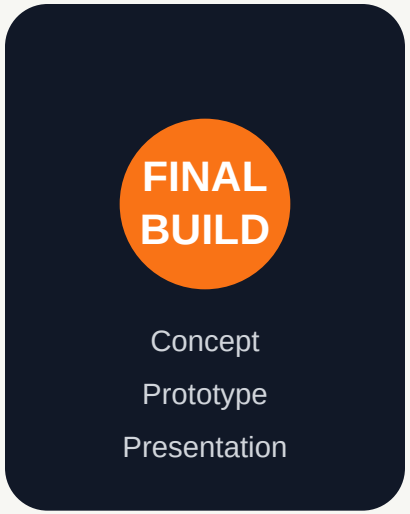
TEAM METALLICA DESIGN PROJECT

The Electric Stick

Design Map + Final Presentation

This class project focused on creating a simple, affordable, and fun-to-play musical instrument. The team moved from early concept sketches and rough prototypes to a CNC-cut electric string instrument designed to be tunable, amplifiable, low-cost, and accessible for beginning musicians.

Included Team design map and final class presentation slides



Compiled for Joseph Lilly Jr. | Spring 2025

Week 1-3

Mission:
To create a simple, cost effective, and fun-to-play instrument

Concept:
Musical Instrument

Constraints & Criteria:
- Be original
- Have at least 23 pitches (2 octaves)
- Be easily tunable
- Produce at least 70 dB at 2 meters / connectible to an amplifier
- Use accessible materials
- Assembled within 8 hours
- Cost no more $60

Initial Thoughts/ Ideas:
When initially drawing the prototypes for the in class assignment, team members mainly drew string and percussion instruments.

Rough Rapid Prototype 1:
We tried to imitate a pan flute by taping multiple straws together and cutting them diagonally from the bottom part.

Rough Rapid Prototype 2:
This is a rough prototype of sticks on a ruler secured with rubber bands. While on a table, flicking the sticks makes a buzzing sound.

General Notes that came out of brainstorming:
Brainstorming helped us experiment with different types of instruments which helped us build our prototypes.

Prototype 1: This is a recorder-like instrument. The balloon was taped to serve as a mouthpiece, with a hole cut into it. Additionally, 4 holes were drilled into the recorder: 3 on the front, 1 on the back. To further improve this instrument, more holes could be drilled and a real mouthpiece could be built.

Prototype 2: This is a guitar-like instrument with multiple real guitar strings screwed into the wood. This could be improved by using a wider wood to add more strings.

Prototype 3: This is an instrument where putting pressure on the wood pieces from different lengths makes different sounds. It resembles a thumb piano, and could be improved by securing the sticks on real wood.

General Notes that came from prototypes: The prototypes were definitely an improvement from our rough rapid prototypes. This takes us a step further to develop our instrument. All 3 prototypes have good potentials to turn into real musical instruments.

Week 4-5

Cool Concept Prototype 1: The recorder prototype was pretty good for our first real prototype and we got feedback from other people in the initial designs showcase. The YoYo day was a good opportunity to decide what to improve on. More and smaller holes could be drilled and a real mouthpiece would be a good way to improve on this recorder-like instrument based on the feedback.

Cool Concept Prototype 2: This carved wood piece is a good start to develop a string instrument and could definitely be improved on. Adding strings, a base to the guitar and a tuning system could better this and turn it into a real instrument.

General Notes that came from cool concepts: Feedback from the initial designs showcase helped us listen to other perspectives and have an idea on how to improve our prototypes. We decided to move forward with Prototype 1 & 2 eliminating the third one. The first two definitely have more potential as instruments. Some feedback we received were that the first prototype needed a mouthpiece and more holes and the second prototype could be improved by adding strings, a headpiece and a tuning system to become an electric guitar.

Week 6-7

Testing & Validation 1: Testing and evaluating each prototype helped us decide to continue with the first two prototypes. The third prototype didn't resemble an instrument as much as the first two. We could associate the first one with a recorder and the second one with a guitar. Therefore, with the feedback from the showcase and discussing as a team, we stuck with Prototype 1 & 2.

General Notes from Testing: After careful discussion with the team, we all agreed on keeping and improving on the first two prototypes. Everyone was content with this decision so it all worked out.

Week 8-9

Prototype 1:
Good:
- Has holes
- In the right shape
- Makes sound

Bad:
- Not enough holes
- Holes too big
- No recorder head
- Large

Prototype 2:
Good:
- Base is complete

Bad:
- No strings
- No aux cord
- No guitar head

General Notes from Working Prototypes: Making full working prototypes from each option helped us take a step closer to turning them into real instruments. The initial showcase definitely helped with knowing what to improve on. For the guitar, we will add strings and an aux connector to make the electric guitar audible and functioning. And smaller holes with a mouthpiece would improve the recorder to the next level.

Week 10 - 11

One possible improvement: the recorder would be adding a real mouthpiece. This will be done after the intermediate designs showcase if we decide on the recorder as our final instrument.

One possible improvement: our Electric guitar prototype would be to add strings. We are planning on adding strings before the intermediate designs showcase.

General Notes from Improvements: Trying out variations included using paperclips and screwing them on the wood which took some effort but worked out in the end. For the flute, drilling small holes made this variation better than the previous ones.

SHOWCASE

Chosen Final Design:
We presented both prototypes in the intermediate designs showcase and received feedback from other teams. Since the aux cord was missing the guitar did not make sounds that were loud enough to be heard but the strings were still functioning. The recorder made sound but was missing its headpiece. Besides that, we did a good job as a team and will probably decide on the guitar as our final instrument.

General Notes from showcase: The showcase helped us hear other people's perspectives on our two prototypes. They both received good feedback. Based on that, a guitar head, a recorder head and visually better looking instruments could improve our instruments.

Week 12-14

Testing and how we evaluated technical specifications:
High satisfaction with the design and quality despite being made from cheap materials

Interviews with musicians about the design: Constrict the strings more
Lower the bridge for the height of the strings to be lower
Readjust the frets to be closer to the base (rule of 18ths)

General notes: Testing and interviews with musicians helped us gain some tips on how to improve the design. For it to look like a guitar we could add a guitar head and the design could visually improve.

One possible improvement: to the design, is adding an aux cord so the tunes are more audible

One possible improvement: to the design, is visually improving it by painting it and using the same type/color of strings.

One possible improvement: to the design is adding a guitar head.

Adding an aux cord definitely helped a lot but we do need a speaker for it to be loud enough. We used the same type of strings, however one of them broke.

Due to time constraints we could not add a guitar head but we still made the design look cooler.

General notes: The final design was visually appealing but playing it was hurtful on the hand so it's not an instrument that could be played for long periods of time.

FINAL PRODUCT

Final design for final showcase: Our final design looks visually more appealing however we had four strings and one of them broke which was unfortunate. Besides that the aux cord worked well and the tunes are audible enough.

Some general notes for future designs: Creating the final design was very time consuming so we could have just used the prototype and improved upon it.

Notes/Ideas | Image w/ Description | Testing and Validation

The Electric Stick

Musical Instruments Final Presentation

Metallica

Presented by
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Date: 4/16/25

Purpose of This Project

Purpose:

- Make Affordable Music

Target Audience:

- Anyone getting into music

Why is it Important?:

- We believe it’s important to give everyone an equal opportunity

Our Design Must...

- Be Original
- Have at least 23 pitches
- Easily tunable
- Produces at least 70 dB
- Materials are accessible
- Cheap Cost

Our Best Design

Improvements:

- New material
- CNC cut to precision
- More durable (doesn’t split)
- Looks cooler

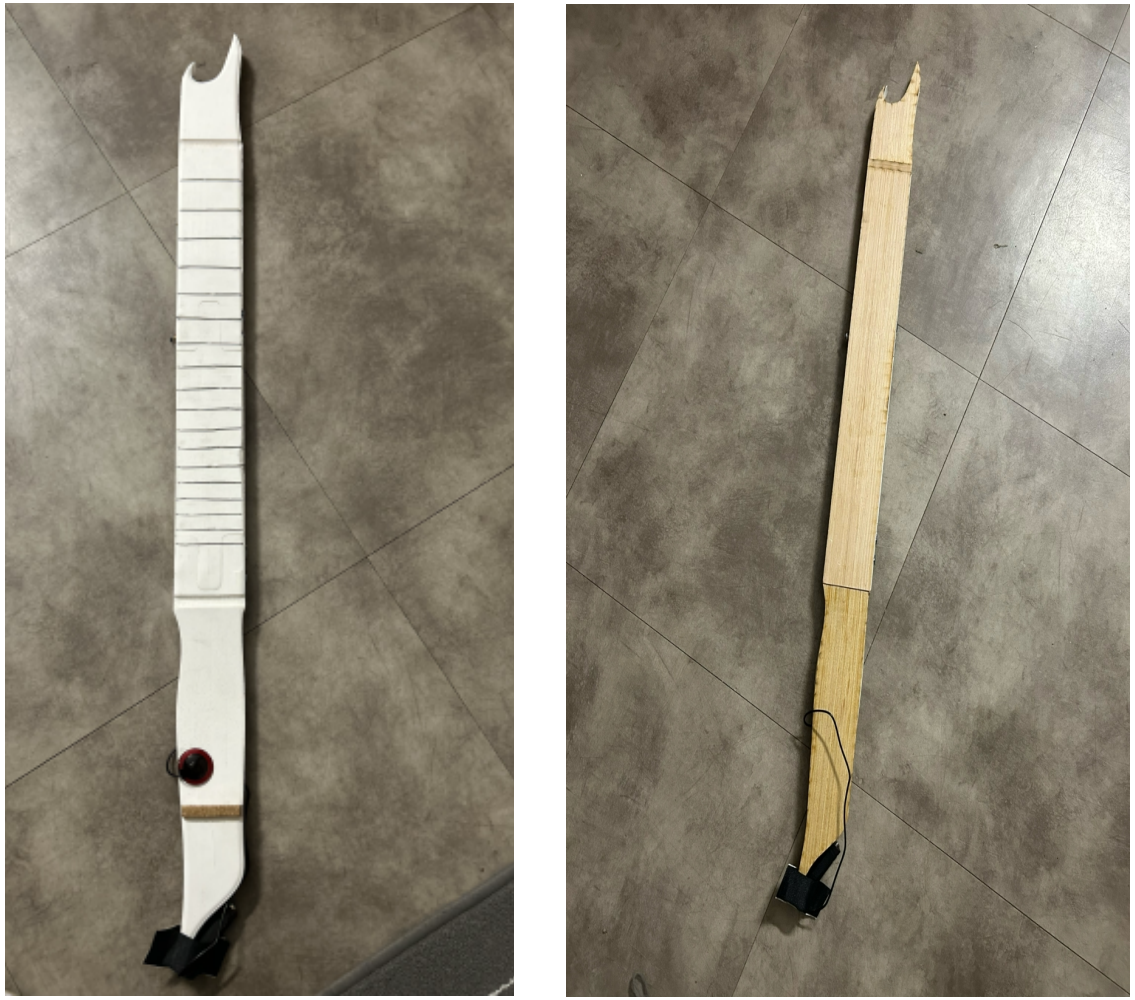


Figure 1: Final Design

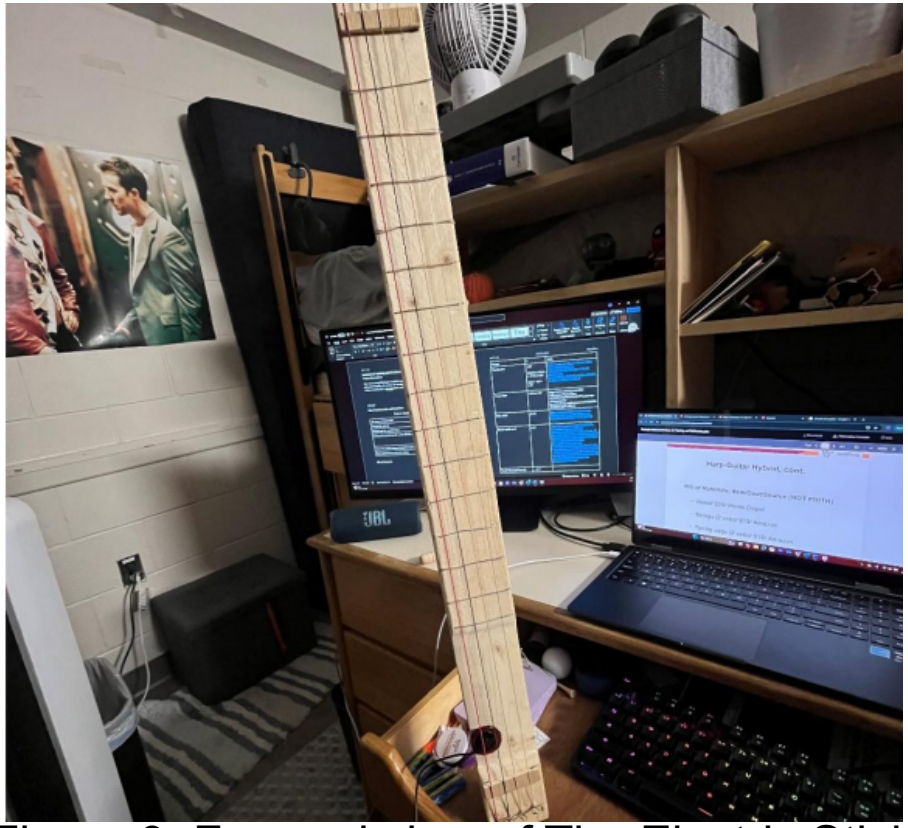


Figure 3. Forward view of The Electric Stick v2

Figure 4. Side view of The Electric Stick v2

The Electric Stick Visuals

Table 5: Pitch Data

Pitch #	Initial (Hz)	At 15 min (Hz)		Pitch #	Initial (Hz)	At 15 min (Hz)
1	247.56	247.1 (B)		13	237	237 (A#)
2	244.7	244.7 (Bb)		14	253	252.45 (B)
3	160	160.79 (Eb)		15	128	128 (B)
4	161	161.25 (Eb)		16	176	176.2 (F)
5	118	117.8 (A#)		17	284	284.1 (C#)
6	243	243.7 (A#)		18	305	305 (D)
7	81	80.69 (D#)		19	221	220.76 (A)
8	260	259.8 (C)		20	225	224.5 (A)
9	131	130 (C)		21	178	178.1 (F)
10	76	67.2 (C)		22	144	144 (Db)
11	240	240.5 (B)		23	409	408.34 (Ab)
12	160	159.98 (Eb)		24	635	636 (Eb)

Cost Table

Amount and Description	Total Cost ($)	Source (Frith, or other source's URL)
Wood	5	here
Strings	1.89	here
Tuning pins	3.28 41 dollars/50 pins = .82 $ per pin 4pins * .82 = 3.28	here
Paper Clips	3.88 for 100	here
Mini AMP	20.90	here
Guitar audio cord	6.64	here
Total Material Cost ($)	~ 41.59	

Table 2: Costs of materials

Baseline Conditions for Testing

Table 1: Conditions & Testing for Electric Stick v2

Air source, if applicable	No additional air is needed
Weight (lb and oz)	3 lb (48 oz)
Output jack for amplification	Included near the base
Estimated material cost for a non-ENGE student ($)	Wood: ~5 dollars Strings: ~ 6 dollars Pick up: 2 dollars Screws and nails: ~ 2 dollars
Setup time, from storage/transport to play (minutes)	2 mins
Pitch adjustment method for tuning	Tighten top screws

How to Assemble / Past Prototypes

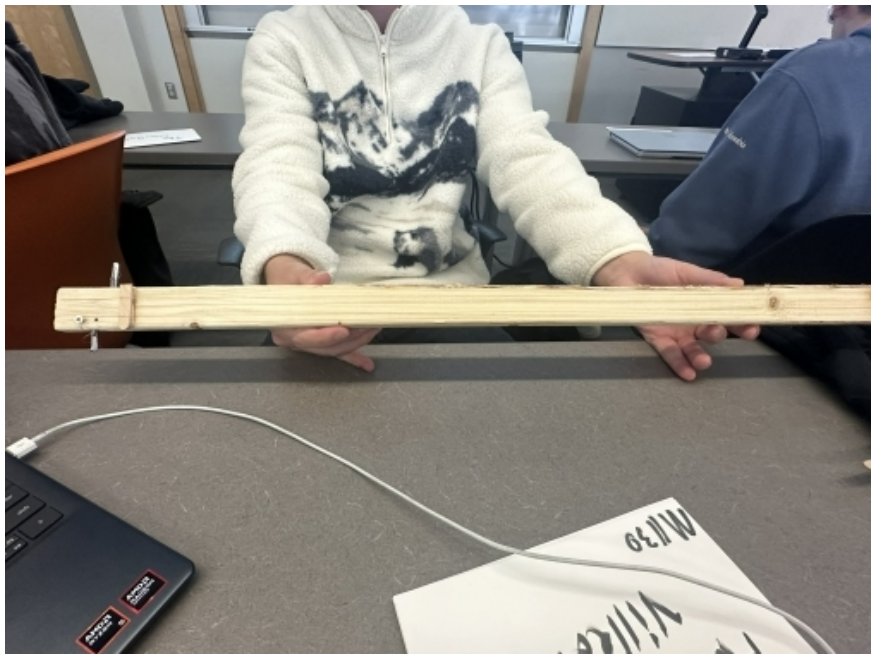


Figure 2: First Design Electric Stick v1

This is our first prototype. There was 2 strings, and it was there were many cons.

- Hard to play
- 2 strings
- Bad sound
- Looks bad
- Very hard to tune

How to Assemble

Figure 5: The Sketch

Figure 6: The CAD

Figure 7: The CNC

Limitations

Pros:

- Slim Design
- Tunes well
- Makes Good Sound
- Fun to Play
- Safe

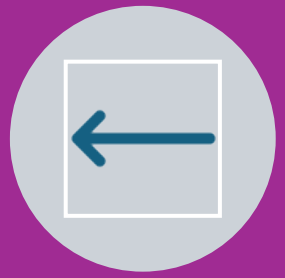
Cons:

- Bows
- The strings are too high
- Messy
- Pickup Falls out

essons Learned – Technical Perspectiv

Electric Parts are no Joke

CNC Router



Redo CNC cuts

Different materials

Lessons Learned - Professional Skills

01

START FINAL DESIGN SOONER

02

COMMUNICATE MORE

03

DIVIDE UP WORK WITHIN ASSIGNMENTS

04

MEET MORE OFTEN

Musician Feedback

- High satisfaction with the design and quality despite being made from cheap materials
- Constrict the strings more
- Lower the bridge for the height of the strings to be lower
- Readjust the frets to be closer to the base (rule of 18ths)

Summary

- Revolves around its simplicity, affordability, and enhanced functionality.
- The Electric Stick v2 is crafted with CNC precision using durable materials, ensuring reliability and longevity.
- It’s easily tunable,
  - clear sound with at least 23 pitches and reaching over 70 dB output.

This accessible design empowers aspiring musicians, allowing them to create music without the burden of high costs. With improvements to aesthetics and performance, The Electric Stick v2 truly stands out as a practical yet innovative solution.

References

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