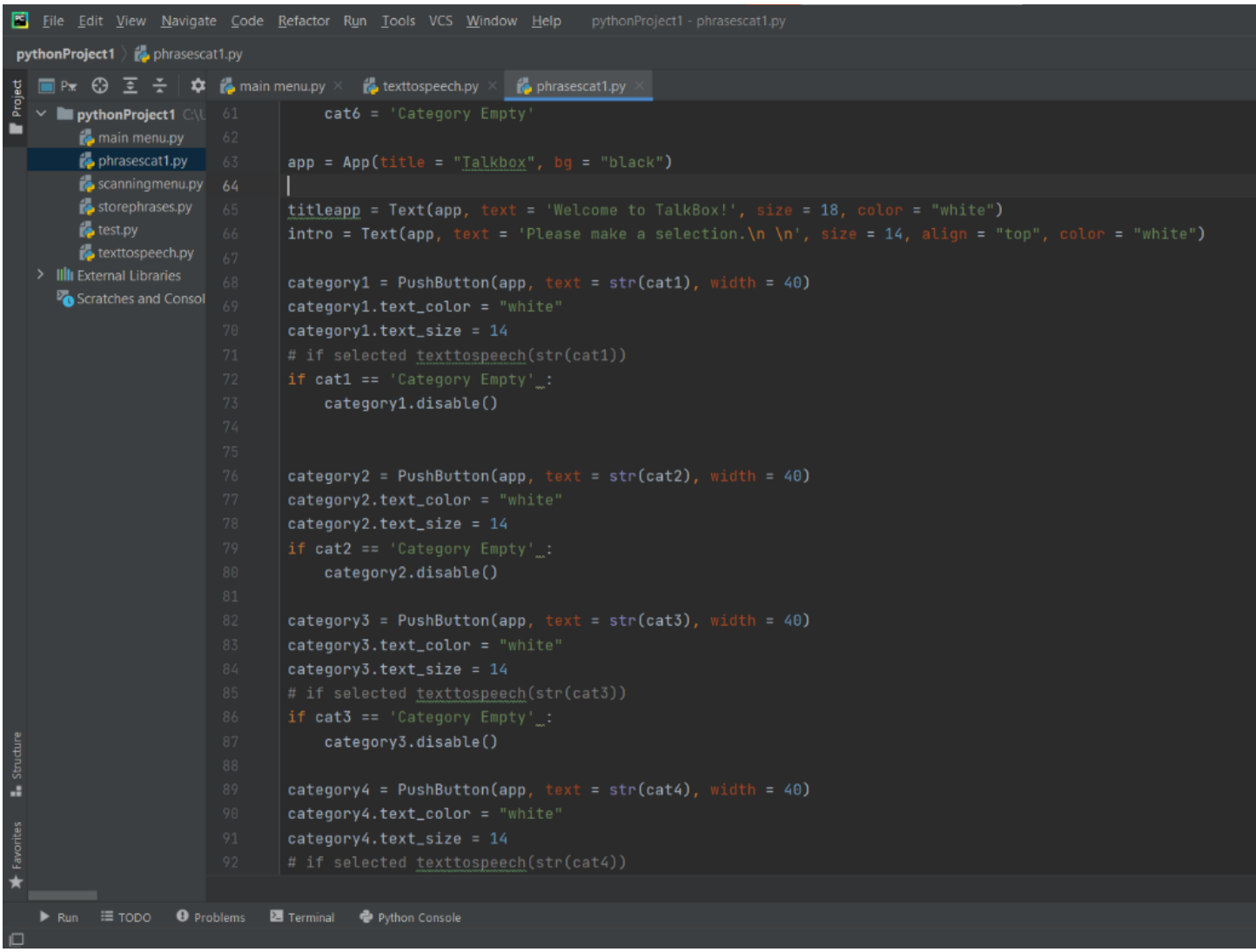


Figure 4.2.3 - Code for GUI

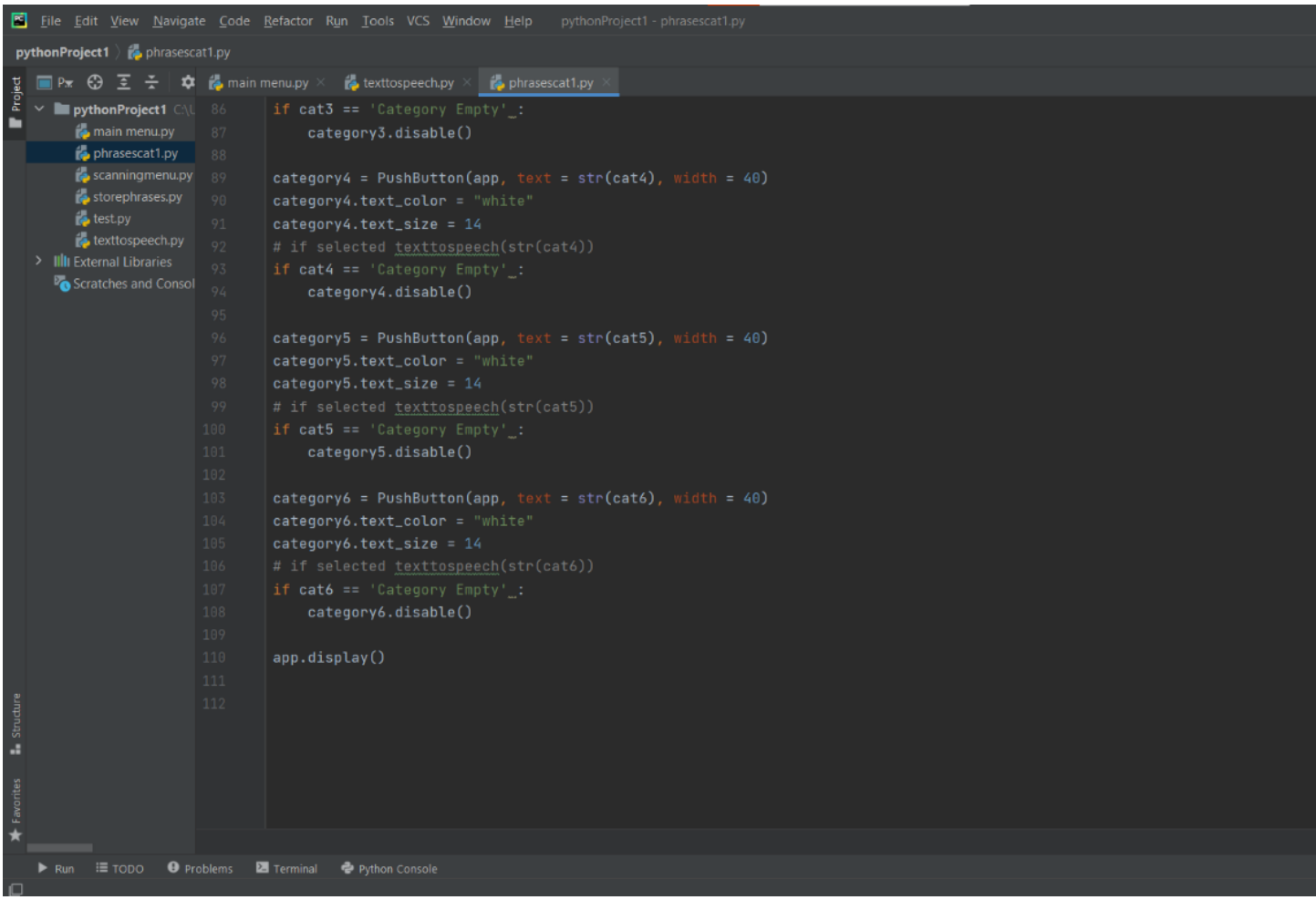


Figure 4.2.4 - Code for GUI

4.2.2 Subsystem 2 – Text-to-speech

Below is the generated text to speech program. This program will take an input “selected phrase” and save it as an MP3, which is then played through the device. This function will allow the user to play a phrase of their choice, and then have it voiced out loud. This will be programmed into the Rasperry Pi, and will operate through the use of selection, by the joystick and the speaker, which will be attached to the Raspberry Pi.

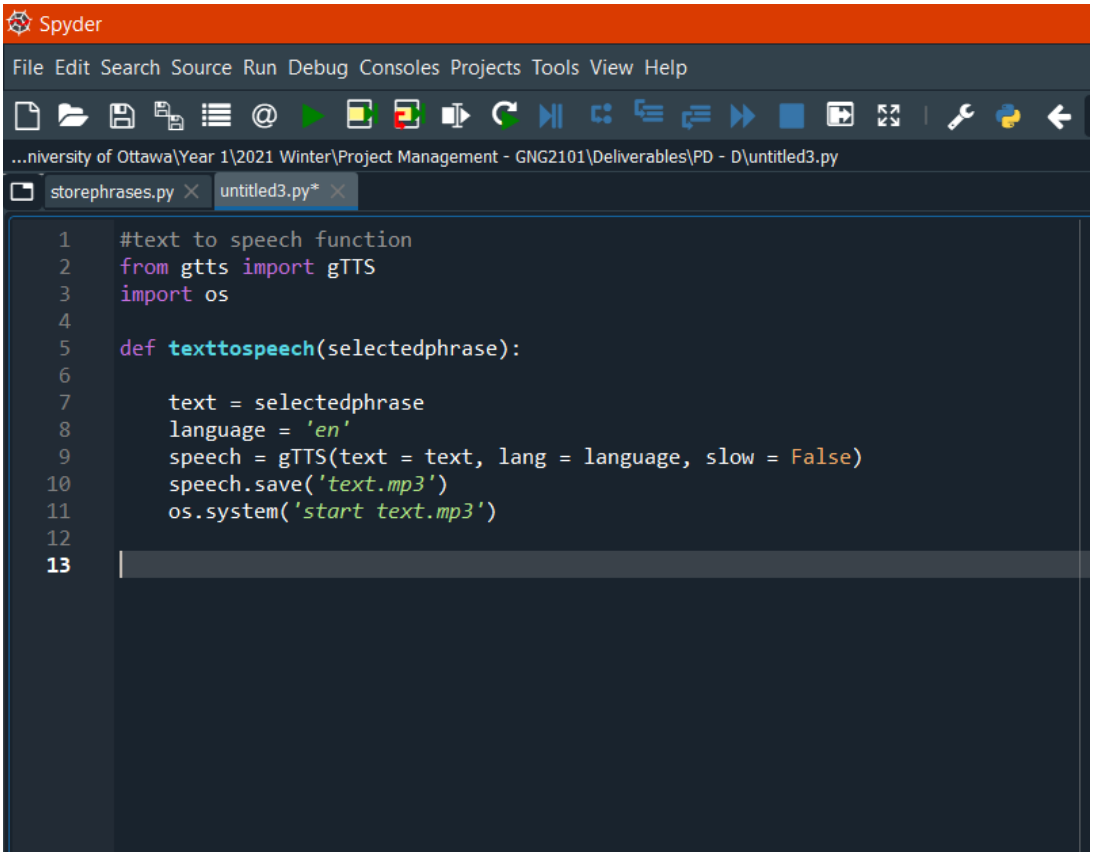
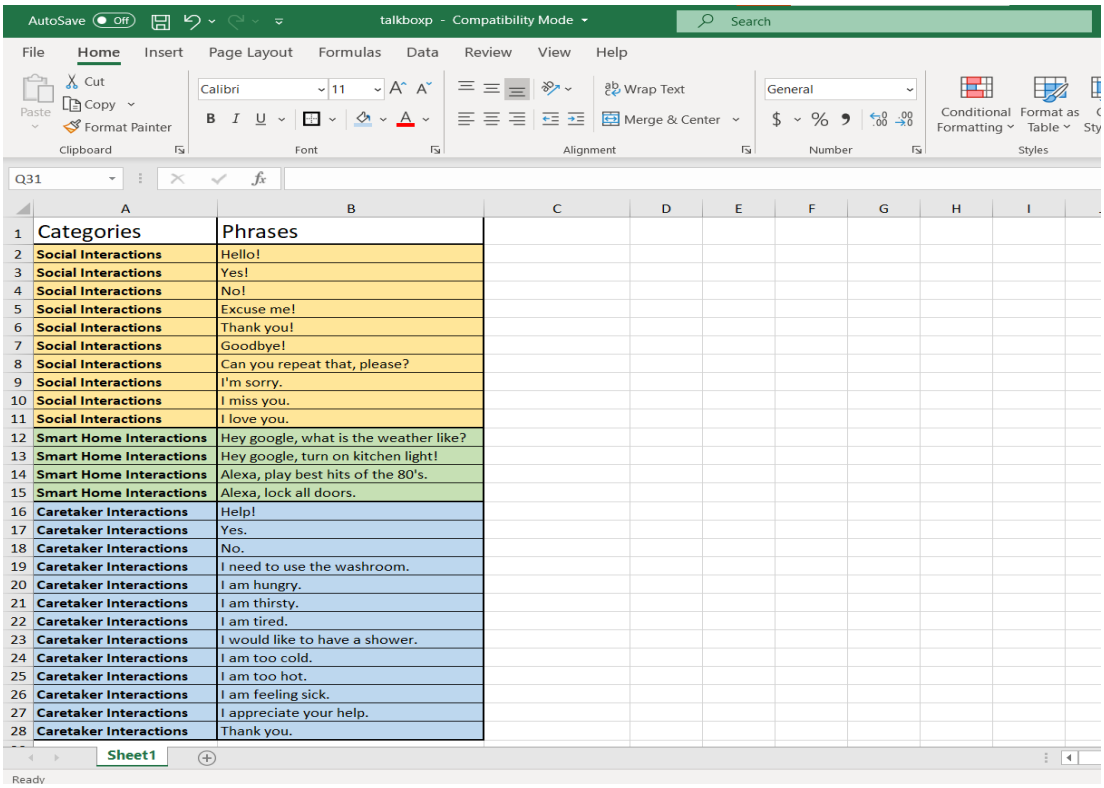


Figure 4.2.5 - Text-to-Speech Program

4.2.3 Subsystem 3 – Caretaker Interactions and Phrase/Category Storage

Below, in Figure 4.2.6 is a list of the phrases and categories that the team has developed. The document is editable, and a caretaker can add, remove, or change the phrases in the excel document. The phrases are then taken from the file and scanned into python, then saved and updated, then stored as variables in a list form. The variables are then returned so that they may be used in other areas of the developed software. They are then converted from the list into strings and added as the name of the buttons shown on the graphical user interface.



	A	B
1	Categories	Phrases
2	Social Interactions	Hello!
3	Social Interactions	Yes!
4	Social Interactions	No!
5	Social Interactions	Excuse me!
6	Social Interactions	Thank you!
7	Social Interactions	Goodbye!
8	Social Interactions	Can you repeat that, please?
9	Social Interactions	I'm sorry.
10	Social Interactions	I miss you.
11	Social Interactions	I love you.
12	Smart Home Interactions	Hey google, what is the weather like?
13	Smart Home Interactions	Hey google, turn on kitchen light!
14	Smart Home Interactions	Alexa, play best hits of the 80's.
15	Smart Home Interactions	Alexa, lock all doors.
16	Caretaker Interactions	Help!
17	Caretaker Interactions	Yes.
18	Caretaker Interactions	No.
19	Caretaker Interactions	I need to use the washroom.
20	Caretaker Interactions	I am hungry.
21	Caretaker Interactions	I am thirsty.
22	Caretaker Interactions	I am tired.
23	Caretaker Interactions	I would like to have a shower.
24	Caretaker Interactions	I am too cold.
25	Caretaker Interactions	I am too hot.
26	Caretaker Interactions	I am feeling sick.
27	Caretaker Interactions	I appreciate your help.
28	Caretaker Interactions	Thank you.

Figure 4.2.6 - Excel Spreadsheet of Phrases

Openpyxl be used to develop this program. It can read the contents of excel and print it on python. To while loop with the max Lenth of excels row and column to make sure it gets all the phase and categories of excel.

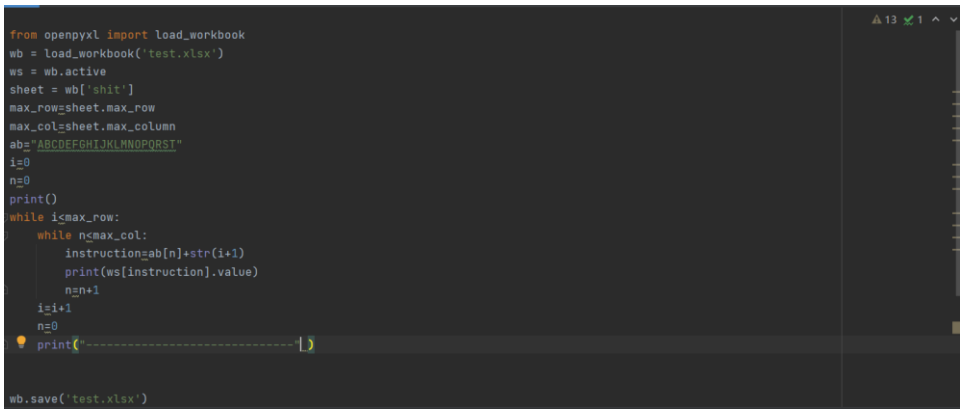


Figure 4.2.7 - Python Code for Scanning Excel

5 Testing

Table 4.2.3.1 - Focused Prototypes

Focused Prototypes	**Subsystem**	**Target Value**	**Actual Value**
Physical Prototypes			
Containment of the TalkBox	6	Contains LCD and Raspberry Pi	Contains LCD and Raspberry Pi
A Joystick	1	Joystick and cover are assembled and function.	Joystick and cover are assembled and function.
Software Prototypes			
Graphical User Interface for Main Menu	1	Program compiles and functions.	Program compiles and functions.
Text-to-speech Program	2	Program compiles and functions.	Program compiles and functions.
Caretaker Interactions and Phrase/Category Storage	3	Program compiles and functions.	Program compiles and functions.

5.1 Physical Protype Testing

5.1.1 Subsystem 6 – Containment of TalkBox

The containment for the TalkBox must house both the LCD screen as well as the Raspberry Pi. This is possible with the case illustrated below. To test, the Raspberry Pi and the LCD were both put in the case at the same time, and both fit inside together. There is little wiggle room inside, so if other components are added, a new case will need to be made.

Figure 5.1.1 - Case with LCD and Raspberry Pi

5.1.2 Subsystem 1 – A Joystick

The joystick was made using a cover and a joystick part. The part fit over the controller and moves without inhibition for the components below. It also has multiple inputs and outputs to make it easier to control. The joystick was deemed to be compatible with the Raspberry Pi, and in the future a case will be built specifically for the joystick.

Figure 5.1.2 - Joystick Top View

Figure 5.1.3 - Joystick Side View

5.2 Software Prototype Testing

5.2.1 Subsystem 1 – Main Menu GUI

The Main Menu GUI was tested using PyCharm a python IDE. There main menu needed to display the categories in the excel sheet. If there were fewer than six categories, the program needed to catch the error and modify the categories so, the program was modified to make the buttons become grey and unpressable and show category empty on the screen. If there are more than six, the last category will not be present in the program. The buttons deform when clicked on, and do not have paths yet, but will in the future. The caretaker modifications and phrases/category storage were run along with the program and was tested before the main menu GUI. The program compiled and functioned according to design. In the future the main menu will lead to the sub

menus containing the phrases. This will also include a GUI for the phrases, as well as the implementation of the text-to-speech program. The main menu will continue to evolve into prototype II, as more features and functionalities are added to the programming, and as the construction of the product begins. Below, the current GUI for the main menu is displayed.

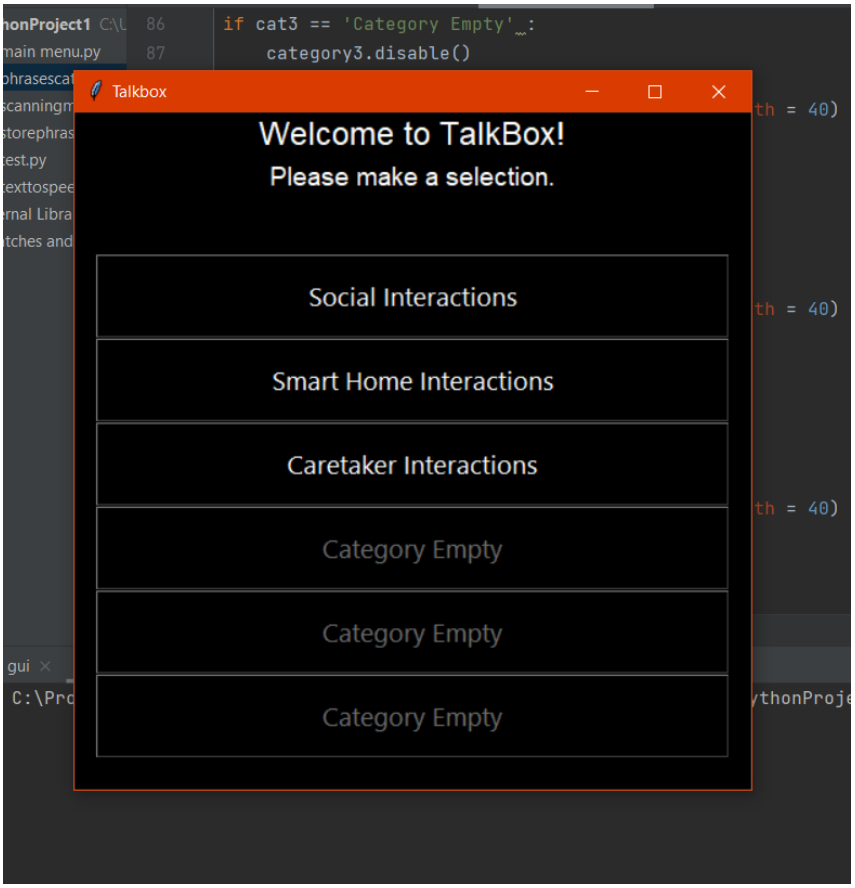


Figure 5.2.1 - GUI Test

5.2.2 Subsystem 2 – Text-to-Speech

The text to speech program was tested using Spyder, a python integrated development environment was used to both create and test the code. The code opens an MP3 played which plays

the input of the “selectedphrase” in the text-to-speech function. No errors were detected during the test. In the future, we would change the MP3 player to open behind the program, as not to interfere what is on the screen in front of the user. As seen below in the picture of the MP3, the file text.mp3 is playing. The program functioned and compiled, according to design.

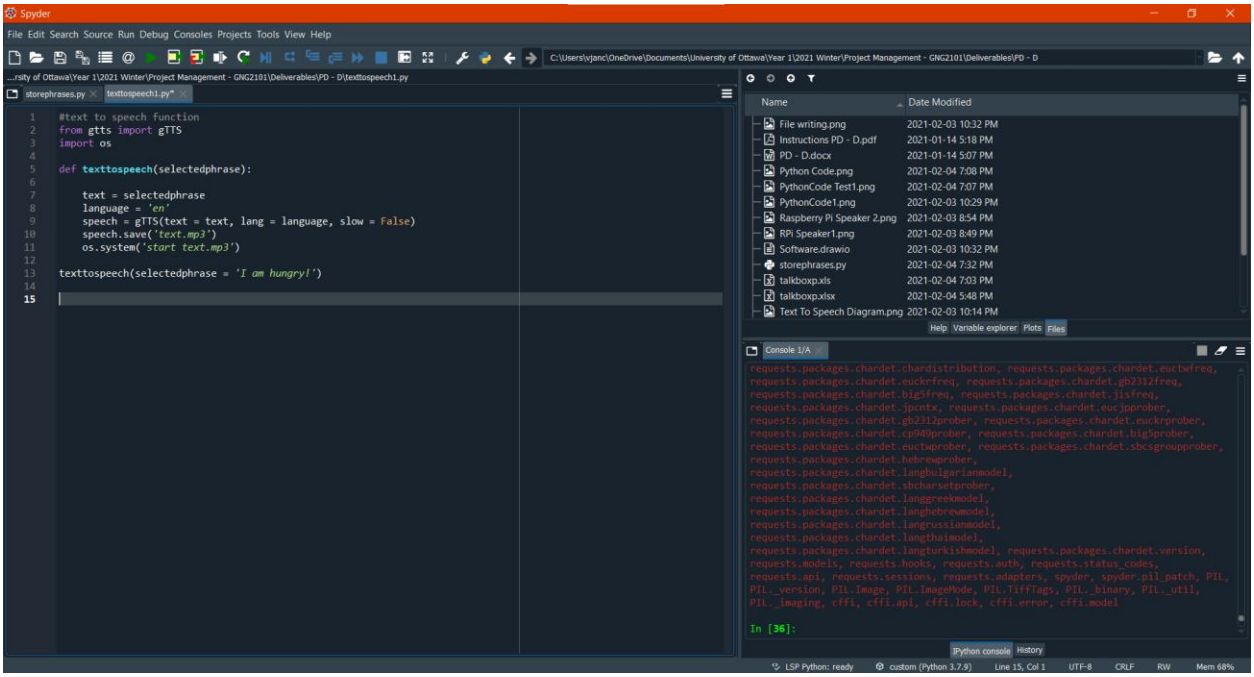


Figure 5.2.2 - Text-to-Speech Program Testing

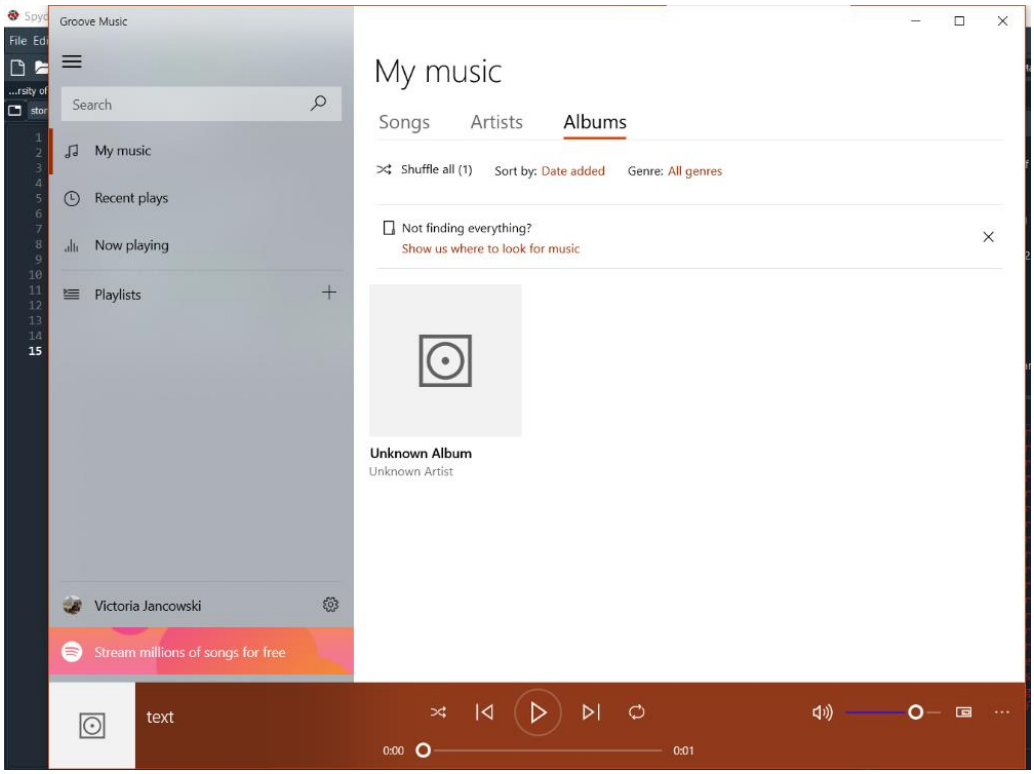


Figure 5.2.3 - MP3 Playing of Text-to-Speech

5.2.3 Subsystem 3 – Caretaker Modifications and Phrase/Category Storage

Below is a figure of the test of the software that scans in the excel function. The test was done using the print function in python. The software scans the document and stores the columns of categories and phrases into their own individual lists, stored in variables. The only bug that was found was when there were blank values remaining in the excel sheet, the output resulted in ‘nan’ appearing in the lists. This was corrected using the. dropna() function. The program functioned and compiled according to design.

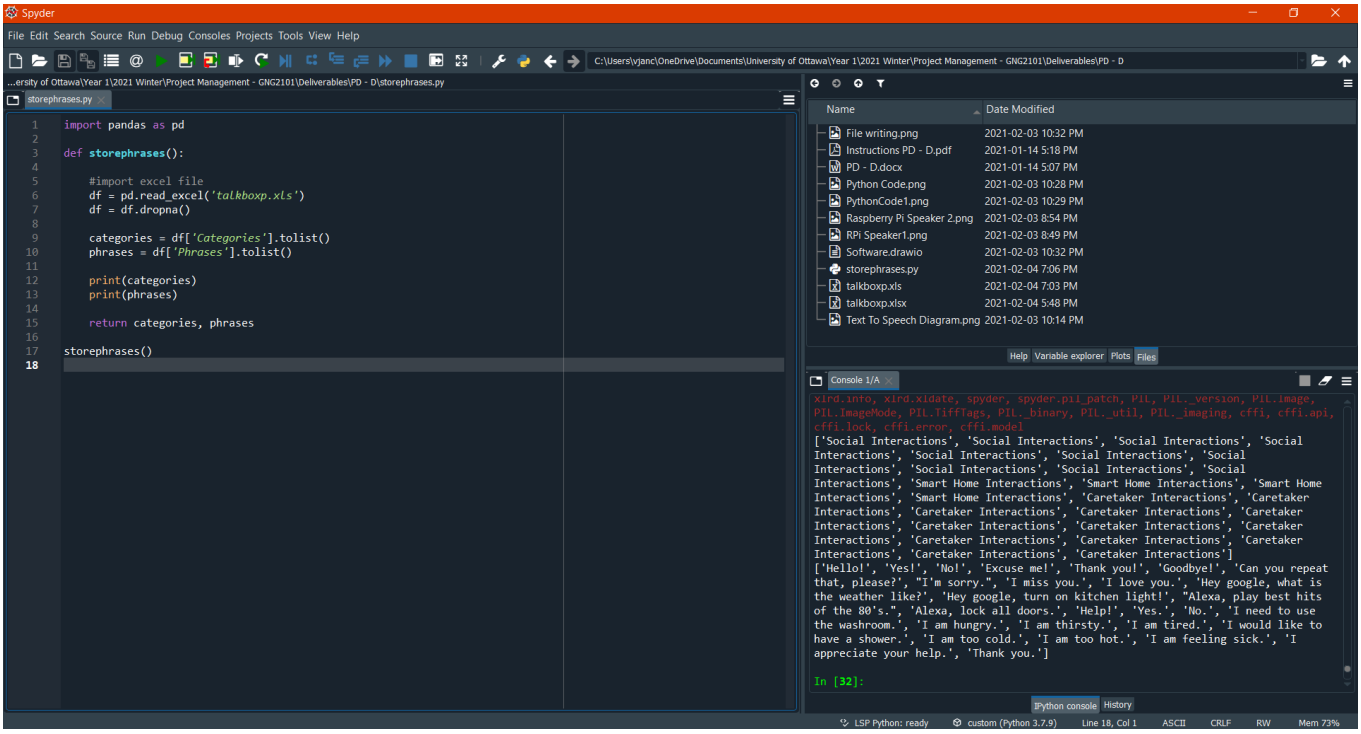
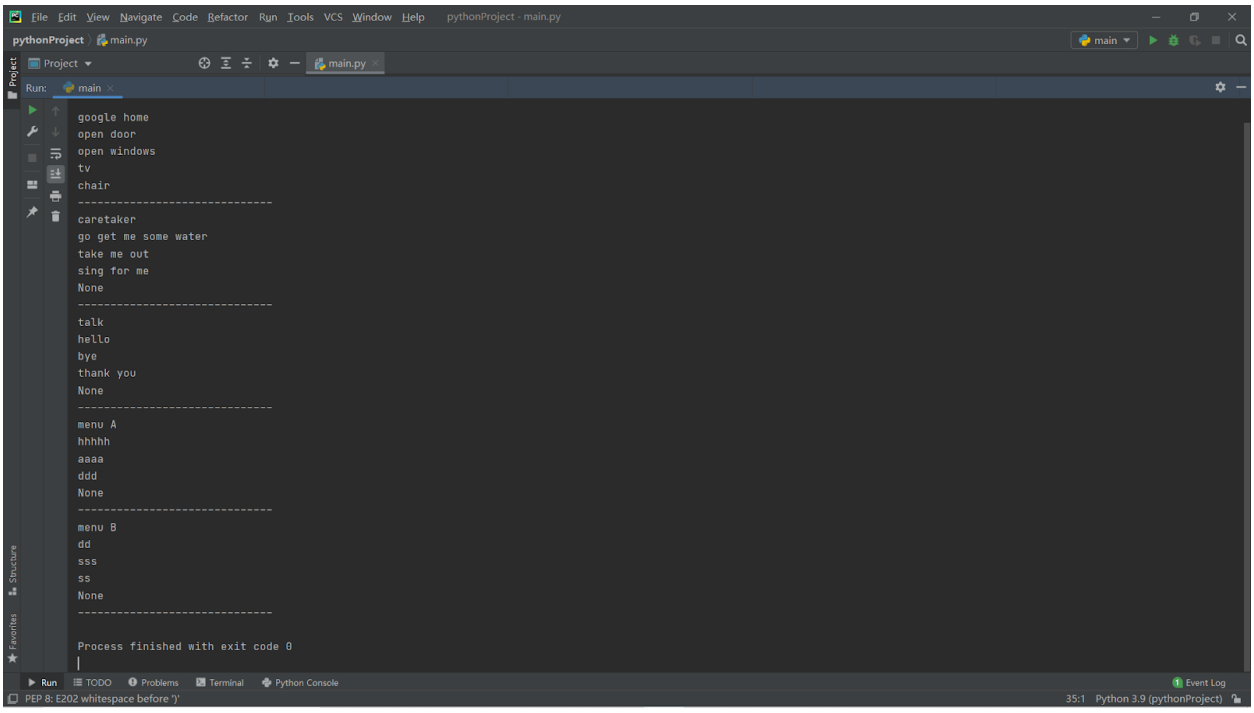
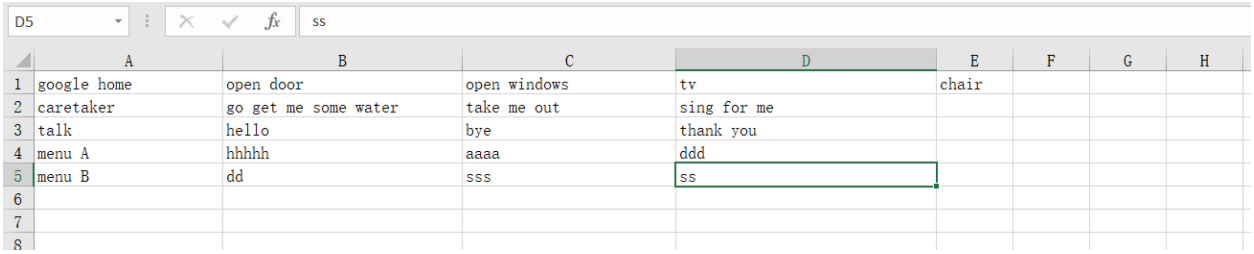


Figure 5.2.4 - Testing of Subsystem 3

The test is sucessful





	A	B	C	D	E	F	G	H
1	google home	open door	open windows	tv	chair			
2	caretaker	go get me some water	take me out	sing for me				
3	talk	hello	bye	thank you				
4	menu A	hhhhh	aaaa	ddd				
5	menu B	dd	sss	ss				
6								
7								
8								

6 Client Meeting III Outline

For the next meeting, we are going to show our subsystems of physical design and software design, which was based on their needs and improved according to their concerns they gave from the last meeting, along with the protypes we created so far. As well, we are going to let the clients know the of the materials we intend to use in the design, so they will have a better view of the physical quality of our product and the content.

For the questions to ask the client, we would like to ask the clients to verify the critical assumptions we have produced and ask if they have any insight into other assumptions. We will also ask for more feedback on the progress we have made and if there is anything the think we might have over-looked, or if there are any other design ideas they might have for future prototypes.

7 Bill of Materials

Table 5.2.3.1 - Bill of Materials

Materials	**Cost**

Raspberry PI 4	$0
LED/LCD Screen 3.5	$29.98
Joystick and case for joystick	$1.37
XLR Cable, to micro-USB	$23.79
3D Printed Case	$0
Speaker for Raspberry Pi	$16.01
Various Wires	$0
Cable Braids	$4.00
Goose Neck Camera Mount	$19.95
TOTAL COST	$95.10

7.1 Links for BOM Materials:

LCD Screen:

https://www.amazon.ca/gp/product/B07P3GBWGL/ref=ppx_yo_dt_b_asin_title_o01_s00?ie=UTF8&psc=1

Joystick:

https://www.aliexpress.com/item/32345829014.html?src=google&albch=shopping&acnt=708-803-3821&isdl=y&slnk=&plac=&mtctp=&albbt=Google_7_shopping&aff_platform=google&aff_short_key=UneMJZVf&&albagn=888888&isSmbAutoCall=false&needSmbHouyi=false&albcp=7386552844&albag=80241711349&trgt=743612850714&crea=en32345829014&netw=u&device=c&albpg=743612850714&albpd=en32345829014&gclid=Cj0KCQiAmfmABhCHARIsACwPRAByXUUgfosEl7IODSD2qeWstnqXiUWTK5ToAm9gVxiJJ9KTfsQlHMYaAtcaEALw_wcB&gclsrc=aw.ds

Speaker:

https://www.amazon.ca/gp/product/B07MH1GG2B/ref=ppx_yo_dt_b_asin_title_o00_s00?ie=UTF8&psc=1

Gooseneck Camera Mount:

www.walmart.com/ip/Fotodiox-Gooseneck-Clamp-with-GoTough-Camera-Tripod-Adapter-II-Mount-for-GoPro-HD-Hero2-Hero3-3-and-Hero4/772024779.

XLR to USB:

https://www.amazon.ca/Microphone-Adapter-Female-ConnectorMicrophones/dp/B07ZRTNRBP/ref=sr_1_2_sspa?dchild=1&keywords=xlr+to+usb+cable+6ft&qid=1612651363&sr=8-2-spons&psc=1&smid=A11O4ZQ8R1S7T3&spLa=ZW5jcnlwdGVkUXVhbGlmaWVyPUFXMjQxSEVVVlc5WTImZW5jcnlwdGVkSWQ9QTA2MjM4MTkxOU9ZVzA0OVBQMVhBJmVuY3J5cHRlZEFkSWQ9QTAyMzU5NjBYS1I2T1JNMU5FWEEmd2lkZ2V0TmFtZT1zcF9hdGYmYWN0aW9uPWNsaWNrUmVkaXJlY3QmZG9Ob3RMb2dDbGljaz10cnVl

Cable Braids:

https://www.cabletiesandmore.ca/nylon-braided-sleeving?pid=22086&gclid=Cj0KCQiAmfmABhCHARIsACwPRADgvb7h0m7VC76KTGSz4GWK1nKF0qb2zJ07qldTTXjlNGwHNAdzEacaAj51EALw_wcB

8 Future Recommendations and Conclusion

The prototypes were tested and completed in a timely manner. The team also managed to incorporate ideas and suggestions into the prototypes from Anthony and Roy from the previous client meeting. A bill of materials was developed as the prototyping phases began as supplies were identified and broken down into the products that would best fit our design. For prototype II, the team will continue to assemble, program, design and test the various subsystems identified in the detailed design, as well as develop and look for areas where other systems could be developed or exploited in order to create the best possible design.

9 Bibliography

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"Fotodiox Gooseneck Clamp with GoTough Camera Tripod Adapter II Mount for GoPro HD Hero2, Hero3/3+ and Hero4." *Walmart.com*, www.walmart.com/ip/Fotodiox-Gooseneck-Clamp-with-GoTough-Camera-Tripod-Adapter-II-Mount-for-GoPro-HD-Hero2-Hero3-3-and-Hero4/772024779.

Amazon. (n.d.). [Case for Raspberry Pi]. Retrieved February 06, 2021, from https://www.amazon.ca/gp/product/B07P3GBWGL/ref=crt_ewc_img_dp_1?ie=UTF8&psc=1&smid=AD7LID9K1N4N9

APPENDICES

APPENDIX I: Project Management

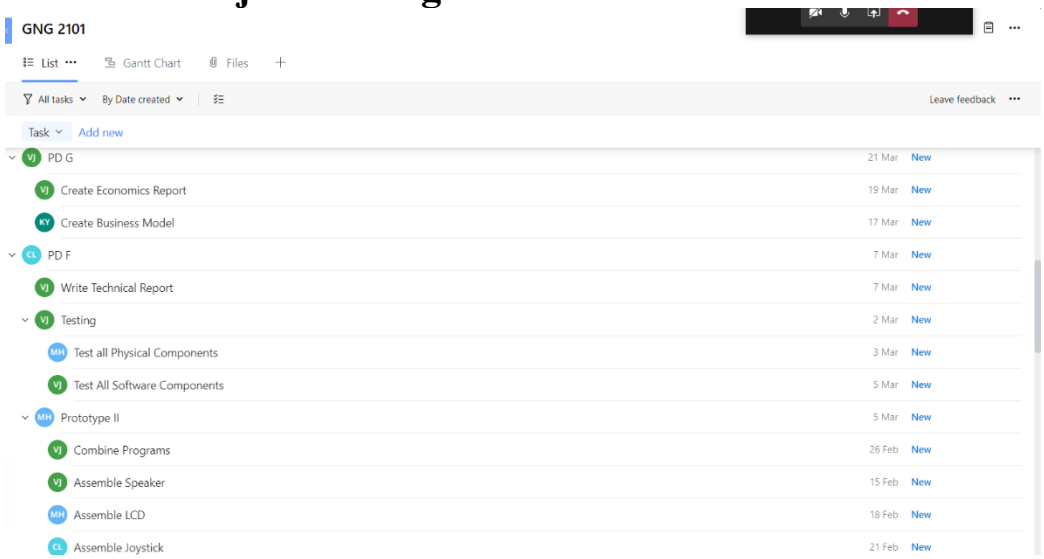

Figure 7.1.1 - Project Management

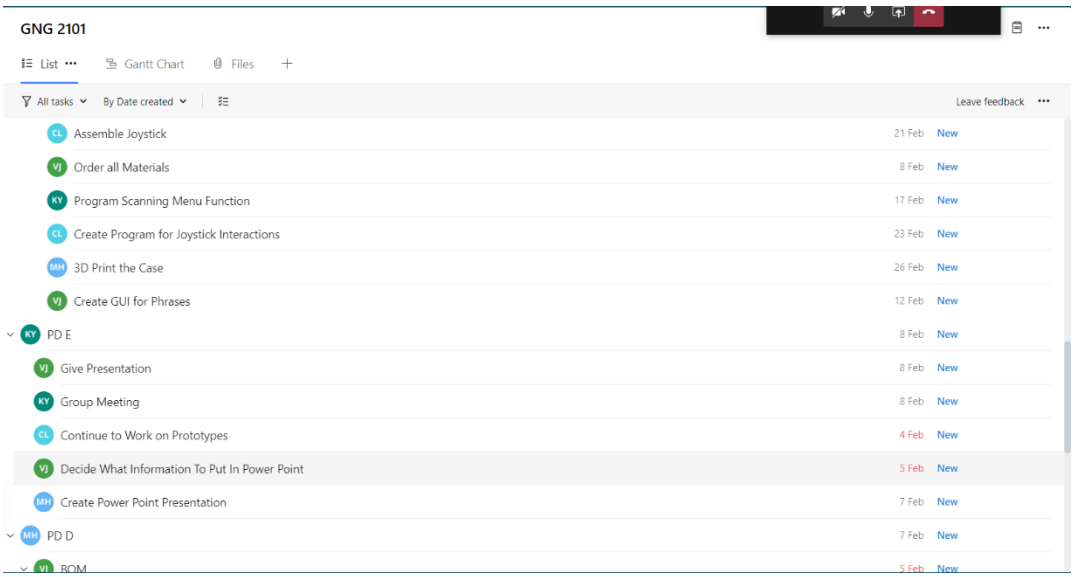

Figure 7.1.2 - Project Management

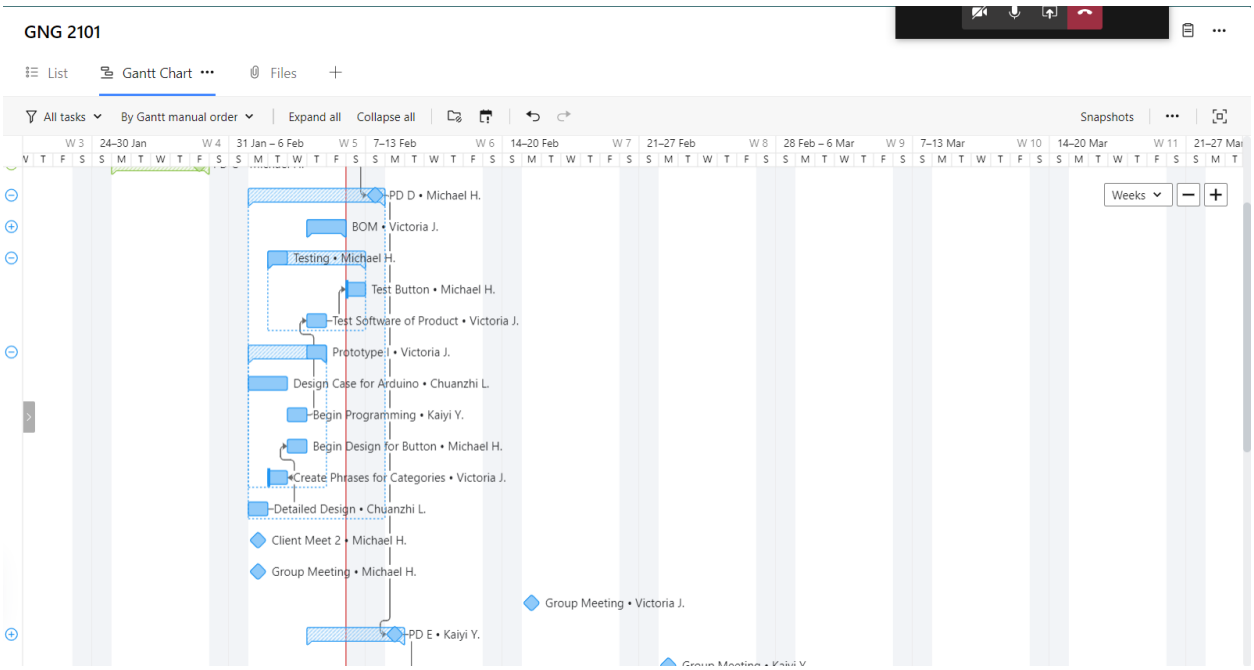

Figure 7.1.3 - Project Management

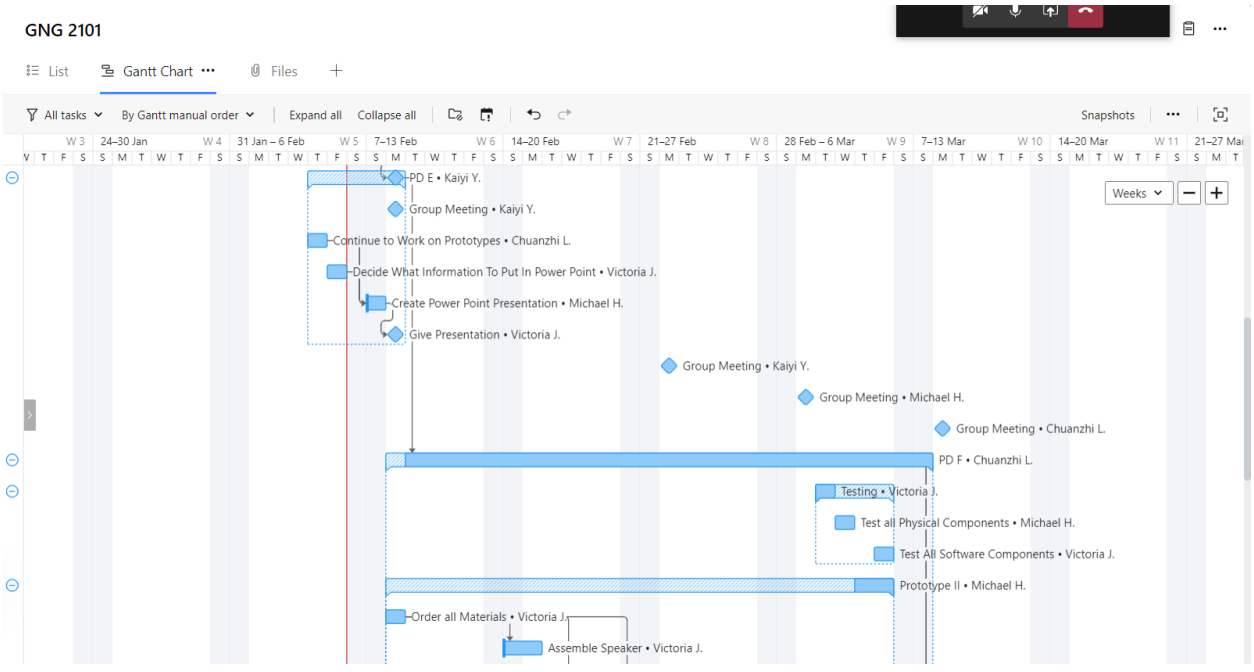

Figure 7.1.4 - Project Management

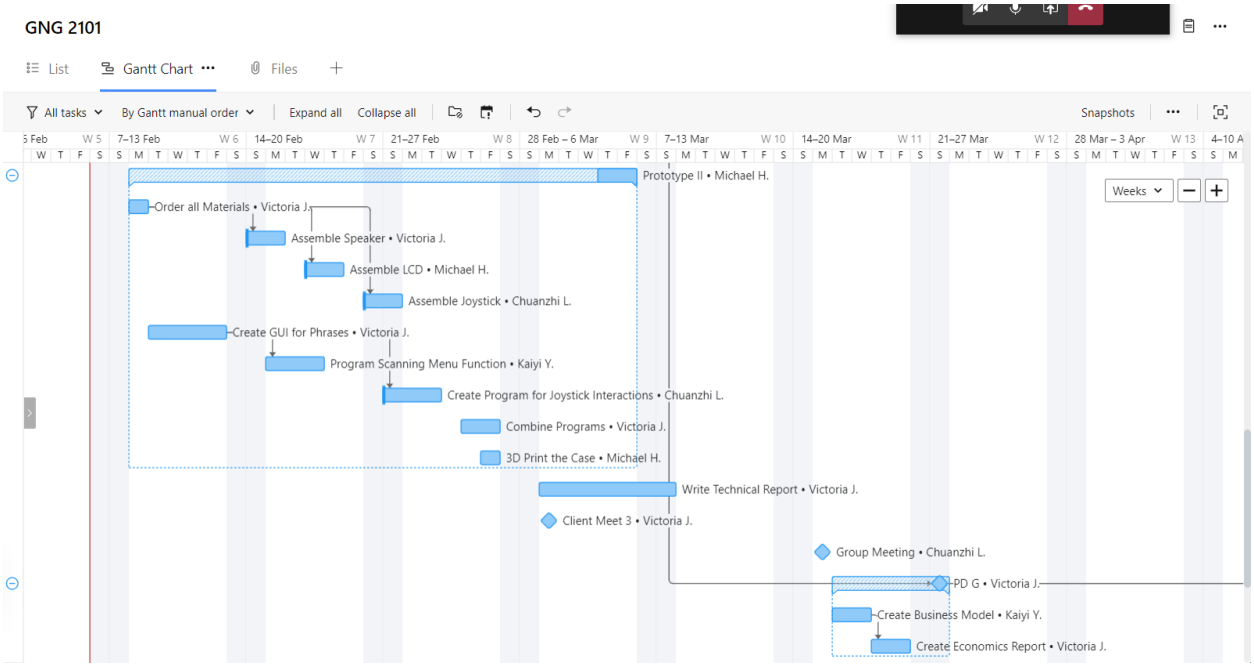

Figure 7.1.5 - Project Management