# GNG 2101

**Product Development** 

# Group 12: Assistive Guitar

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### Abstract

This report exists to document the process undertaken to create a viable and effective product in GNG2101. Our client is paralysed on one side of her body, and wishes to play the guitar. The design is a guitar strumming module, accompanied by a chord assistant module, which, in tandem, make playing the guitar an achievable feat for anyone in our client's position.

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#### Introduction

- Explain why the problem is relevant ("So What?")
- Explain the basic user requirements ("Who Cares?")
- Explain the differentiation in your design or the key aspects that make your product better ("Why you?")

### **Discussion of Work**

- Structure this well (e.g. using an appropriate process, like we did in the course).
- Most of your project deliverables could appear in your final report. Make sure that you Include:
  - Provide documentation for your design process and solution, showing the required research and assumptions that justify your final solution as being the best or most appropriate one. Provide details on how you would take your product to market.
  - Need identification and product specification process (problem statement, benchmarking, metrics, target specifications)

In accordance with the design process taught in 2101 the first step to take was to identify the real problem to be solved. This was done in many ways beginning with a meeting with the client to empathize with her and determine her true needs and any potential client driven constraints of the design. In this first meeting with the client and her father we identified her core needs as:

- 1. A device to do the act of strumming at her input
- 2. A device to make pressing the strings to play chords require less dexterity and force than traditional fretting
- 3. A natural/normal guitar playing experience
- 4. Ability to play favourite song
- 5. A light and balanced guitar to allow for standing play
- 6. A solution that is intuitive to learn, play, assemble, and is durable

After determining these core needs a problem statement was developed to be "There is a need for a product that will allow the guitar to be played through assistive strumming, that is both easy to hold in a natural position and easily assembled. The product is able to be aesthetically pleasing and be adaptive to allow for play of a variety of different chords in a natural playing experience." According to the design process the next step is to benchmark and research. In this step many existing products were found to compare and learn from. These products were largely passion projects that were highly specific with little adaptability to a wider client base. From this research some benchmarks were generated from the shared specifications of the products found. These are largely qualitative as all of the products were presented as hobby inventions rather than well documented projects. The benchmarks were adapted into target specifications which are:

- Produce a similar sound to a traditional guitar in strumming. The loudness should be 50-70 Db and 100-300 strums per minute.
- Be responsive when strum button is pressed with a response time 0.1-0.5 as that is standard in software development.
- The system should not largely affect the weight of the guitar with a system weight of less than 1.7Kg
- The size of the system should not extrude from the guitar more than 13 cm as this would become cumbersome for the user.
- The system should not cost more than \$100.00 CAD according to the course requirements, however the costs of the devices benchmarked are much higher and show that this will be a challenge.

Based off of the benchmarking and the target specifications, a conceptual design was developed. This included a foot pedal for the input system, a series of motors for the strumming system, and a device that could be strapped to the neck of the guitar in order to make playing chords easier.



Figure 1

For the original design of the strumming device (Figure 1), there would be six picks and six motors, each hovering over one string. This allowed for individual strings to be picked at a time, which meant that picking would also be an option (not just strumming), and the device could be programmed to only strum a certain number of strings for the appropriate chord. The motors would slightly spin each individual pick in order to strum the guitar. A foot pedal would make up the input system. There was a bit of flexibility with this, since multiple pedals could be used to do different things. Some of the possibilities included one pedal for down strums and one for up strums, one pedal for ever strum, or one pedal for each chord (so only the appropriate number of strings would be played each time).

An important step of the process for any start-up after conceptual design is a quick reality check: we refer to this as a feasibility study. This project's budget seemed feasible at the time, based on our estimated Bill Of Materials (BOM). The timeline was feasible as well, despite the complexity of the project. This timeline however was greatly disturbed by Canada Post's strike (which will be discussed later). The level of interest from the general public that is necessary for success was also deemed feasible, and this estimation was proven correct with a great deal of interest at Design Day, including a radio interview and local schools inquiring about having us present the prototype to their students. Additionally, with the preliminary research we conducted, we discovered that a large proportion of Canadian society could benefit from the device: many people have strokes, are born with an ineffective or missing limb, or have injuries that make playing a guitar naturally impossible. Given these details, it is clear that the design is feasible, and the creation of prototypes began.

Our first physical prototypes were made from cheap materials that were easy to find around the house, like popsicle sticks and cardboard. They were mainly used for measurements, to see if the different components would fit properly on the guitar, and to determine what the client was comfortable with. She also had a hard time visualizing the solution based off of our drawings, so our first prototypes helped give her a better understanding of what it would look like and how it would work.

The first conceptual design for the strumming system consisted of a device that mounts to the surface of the guitar with a motor and pick for each string of the guitar. The prototype pictured in figure 2 is a low fidelity prototype designed to get input from the client and communicate the direction we were taking

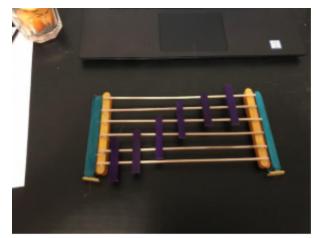
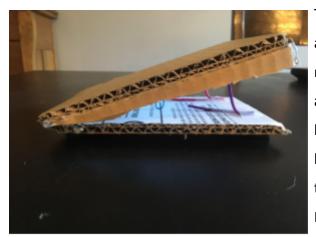


Figure 2

with the project. It was because of this meeting and this prototype we learned that the 1 motor/pick : 1 string concept was not feasible for weight, balance, volume, budget and aesthetic constraints.



The foot pedal (Figure 3) was made of cardboard and elastics, and it was used to mainly for measurements. We asked our client if the size was alright, and we measured how high she could lift her foot off the ground. This was used to determine how high the pedal could be while still allowing her to press it comfortably.

Figure 3

For the chord assistant (Figure 4), our first physical prototype was also made out of cardboard. It was used to test if it would fit around the neck of the

guitar, as well as what size button our client was comfortable using. We measure how far each each of her fingers could stretch apart from each other, and how far she could stretch them upwards, in order to determine how far apart the buttons could be.

Both the chord device and the pedal had second physical



prototypes, while the strumming device went straight to the final product. Our second prototypes were printed from 3D models, and again

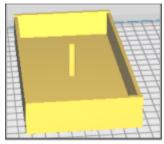


Figure 4

used mainly to make sure our measurements were correct. The prototype for the chord device (Figure 5) was used to determine how the device would sit on the neck of the guitar, as well as to measure the distance between strings and determine where we could put additional supports.

Figure 5

The pedal was also 3D-printed (Figure 6), and was used to help our client visualize the final product and to make sure it was the right size. We tested it with her foot size to be sure she could step on it properly. We chose to use a keyboard beneath the pedal, so that



the pedal would press one of the keys every time it was stepped on. A peg was placed in the center on the bottom of the pedal in order to push the key. Figure 6 shows a 3D model of the pedal upside down, with the peg facing upward.

The final strumming device (Figure 7) was created through the use

Figure 6

of 3D and purchased components. It was loosely based off of a passion project called MuseX. In the model we created there were two servo motors that were used to adjust the picks height while a stepper motor and belt was used to move the pick and pick holder across the strings. With all of the motors were hooked up to an arduino. In addition the two base plates that were 3D printed had command strips attached to the bottom in order to adhere to the



Figure 7

guitar. For the testing component we ran several codes to ensure all of the motors moved in the correct directions and at the right speed. Both of these tests were successful and demonstrated that with the proper coding it could work to the desired specifications. During testing however it was found that the code created for the arduino was not compatible and thus no full scale test was conducted.



For the final foot pedal product, we attached the pedal to a keyboard using two bolts at the back. A spring was place underneath at the front to allow the pedal to hover over the keyboard, and so that the peg underneath would press the enter key whenever the pedal was pressed.

Figure 8

For the final prototype of the chord assistant a few modifications from prototype 2 were made. First the dividers were added to hold each button more securely on the strings and help in

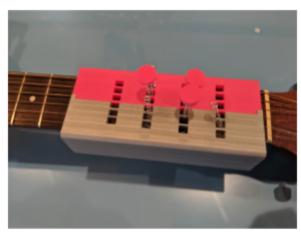


Figure 9

keeping them centered. The enclosure over the neck was also redesigned to be smaller and optimized for the clients hand size. Finally bumpers were added to the inside of the enclosure to keep the whole device in line with the neck and prevent it from sliding around. There are still some unresolved issues with the current design most critical of which is the buttons continue to slip off the strings. This is going to be resolved in the future with either a slit in the pad that contacts the string or a spring pad that rests around the string to keep the pad from accidentally contacting the string. This final

prototype does meet some of the original design goals in that it can be comfortably held and used by the client and meets the client's aesthetic consensus needs. It ultimately fails as a final product because of the inconsistent behavior of the buttons and thus will continue to be improved in future.

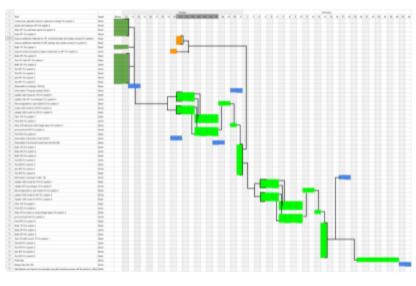
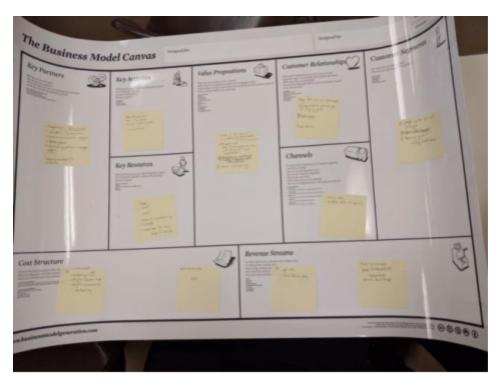


Figure 10

To ensure that we stayed on the desired schedule a Gantt Chart (figure 10) was created for all of our required steps in the creation of our project. In this chart it was outlined all of our dependencies and significant events. During the creation of the design several of our initial plans had to be scrapped or changed and thus changes to the chart also had to be made. One of these changes was for the strummer. We moved from a multiple motor system to

a single stepper motor due to time and feasibility. This was a big change that cost a lot of time and required new concept designs to be created or adapted. This put us behind our desired time scheme. In addition delays in deliveries from canada post and Amazon caused further delays in our project planning and timing.



## Figure 11

After discussing pay per download models, manufacturing and open source models, it was decided that the system we will use as a business model is one of free downloads with a link to donate money. The license will be open source, creative commons license attribution noncommercial. This was decided to limit the amount of work necessary to keep up the business whilst maximizing our triple bottom line. Our triple bottom line features a negative fiscal bottom line that becomes less and less negative over time until at some point the donated money is equal to or greater than the amount of money spent on this project. The social bottom line however is what stands out, as this model allows us to maximize the positive social impact of our enterprise: anyone and everyone who desires the device may have the device at only the cost of their time and the parts.

This project cost much more than expected to create and produce. We had an initial budget of \$100 but later had it increased to \$150 due to the shear amount of high cost purchases that needed to be made. Our final cost came to a grand total of \$198.69 including shipping costs. This value is almost \$50 over our raised budget and will have to be absorbed by the team. In addition a business expense plan was created for the first three years, if we

decided to continue this and turn it into a business. The following data is our business expenses:

### Three Year Income Statement

	Year 1	
Sales Revenue		\$90,000
Cost of Goods Sold		\$50,000
Gross Profit		\$40,000
Operating Expenses		
	Facility Rental	\$5,500
	Electricity and Utilities	\$4,000
	Staff and Work Insurance	\$10,000
	Staff Salary	\$30,000
Operating Income		
		-\$9,500
Costs Equipment		\$10,000
Patents for Design		\$9,000
Software Set Up		\$7,500
Final Income		
		-\$36,000

Year 2			
Sales Revenue		\$100,000	
Cost of Goods Sold		\$50,000	
Gross Profit		\$50,000	
Operating Expenses			
	Facility Rental	\$5,500	
	Electricity and Utilities	\$4,000	
	Staff and Work Insurance	\$10,000	

	Staff Salary	\$30,000		
Operating Income		\$500		
Year 3				
Sales Revenue		\$130,000		
Cost of Goods Sold		\$45,000		
Gross Profit		\$85,000		
Operating Expenses				
	Facility Rental	\$5,500		
	Electricity and Utilities	\$4,000		
	Staff and Work Insurance	\$10,000		
	Staff Salary	\$30,000		
Operating Income		\$35,500		

Our other option was to do a pay to download business plan. In this way customers would pay us per download for the instructions and STL's. We proposed that we would average around 100 downloads annually after the first year. And remaining steady for a continuous 4 to 5 years.

### **Conclusions and Recommendations for Future Work**

Lessons Learned:

- Evolutionary design techniques are efficient and also allow for a great amount of innovation. Initially our perception of this design technique was negative, however, we learned that reinventing the wheel on each design is time consuming and risky.
- Start ordering parts early in case of shipping slowdowns: Canada Post, as mentioned before, had a strike that caused much of our hardware to come late, which pushed our schedule out of the realm of possibility.

Suggestions for more productive avenues:

• Limit dependencies and establish a more concrete BOM earlier on, our team suffered from a longer than necessary critical path that was made impossible by a strike with Canada Post.

# Bibliography

• https://www.instructables.com/id/Musex/

### Appendices

User Manual:

https://docs.google.com/document/d/18ze\_sOJfKRPIPrjGveyIkqRh9LX0-I3tp6fUjCXlsxY/edit?us p=sharing Foot Pedal STL:

Source Codes: https://drive.google.com/drive/folders/1Ex5sl4sEEd4Uo1CsccgQOgKYsoKSe7Rb?usp=sharing

STL's Used for strumming component: -<u>BeltRectangle.STL</u> -<u>MotorHolderBaseAssembly-ACTIVE.STL</u> -<u>MotorHolderBaseAssembly-PASSIVE.STL</u> -<u>DowelServoMotorConnectors.stl</u> -<u>PickCart\_April9.STL</u>