MIDIfiable

Technological Design Project

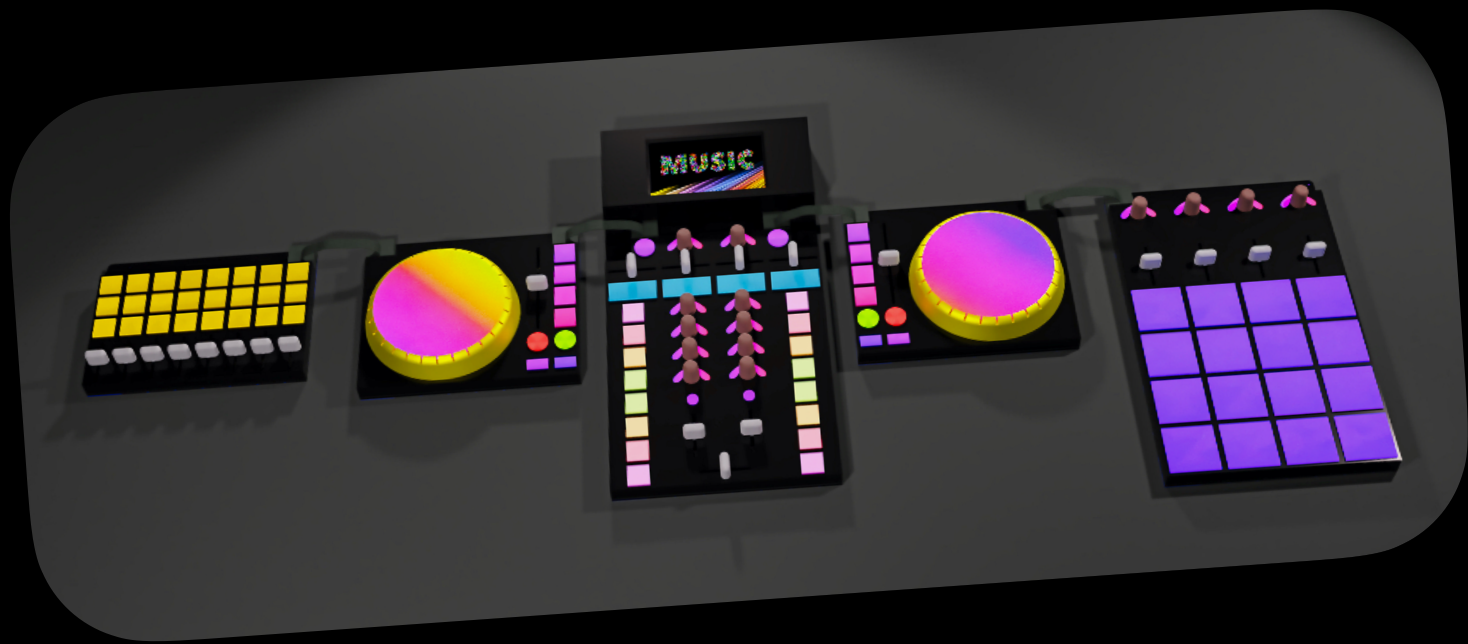
Year: **12**

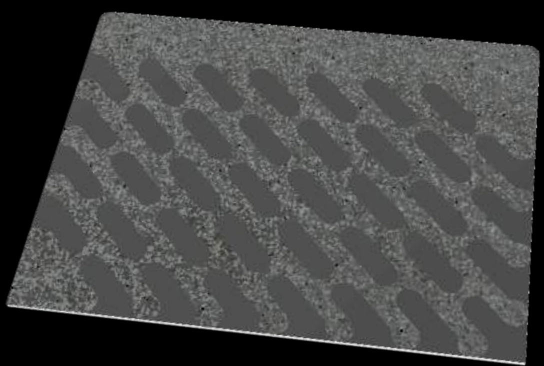
Design Statement:

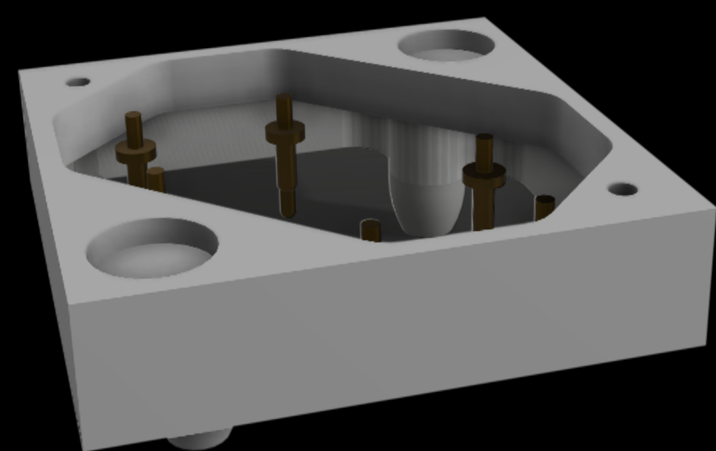
To improve the **flexibility** and **customisability** of **MIDI based Human User Interface devices** such as **DJ controllers**. This will be achieved by creating a **<u>Modular MIDI controller</u>** that is **user customisable** and effective in a **wide variety of MIDI systems**.

Synopsis:

Current MIDI controllers, **especially DJ controllers**, **lack** the **flexibility** to **customise hardware configurations**. They also have **limited serviceability** and **repairability** with many vital components being **prone to breaking**. Making a **modular MIDI controller will alleviate** both these issues and would be perfectly **suited to hobbyist DJs** looking for the latest innovations in musical computer hardware.







1. Project Proposal & Management

PROBLEM IN SOCIETY	FURTHER EXPLORATION	JUSTIFICATION
The Health Advice Problem has been created from the excessive amounts of research and information making it hard for everyday people to find reliable medical advice.	✓	I will look further into this as it is something I have personally found to be a problem especially when looking for natural solutions.
Function Planning can be difficult when everyone specifies days they are and aren't available. It can become hard to solve which day suits the best.	✗	I won't look further into this as I believe it is more an inconvenience rather than issue.
Popular search engines such as Google are notorious for logging user data and tailoring results to each person. Trying to find **unbiased information** such as news can be an issue.	✓	I will look further into this as I value privacy and unbiased information and believe this issue is growing at an ever increasing rate.
MIDI Controllers are a tactile interface for controlling computers, especially in musical applications and stage lighting. However, requirements vary and with thousands of available choices, finding one perfectly suited to a users needs can be extremely difficult.	✓	I will look further into this as I see a vast range of related issues and plenty of scope for improvement. It is also an issue that has affected me personally.
Heat Shrink is commonly used to insulate electrical cables, however, it relies on having a free end of the wire to thread it onto. Electrical tape is not an effective solution as it leads to electrical hazards as it deteriorates.	✗	I will not look further into this as it is not my area of expertise or interest. I also believe this is likely already solved by other products.

Ideation:

I initially brainstormed many problems in society, a section of which are shown in the notes above. I discovered around **25 problems** I was **interested in or had experienced**, then picking the **top 5** for the table to the left.

This table was an **effective organiser** for me to compare these problems and decide whether to continue with further exploration. I decided to look further into **three of these** to gain a broader understanding before deciding on a single one to continue with for my HSC Design and Technology Major.

Identification & Exploration of Genuine Needs and Opportunities

1.1

The Health Advice Problem

The **Health Advice Problem** refers to the issues around health advice for **minor medical issues**. Firstly, according to doctors judgements, around **41%** of GP visits are **unnecessary**. (See: https://pubmed.ncbi.nlm.nih.gov/2284523/) On top of this, personal experience often reveals that for these minor issues, many doctors would **give completely different advice**, often prescribing antibiotics when **not necessary** to solve the issue. This is accentuated with patients who would prefer **natural** rather than **chemical** solutions, only to find the extremely vast variety of "cures" online makes it **impossible to find the verdict**.

Design Situation & Target Demographic:

Far too much medical information is available online, often with **no effective sorting** solutions. The tech savvy demographic and home remedy gurus need an effective solution to l**ocating reliable medical information** online that **aggregates sources** and provides **relevant and proven true information**.

Market Opportunities & Research:

Various websites already exist attempting to solve this problem, **Medscape** for example provides supposedly reliable medical news (See: https://www.medscape.com/). **Mayoclinic** offers a **symptoms checker** that attempts to suggest the issue based on the users **symptom descriptions** (See: https://www.mayoclinic.org/symptom-checker/select-symptom/itt-20009075). While these individually seem to solve various areas of the issue, it still **isn't a complete solution**. Firstly, each only involves a **single source of information - their own databases**. Secondly, the **financial motives** of the companies are **unknown**. They could have **tailored information** aiming to **sell more pharmaceutical medication**.

SWOT Analysis

Strengths

- Experience with programming
- Experience working with data
- Many sources of information available to combine and utilise

Weaknesses

- Limited medical experience
- Don't have access to the likely high levels of required computing power or servers required
- No current industry links

Opportunities

- Could be beneficial with growing population and limited hospitals
- Recent COVID Circumstances open new needs for limited contact and off site treatment

Threats

- Similar to existing solutions
- To gain market share will require large investments, especially to compete with large search engines

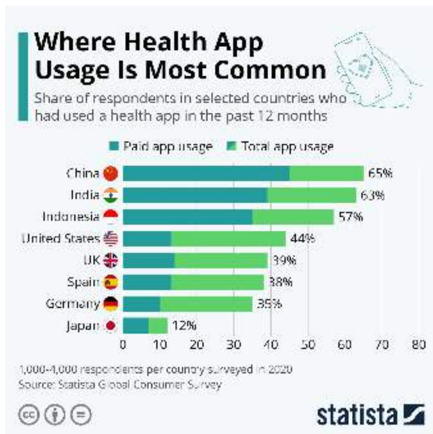
Ideation:

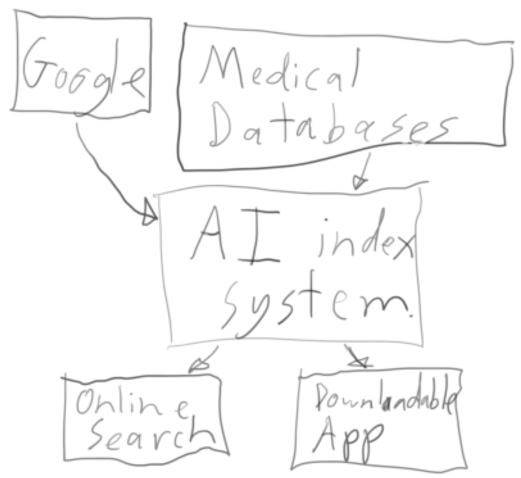
Ideally, a solution would need to **incorporate multiple organisations** and **sources of information**. It should also be able to suggest **secondary options**, such as less common **natural practices etc**. While the need definitely exists, it may be **difficult to fill** this market gap as it is **partially solved** by some companies and many people **may not consider** the problem but rather simply take the **first advice they find**.

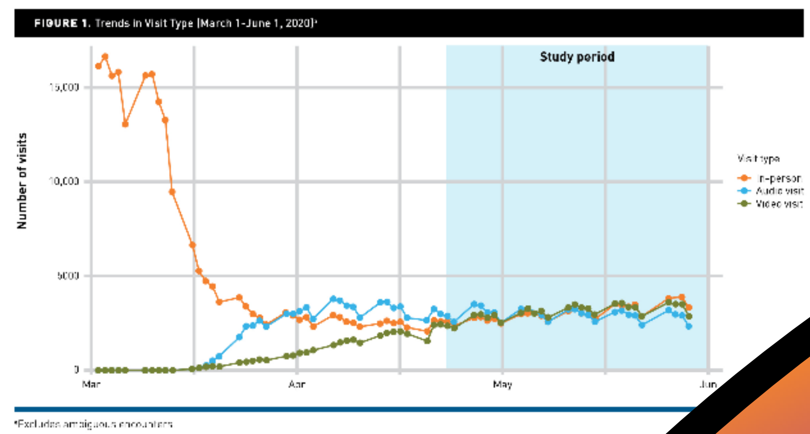
One idea for solving this issue is to create a **data analysis and indexing system** that takes results from medical databases and search engines to **look for patterns**. It would then be able to find **reliable** and **cross referenced** results for any condition. It could give **unbiased results** and show a **"certainty"** factor based on **how well matched** information is from **seperate sources**. The flow chart sketch on the right shows how this would work. It would come in the form of a **simple website** search system similar to Google.

Evaluation:

The Health Advice Problem is a **growing issue** with **many complexities** and **possible solutions**. The nature of the problem involves **masses of information**, and while a prototype may be possible for this MDP, I will not be continuing with this. **My interests aren't in copious amounts** of data analysis or coding and the **market is complex** with many solutions already starting to arise to fill the gap. For this reason, I **will not** be continuing a Major Design Project on this issue.







The Unbiased Information Problem

The **unbiased information problem** is one that has been a part of the way humans have functioned for many years, especially in political scenes. Generally, people are attracted to others with **similar ideas and beliefs**. This means that often, people **aren't confronted** with opposing ideas and values. However, this is **greatly exaggerated** by the **use of technology**, as all the information we digest is **filtered and tailored** to our **best interests**. It is no longer the same newspaper for everyone. Instead, it's a feed **designed to keep our attention** the longest, **regardless of the content**. The result is inevitably that people are **only fed with what they agree** with, causing a greater divide and **less understanding in the world**.

Design Situation & Target Demographic:

With most of the younger generations and working population using **modern technology** for finding information and news, getting a **well rounded** view of what is going on in the world is very difficult. The basis of this issue stems from the **largest motivator** for current companies being **profit** (through user engagement) rather than equal and **unbiased** representation of results. This growing demographic is in need of technology that gives relevant information while avoiding the extreme targeting that is causing such large divides and misunderstanding in our world.

Market Opportunities & Research:

The market in this area is very **overcrowded** and **cloudy**. Many browser applications like Brave Browser **emulate** popular options like Google Chrome but with claims for **far superior speed** and **reduced tracking**. Many search engines claim to do the same, such as Duck Duck Go, a popular "**incognito**" search engine. The problem is for most users, it is **impossible** to **verify** whether these services live up the their promises. Even many **advanced IT companies** have **failed to verify** how truly protective they are, especially with tracking becoming more and more advanced every day.

SWOT Analysis

Strengths
- Experience with programming
- Understanding of IoT
- Understanding of Digital Tracking
- Experience working with data

Weaknesses
- No access to servers or advanced developer tools
- Minimal industry links
- To make effective final product, advanced programming required

Opportunities
- Could be complimentary and valuable to existing services
- Could help grow the market
- Privacy is often highly regarded in modern society

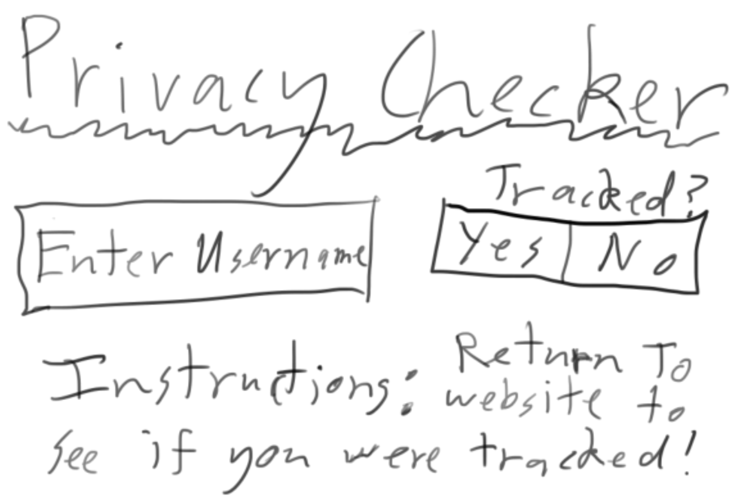
Threats
- Market is overcrowded
- Gaining awareness can be tricky
- Revenue could be hard to generate
- Can be tricky to make guarantees

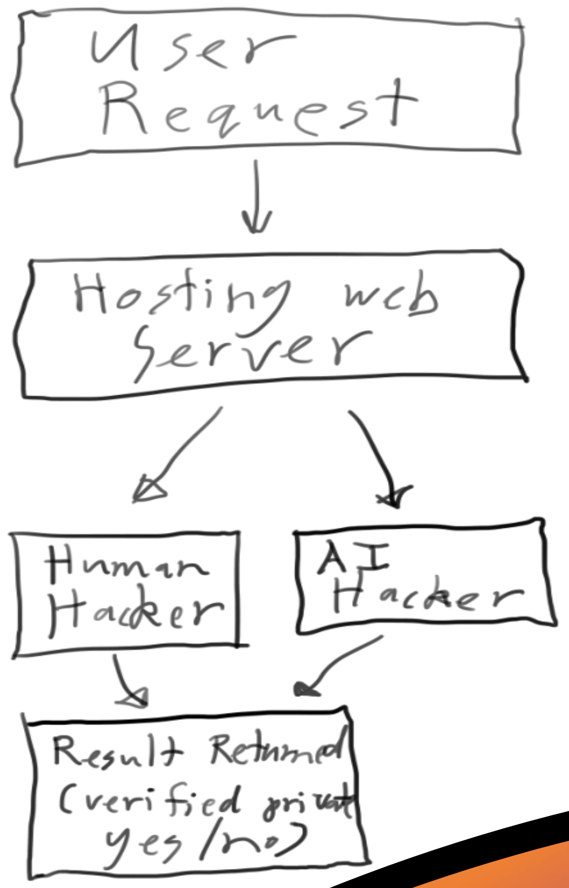
Ideation:

With the market being so complex and many solutions being offered, one possible solution is to create a service to **test the products** made by these companies. It would likely be an **online website** that uses all the **common tracking techniques** as well as **newly emerging** ones. This website would allow users to check whether it was successfully able to find any of their information or **track their access**.

Evaluation:

The **unbiased information problem** is very complex and has a crowded market surrounding it. This makes it **very difficult** to create an **effective solution** without lots of experience in the field. It also will likely include lots of **computer programming** or **data analysis** and **management**. Due to these reasons and a **lack of deep interest** in the area, I **will not** be continuing a Major Design Project around this issue.





The MIDI Controller Problem

MIDI stands for **Musical Instrument Digital Interface**. Despite being originally created for **connecting instruments to computers**, it is now used for many purposes including **performing as a DJ**, **Stage Lighting**, **Computer Control** with **Photo** and **Video editing**, **Gaming** and **Aeroplane Simulators**. MIDI has become a popular way to connect **any sort** of button, knob or other controls to computers - a physical interface other than the keyboard and mouse. Many products commercially available as well as an **infinite amount of uses** which will differ on an individual's needs and preferences. This is a problem because everyone has a **slightly different** way to use them - much like a home screen of a phone has the same basic icons yet everyone arranges them completely differently.

Design Situation & Target Demographic:

The ability to **buy or create** MIDI controllers **well suited** to a specific need and/or user is **currently not presented** in the market and **effective solutions do not yet seem to exist**. Whilst MIDI controllers are used for many different applications, the **target audience** would be **music producers, live musicians, and DJs**. Live DJs and music producers **need an adaptable solution** that allows customisation and adjustment on a **user and application specific basis**.

Market Opportunities & Research:

The market for MIDI controllers in general is very large as these controllers are used for a **massive variety of purposes**. They are commonly used by **DJs, Musicians, Live Video DJs, Visual effects & Lighting, Video Gaming, Simulators (Such as Flight Simulators), Video Editing, Photo Editing and much more**. Many of these industries tie into one another, leaving a **perfect gap for my product**. A modular controller that can be used **for all of these functions**.

Ideation:

Most ways to solve this problem revolve around the concept of **modularisation**. This has long been a part of the evolution of **analog synthesisers (A)**, however **has not** made its way into the **new digital era**. Rather than making completed boards, they must be **broken into smaller pieces** that can be assembled in any way the user wants. The first idea that comes to mind is a system similar to Lego, in which a **user can select** from a **large range** of possible parts and **clip them together however they like**.

Evaluation:

The possible design scope with this project is **very large** and the need for modularisation and user configurability has been **seen again and again throughout history**. This **genuine need** can apply to many different areas and could benefit a **wide range of users**, making this the **perfect project for my MDP**. I also have interests in the areas of **music, programming, construction and circuitry** which is why I **will be continuing on with this design project**.

SWOT Analysis

Strengths
- Experience with programming, circuitry & MIDI Devices
- Experience with Soldering etc.
- Passionate in the field
- Have industry links

Weaknesses
- Could become complicated to design and program
- Complicated designs could lead to unreliable product for end users

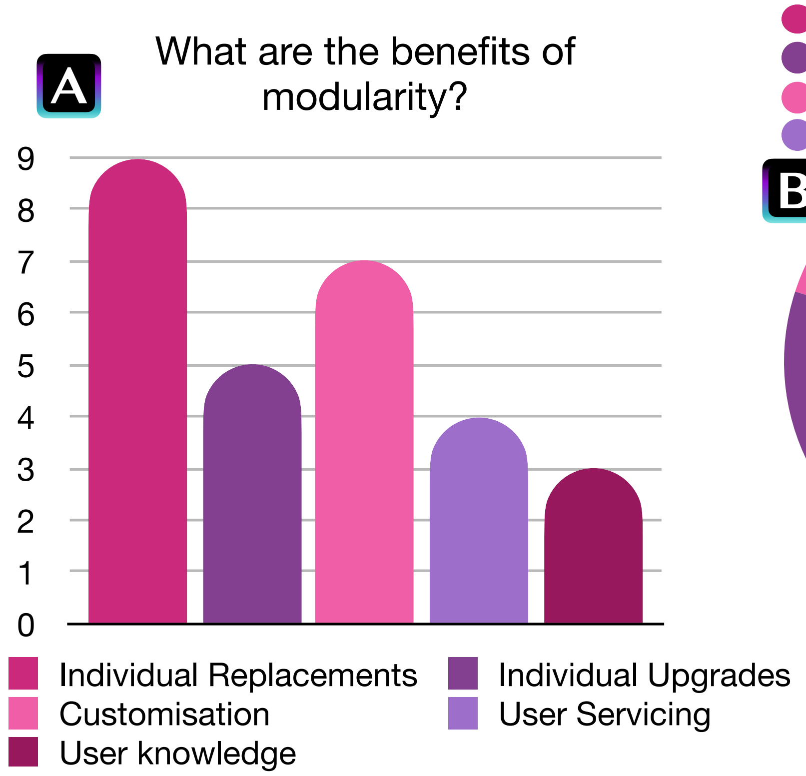
Opportunities
- Suitable market gap
- Applicable to large range of users
- Works well with growing issues related to repairable goods

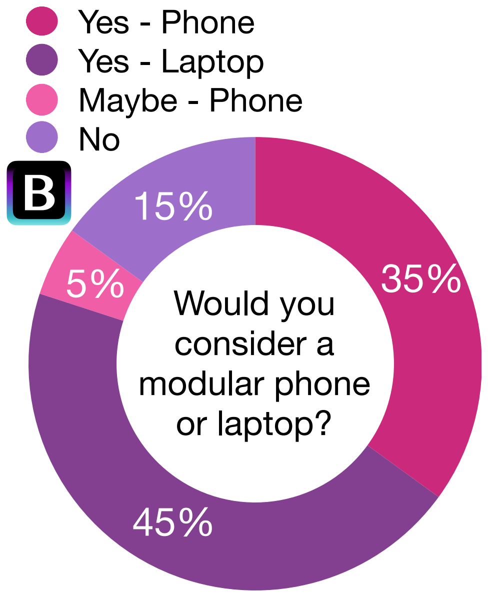
Threats
- Hard to compete with big brands
- Gaining awareness could be tricky
- Quality Control of products with many pieces could be difficult

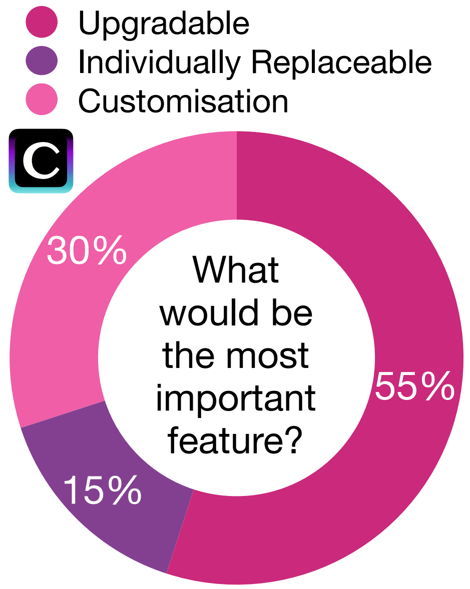
Primary & Secondary Research - Survey Data & Statistics

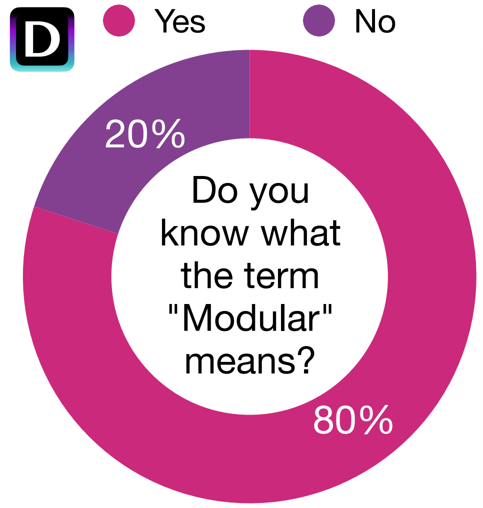
Through my research, I have created a page spread showing all the existing research and statistics related to the MIDI controller problem. I also performed a survey which provided interesting results. These are detailed on the following page. **Overall, the outlook on modular devices is very positive**.

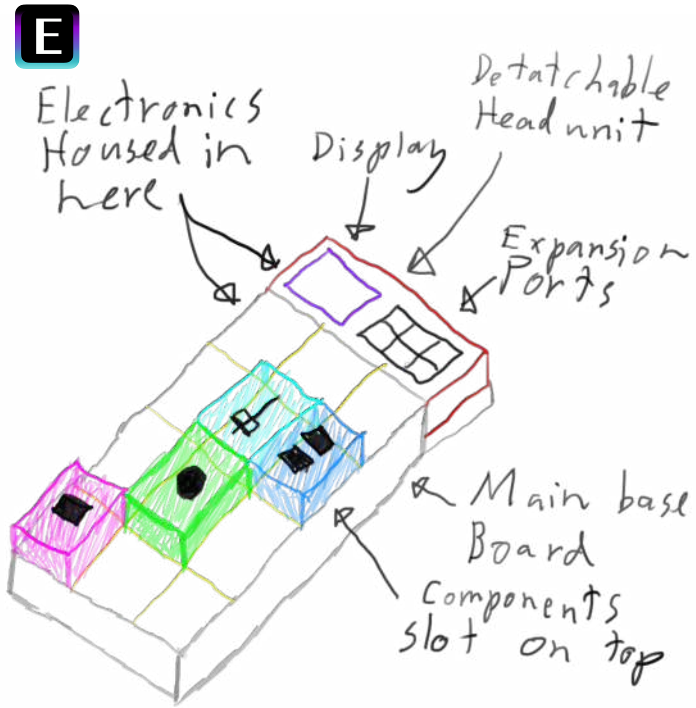
Identification & Exploration of Genuine Needs and Opportunities 1.1

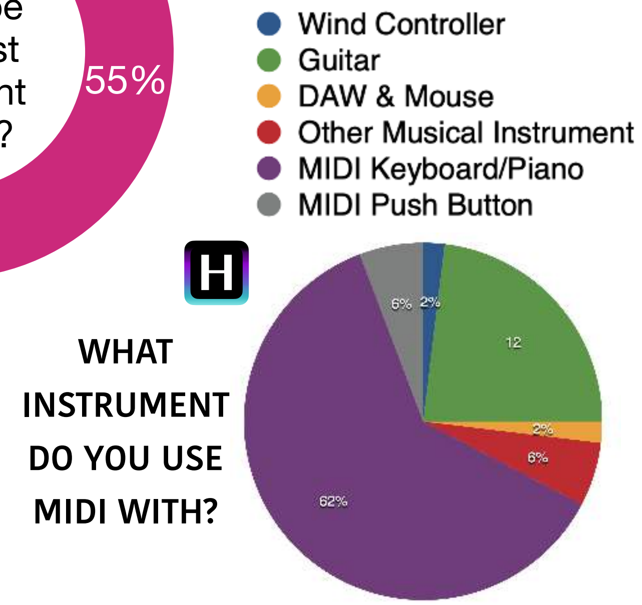


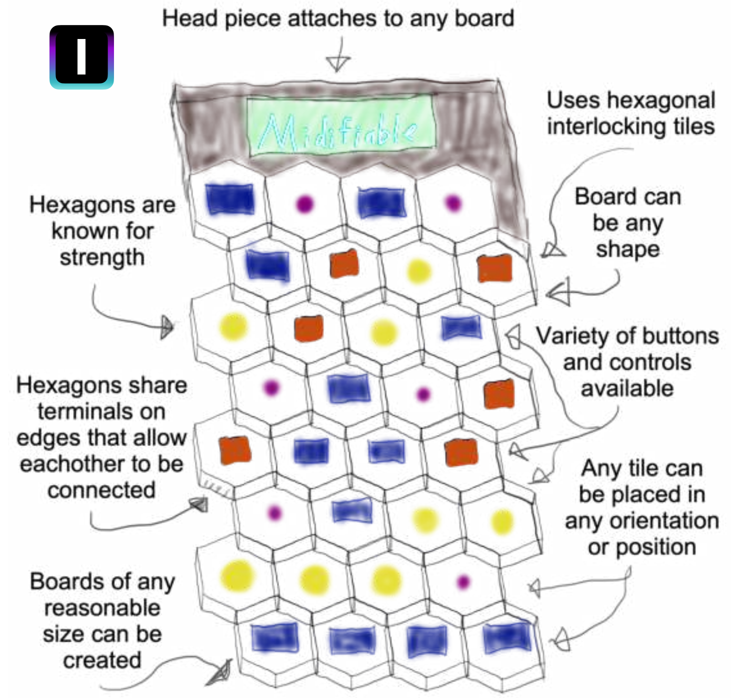


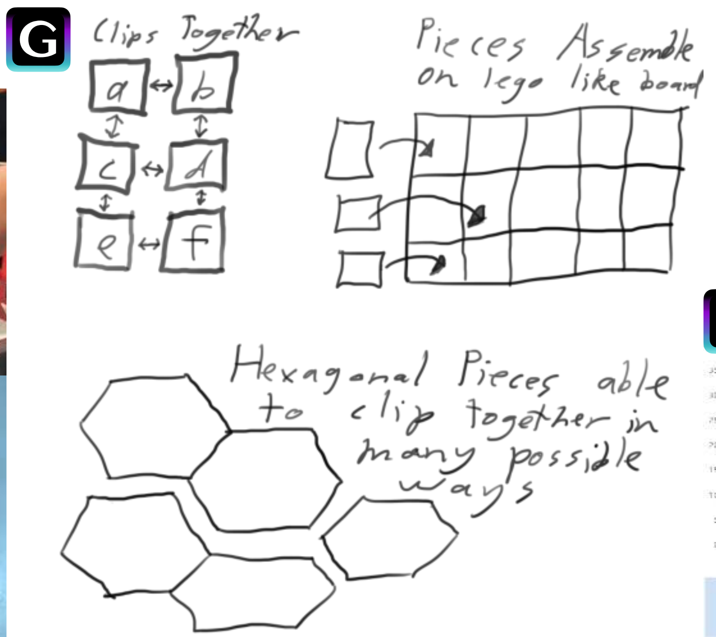












Through this section, I have found the research into these individual ideas very valuable. As I researched the MIDI Controller Problem final genuine need, I decided to pursue it and consequently continued on with further research to validate this decision. This includes the survey data, in depth market research and ideation sketches. I decided it was best to conduct all my survey research early on, which is why I provided all the results on this page. Through this, I knew exactly what I was working with from early on, giving me the best knowledge of the consumer market and broadest view of the genuine need at hand. I also performed sketching and ideation very early as to allow these ideas to continue to grow over time. Through this, I let myself create a much wider range of solutions to solve the problem.

Central Claim - The MIDI Controller Problem

As a keen recreational DJ & Musician, experienced programmer and electronics hobbyist, I love to **create, rearrange and modify things**. I **deeply understand** the need for a **modifiable and/or modular MIDI (Musical Instrument Digital Interface) controller**. I am often frustrated with the **limitations of pre made systems** and the **inability to customise devices to individual needs**. I also understand the pain of breaking a single vital component of a larger machine, requiring a replacement of the entire package, even when everything else works perfectly.

I clearly see the need to create a product that fills this gap.

Design Brief

To create a modular MIDI controller that is user customisable and effective in a wide variety of MIDI systems. This should include and be compared/contrasted with common DJ MIDI Controllers.

Design Situation

With ever-growing advancements in technology, many forms of music and instruments have become **digitally based** or otherwise incorporated into computers. This transition has lead to an **abundance of "MIDI" controllers** - interfaces between the user and computer. However, these controllers need to have **particular features or setups for each purpose & user**, meaning companies must make several varieties to fill all needs. **This need is still not properly solved** leaving many users in a **disappointing system** of **complex setups** with **multiple devices required** to fulfil their individual purposes.

Market Opportunities

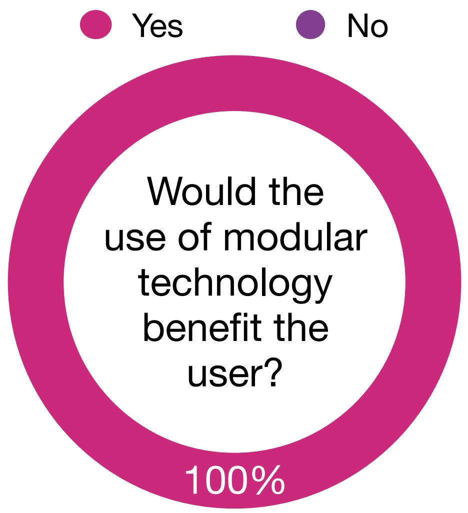
The market for MIDI devices is **very large**, however due to the nature and user requirements for these controllers, it is filled with a large number of **niche solutions** rather than "**one size fits all**". The market opportunity that will be approached is not focusing on a niche area as often traditionally done, but instead attempting to create a **customisable solution** that is suitable for a **large range of users**. It would be in the same price range as middle class controllers but will provide a far larger scope of potential usage and configurations than anything currently available.

Target Market

For this project, there are **two** potential target markets that could be approached. Either a hobbyist DJ who is looking for a **system to explore** their MIDI Controller needs, or a larger scale DJ who is looking to **create elaborate customised rigs** specific to their gig style. As this is my first time designing a solution to this problem, the product will likely utilise lower quality materials rather than high end audio equipment. For this reason, I am going to focus on providing the solution to this need for a **hobbyist or beginner to intermediate range of DJs and other MIDI users in similar situations**.

Survey Data Analysis

The survey created was based on investigating the **perceptions of modular versions of technology**. This was due to having a **very small sample size** of people available to survey. This meant very few people had experience specific to MIDI controllers, so asking more **generalised modularisation questions** was required. This survey has been designed with a variety of examples of technologies and assumes the results found will also **apply to MIDI controllers**. The findings include very high results in favour of modular devices, with **100%** of the participants deciding **modular technology benefits the user**.



Feasibility

Overall, constructing a solution to this project is **feasible given my skillset, experience, research results and timeframe**. The market gap I have identified is **legitimate and available** for innovation. The potential for future expansion is large, with **MIDI devices** being used for **many purposes** with relatively similar designs and setups. While **executing an effective solution** to this problem will **likely be difficult**, I have many years of **experience with coding, technology and construction** so I feel I will be up to the challenge. I also have a strong work ethic and am invested in this issue as it **affects me too**. Additionally, my father, uncle, cousin and a few of my friends are involved in DJ performances & Electronic Music meaning I **have valuable insight and have the ability to trial solutions with feedback from industry professionals**.

Up to this point, I have completed a table of ideas (PG 2), exploration of three needs (PG 3-5) and a statement of intent for my final idea (PG 6). The table of ideas was the result of an extensive 25 idea brainstorm (briefly shown as post-it notes) and was a very effective tool in helping me decide and justify the three ideas I would further explore. From this, the fairly in-depth research of each idea was extremely valuable in providing an understanding of the ecosystem of each area. I specifically used a SWOT analysis for each to directly compare strengths, weaknesses, opportunities and threats across these genuine needs. The SWOT analysis took a fair amount of time and difficulty to complete to a high standard but was ultimately very valuable and played a big part in helping me decide which need to continue with. Finally, the statement of intent helped summarise my research and justify my position, ultimately giving me direction and motivation in continuing this genuine need.

Initial Research & Areas of Investigation 1.2

FURTHER ACTION - COMPLETED IN SECTION:	
	1.4
	2.1
	2.3

AREA TO INVESTIGATE	METHOD OF INVESTIGATION	FURTHER ACTION	PAGES
EXISTING MODULAR PRODUCTS	I will use Google to explore a range of existing products that provide solutions	Perform a comparison between any existing products and the planned features for my product, confirm feasibility.	14, 15, 17
CONTACT PEOPLE IN THE INDUSTRY	I will video call my contacts in the field and record these interviews for reference	Create a summarised format of findings. Analyse these responses and make relevant adjustments to concept and ideation.	23, 24
TIME REQUIRED AND MANAGEMENT	I will research what is required for each section to understand the processes	Create a gantt chart to plan my time based on my findings and estimates of the time required for each section.	11, 12
COST ESTIMATES & RESEARCH	I will research the cost of parts I will likely use and find where to purchase from	Construct a financial plan and a "shopping list" to organise and evaluate the price of the project and its components.	10
DIGITAL MIDI PROTOCOLS	I will use wikipedia to understand the standardised MIDI data protocols	Create a flowchart that structures the code in a way that will support MIDI standards.	24
CUSTOM PCB FABRICATORS	I will research different PCB fabrication companies and find the most suitable to order from	Create a company comparison table including alternatives, comparative price, pros and cons.	20
SOFTWARE TOOLS & PACKAGES	I will research different CAD packages for various aspects of the project to find the most suitable	Create a table that compares the most important metrics and features from different available packages	21
INTERFERENCE TESTING	I will research & experiment with electrical interference to find if magnets will cause issues	Develop and execute an experiment that tests the interference generated by nearby digital signals and decides the safe operating proximity	22
LOCKING MECHANISMS	I will digitally 3D prototype different locking mechanisms possible	Create 3D CAD model in Fusion 360 and use movement tools to develop possible locking mechanisms to test.	16, 17, 18
MANUFACTURING TECHNIQUES	I will compare the manufacturing techniques available at my school	Compare pros and cons of manufacturing tools and techniques to find which may be suitable to use for my product.	23
MATERIALS & ILLUMINATION	I will perform a comparison of various materials to find which is best suited for illuminated parts	Develop and execute an aesthetic comparison between the available materials while taking into account the machining and functional properties	23, 29
SOP FOR TOOLS	I will understand and abide by all safety requirements for the tools I need	Research and learn thoroughly the safety requirements for use with chosen manufacturing tools and techniques.	29
SAFETY & REGULATIONS	I will reach out to potential local users and request feedback on prototypes	Create and supply prototypes to local DJ and request feedback on the look, feel and feasibility of the design	23

The use of a table structure to analyse areas of investigation has been a highly effective tool. By breaking down the task into specific areas to research, I have been able to clearly understand the required steps and keep them organised in the relevant areas of my folio. Some areas of investigation were not included, such as environmental impact and life cycle analysis. This is because environmental considerations are not a high priority for this design. In further stages, if this product was ready to be produced on a larger scale, a life cycle analysis would definitely be an area of investigation.

In the future, I would like to experiment using different formats for this information, possibly a flowchart or similar system. This is because the areas that need investigating often branch out from each other in a chronological sequence. After I completed this task and begun performing research, I often found more areas I would need to further investigate that branch from the initial area. In this case, I just continued my research in the relevant section but didn't amend this table as it has already served its purpose as a cognitive organiser and plan.

Criteria to Evaluate Success 1.3

KEY		
	FUNCTIONALITY	SAFETY
	ERGONOMICS	LIFE CYCLE ANALYSIS
	ASTHETICS	COST

SPECIFIC CRITERIA TO EVALUATE SUCCESS	IMPORTANCE	METHOD TO EVALUATE SUCCESS	STANDARD I EXPECT TO ACHIEVE
ABLE TO ADJUST PHYSICAL ARRANGEMENT OF CONTROLS TO SUIT THE USER	●●●●●	I will continually test to confirm the product is fully user adjustable during the process.	I expect to achieve a device that could be adjusted to suit any user and many purposes with ease.
ABLE TO CONFORM TO MIDI STANDARDS & MIDI ASSIGNMENT IS ADJUSTABLE BY USERS	●●●●●	I will connect controller to a variety of applications to make sure it works as expected with them all.	I expect full MIDI compliance with options for advanced users to adjust how MIDI is assigned to any desired extent.
ABLE TO BE USED FOR VARIETY OF PURPOSES THAT MANY MIDI DEVICES ARE USED FOR	●●●●	I will continually test the controller for different MIDI purposes throughout the project, primarily during programming stages	I expect it to function properly for the majority of MIDI purposes, however it doesn't have to be optimised for all.
BODY SHOULD BE SMOOTH PLASTIC WITH EASY TO GRIP CONTROLS TO AVOID MISS-CLICKS	●●●●	I will survey people who use MIDI controllers, asking them to test my prototype and make a judgement on surface and ergonomics.	I expect a user perceived result equal to or better than common mid range controllers currently on the market.
COLOURS MAKE IT EASY TO DIFFERENTIATE BETWEEN BUTTONS IN LOW LIGHT	●●●●	I will place the controller in low light situations and try to utilise it, comparing my results to normal lighting conditions.	I expect minimal differences between lighting conditions, potentially improved aesthetics in a darker scene.
DESIGN IS SLEEK, MODERN AND CLEAN FINISHED. SUITABLE FOR A HIGH CLASS PARTY	●●●●	I will survey people who use MIDI controllers, asking them to test my prototype and make a judgement on design and look.	I expect 50% of collected survey data to rate looks equal to or better than existing mid range products.
AESTHETICALLY PLEASING AND COLOUR SCHEME CAN BE MODIFIED BY THE USER	●●	I will use RGB LEDs and if time permits, will program features that will fulfil this need. It should have user accessible settings.	I expect to have full user customisation of colour schemes, however due to low priority this is only if time permits.
MUST BE FUSED, LOW VOLTAGE AND WON'T EXCEED POWER LIMITATIONS FROM USB PORTS	●●●●●	I will thoroughly test my circuity with a multimeter and lab power supply while simulating usage to ensure specifications are met.	I expect a fully 5v USB compliant device that is fused and will not cause damage or injury in typical situations.
MUST NOT HAVE DANGEROUSLY SHARP EDGES OR HAZARDOUS MATERIALS	●●●	I will thoroughly inspect product to ensure no dangers have been left over from manufacturing.	I expect a safe to use product aimed at a mature age target demographic. It does not need to be child safe.
INDIVIDUAL COMPONENTS CAN BE SERVICED OR REPLACED BY THE USER AND ARE UPGRADABLE	●●●●●	I will ensure all vital parts are designed with ease of access. I will ask my peers to test and confirm this is achievable and user friendly.	I expect simple swapping of components without the requirement of specialised tools or knowledge.
DURABLE DESIGN AND QUALITY MATERIALS WILL BE USED TO ENSURE LONG WORKING LIFE	●●●●●	I will perform durability tests on all materials and parts of my product through usage simulations and scenarios such as being dropped.	I expect moderate and reliable durability that would allow professional users to perform without issues.
COST IS AROUND THE SAME AS THE AVERAGE COMMERCIALLY AVAILABLE CONTROLLER	●●●	I will make a budget plan, perform research and ensure the final product meets this regulation.	I expect the final product to be within $200 of the average mid range MIDI DJ controller.
INDIVIDUAL COMPONENTS CAN BE PURCHASED FOR REASONABLE PRICE	●●●	I will design a simple financial plan and examine the cost of producing each component and find the price of selling them individually.	I expect an individual component to amount to no more than 5% of the cost of the entire controller.

The criteria to evaluate success has been fairly useful for me at this stage but I believe it will be essential to refer back to in later stages of the design. It successfully allowed me to set importance of aspects and justify this to both myself and others reading this folio. By giving each area an importance rating, I am able to focus my efforts in priority order and make sure I am on track to achieve these right from the very first ideation sketches.

In the specific criteria to evaluate success, I have chosen to focus on many important areas of design, however I have chosen not to include environmental factors into these. This is because for my design I have ranked many other areas such as function, aesthetics and ergonomics very highly. I am not able to focus on every possible area and I have decided that due to the nature of my genuine need, I have found this is not an essential element of the design situation.

KEY	
	PARTS & MATERIALS
	TOOLS & MACHINES
	TOTAL OF SECTION

Project Budget

For this project, I have negotiated a **budget of $500** funded by my family. According to my budget, this should **cover the cost** to make a controller with **some spare for unexpected costs** as prototyping reveals required changes.

Commercial Feasibility & Costing

If I was looking to **produce this product commercially**, I have the **potential to be successful** as based on my initial cost estimates **I am far below the average MIDI controller selling price of $800**. However, to produce my product will likely require **advanced machinery** such as the Laser Cutter and CNC machine which are very expensive. I would likely consider **outsourcing** manufacturing to factories that already have these tools available, however this would be a consideration to further research when that point in time comes.

Changes Throughout the Project

Over the course of this project, the items purchased varied considerably from the original plan. These changes included:

- **No PCBs ordered** - Supplier was not capable of producing in time
- **Different displays purchased** - Cost $30 more than expected
- **No Sheet Steel purchased** - Double quantity of magnets instead

Most of the parts were ultimately bought through **different sources** and/or sellers than the original prices were collected from. This meant that many of the prices were different than the initial budget forecasted. **However**, the final cost of all used parts was **$297.15** which was below the **$307.13** and far below the **$500** overall budget.

12/05/2022

ebay

Order information

Buyer
Placed on
Payment method
Paid on
[redacted]

Delivery address

[redacted]
Australia

Order total

6 items	AU $69.81
Postage	AU $4.99
GST*	AU $1.25
Order total	AU $76.05

*The Australian government collects GST of 10% on taxable imports.
Learn more

Items bought from countryiloveyou2000
Order number: 24-08707-77232

Qty.	Item name	Postage service	Item price
1	5-100pcs N50 Super Strong Magnet Round Disc Magnets Rare-Earth Neodymium Magnet (324331927988)	Australia Post Domestic Regular Letter Untracked	AU $11.45

Items bought from simplyonline001
Order number: 24-08707-77233

Qty.	Item name	Postage service	Item price
1	500 Rare Earth Magnet 2mm x 2mm Round Neodymium N50 Disc (152685320700)	Australia Post Standard Medium Box/Satchel	AU $14.99

Items bought from william_1101
Order number: 24-08707-77234

Qty.	Item name	Postage service	Item price
1	M1 M1.2 M1.4 M1.6 M1.7 Phillips Small Self Tapping Screws 304 Stainless Steel (143367967063)	SpeedPAK Standard	AU $7.49

Items bought from hjwonline
Order number: 24-08707-77235

Qty.	Item name	Postage service	Item price
1	20pcs Tactile Switch 6x6x7mm PCB Push Button SPST for Arduino (332906357715)	Australia Post Domestic Regular Letter Untracked	AU $4.90

Items bought from lonelybinary
Order number: 24-08707-77236

Qty.	Item name	Postage service	Item price
1	LONELY BINARY 10K Linear Potentiometer Pot B50K 15mm Shaft knobs ARDUINO UNO R3 (324812404711)	Australia Post Domestic Regular Letter Untracked	AU $24.99

Items bought from digi_master
Order number: 24-08707-77237

Qty.	Item name	Postage service	Item price
1	CD74HC4067 16-Channel Digital Multiplexer Breakout Board for Arduino AU STOCK (393881719676)	Australia Post Standard Parcel	AU $5.99

Go to checkout

Items (15)	AU $281.68
Postage to 2444	AU $11.46
Discounts	-AU $0.75
GST	AU $4.76
Total	AU $297.15

11/12/2021

ITEM	QUANTITY PER BOARD	PURCHASE LOCATION	APPROXIMATE COST	POSTAGE COST	CUMULATIVE COST
TEENSY 4.1	1	Core Electronics	$52.10		$60.10
REV D AUDIO	1	Core Electronics	$29.10	$8	$89.20
INA260	1	Core Electronics	$17.85		$107.05
PROCULUS	1	Alibaba	$80	$10	$197.05
LEDS	88	JLCPCB	$0.05	$10	$211.45
PCB	1	JLCPCB	$10.90	$2	$224.35
SCREWS	2	eBay	$4.20	$4.99	$233.54
ACRYLIC SHEET	1	School Supply	Unknown		$233.54
SHEET STEEL	1	Bunnings	$25	$0	$258.54
MAGNETS	176	eBay	$0.10	$0	$276.14
TOTAL				$34.99	$311.13
LASER CUTTER	-	School Supply	$40000	-	$40,000.00
CNC	-	School Supply	$67000	-	$107,000.00
PCB PRINTER	-	Unavailable	$4000	-	$111,000.00
HAND TOOLS	-	School Supply	$250	-	$111,250.00
TOTAL				0	$111250.00

The use of this Financial Management has been highly effective for planning what needed to be purchased and allowed a clear eBay shopping list to be made.

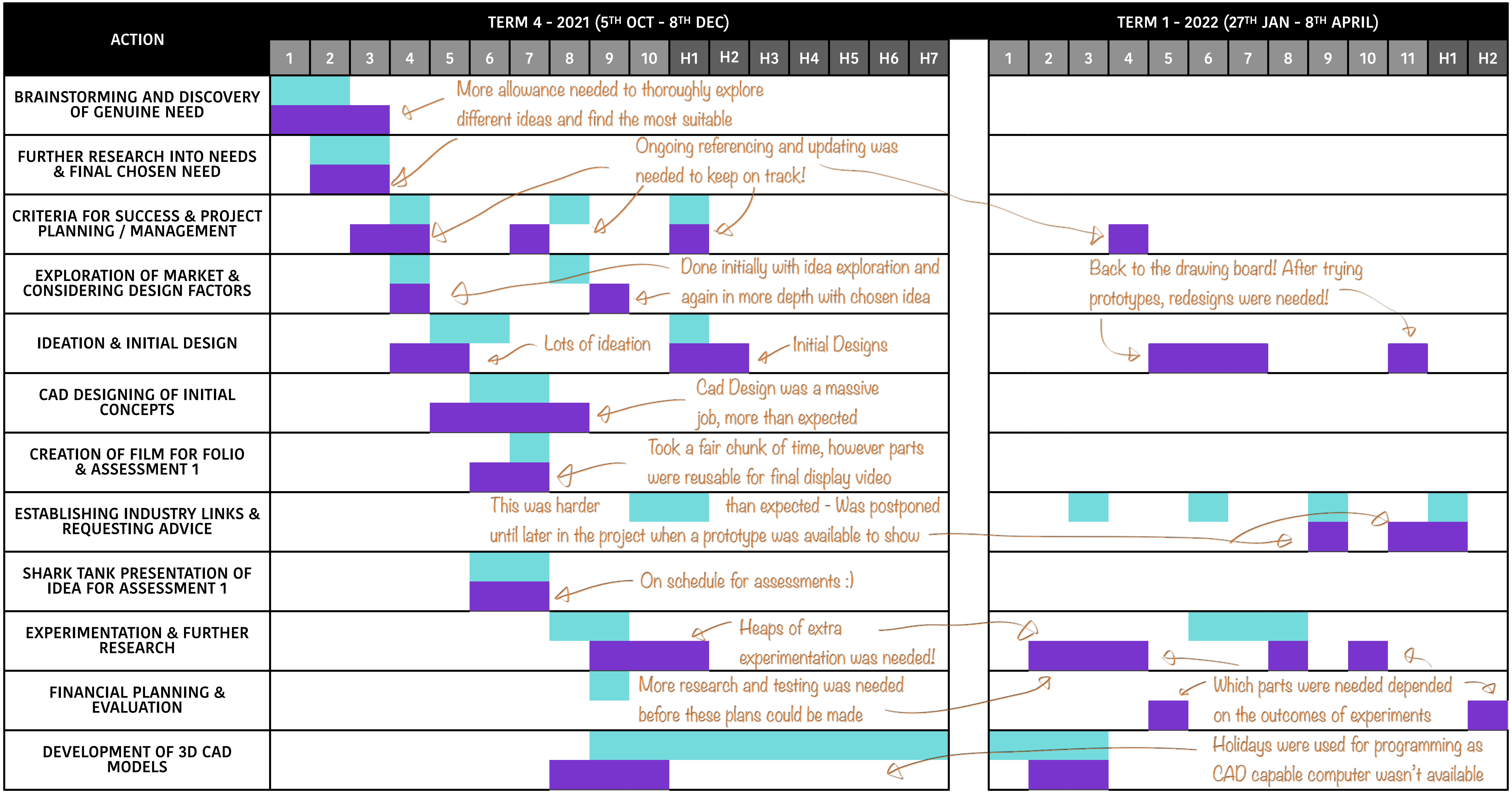
The quantity of items was tricky to articulate with this table structure as smaller items may be bought in bulk but only a set number required per board. However, some items may be needed for other components such as the head unit. This means the quantity column of the above table isn't perfectly reflective of how many components were needed, however it is a good approximation.

As far as commercial feasibility, curiosity led to a breakeven analysis and further exploration than was detailed above. While MIDIfier still showed to be possible, it became quickly evident that proper feasibility analysis requires more concept of what manufacturing processes and what materials will be used. At this stage, this is all unknown as the first prototypes are still in ideation stage.

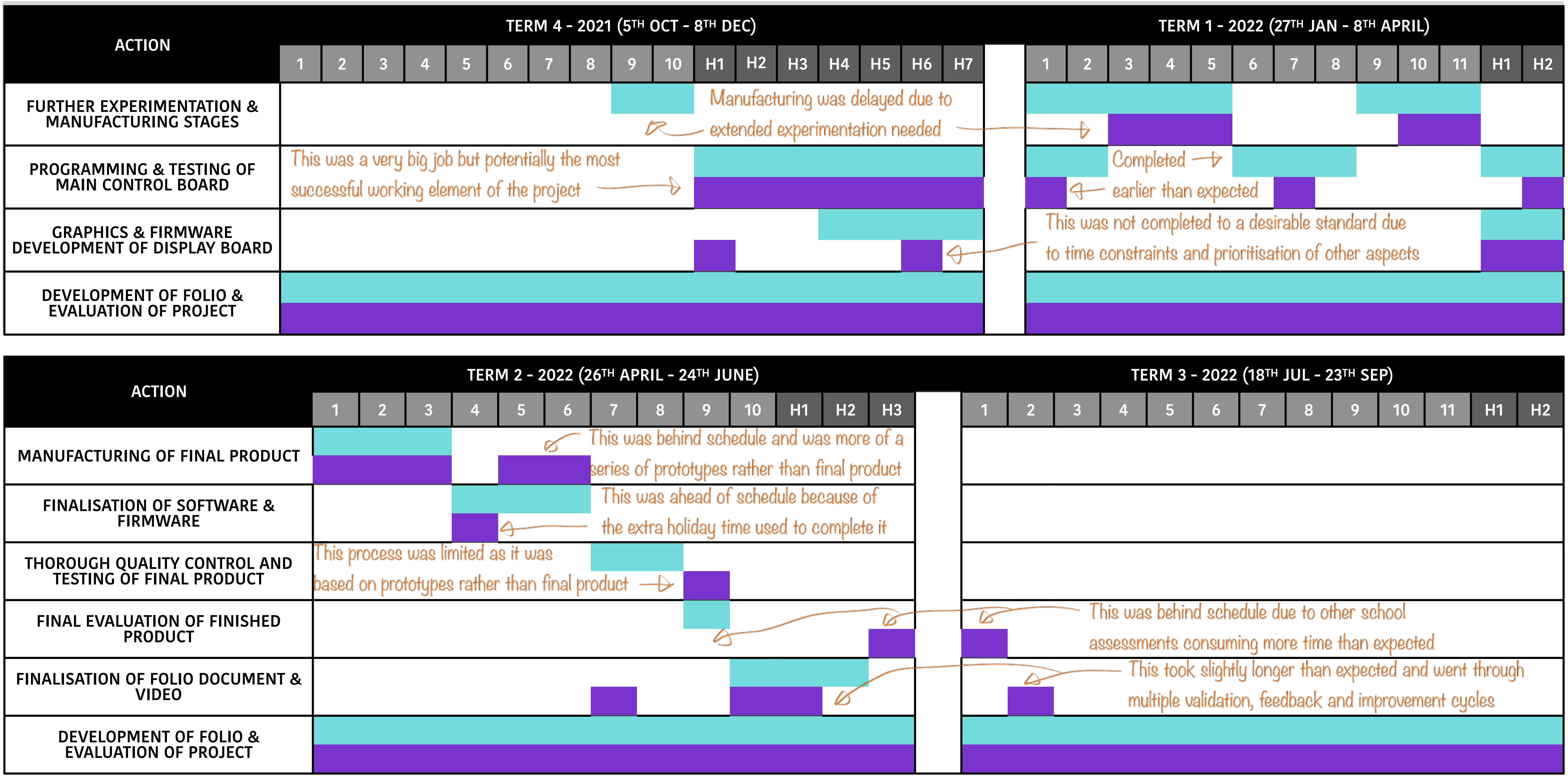
Throughout the project, this initial plan was great to be able to revisit and reevaluate. This effectively kept the project within budget even when different parts had to be ordered or an alternative system was put into place as plans were revised and new prototypes developed.

Project Management - Time & Finance 1.4

KEY	
	PLANNED TIMEFRAME
	COMPLETED TIMEFRAME
	HOLIDAY WEEKS (H#)



This first half of the Gantt chart plan was followed fairly closely. It was definitely the best planned segment of the project and time was spent effectively because of this. The relationship between tasks however meant that any delays accumulated and flowed on, making the send half less closely followed than the first.

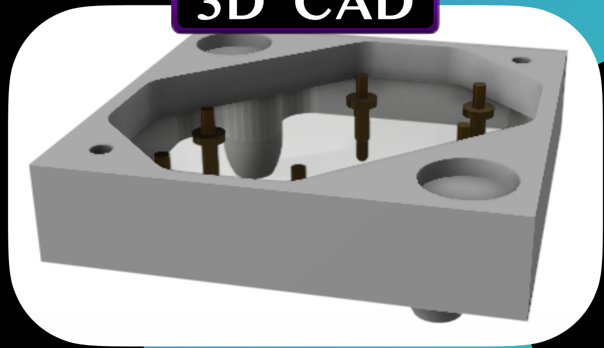


The use of this Gantt chart has been highly effective for planning and was fairly useful in keeping track of time. The Gantt chart approach seems to lack the specific task tracking abilities that are preferable in a digital time tracking software, however these often require a fairly large setup and are a long term solution. This may be invested into for the next project.

2. Project Development & Realisation

Existing Products

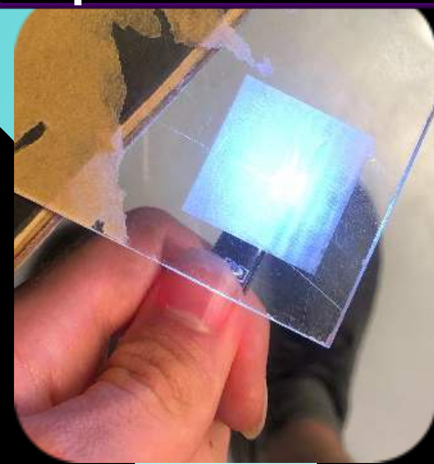
3D CAD



AR Prototyping

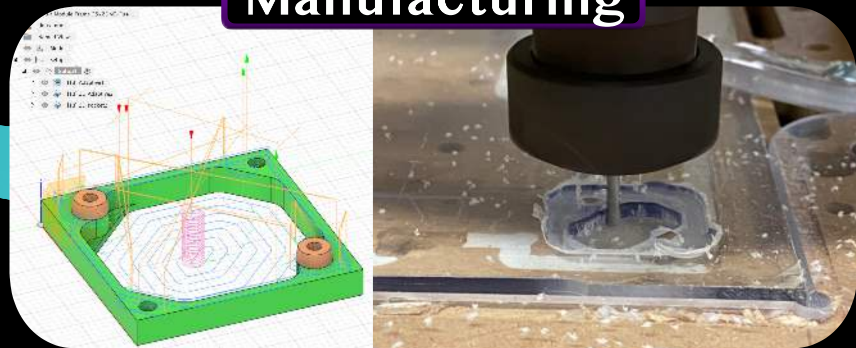
AR Demo

Experimentation

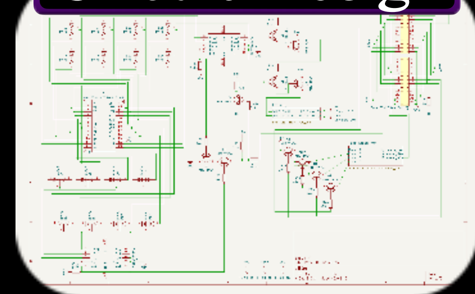


Digital Sketching

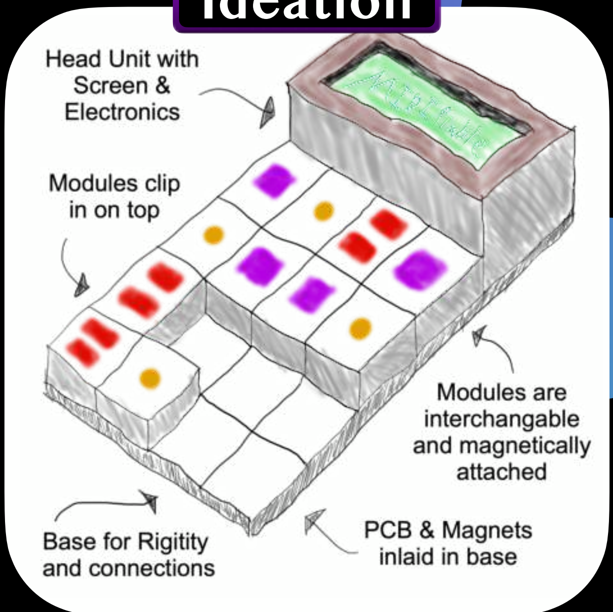
Manufacturing



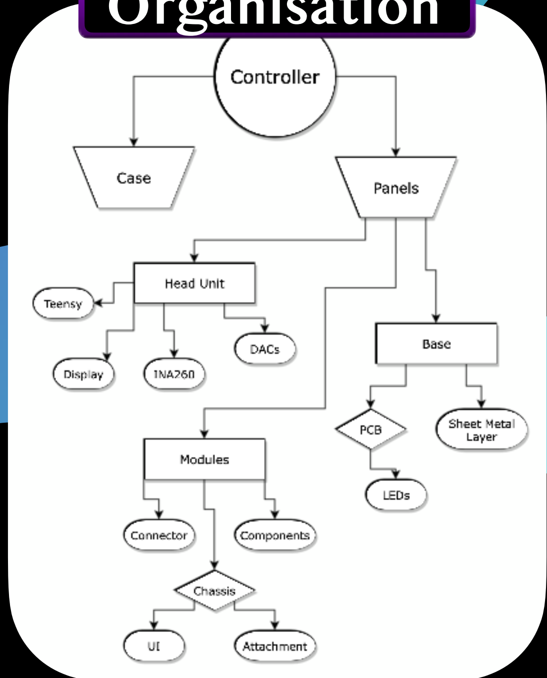
Circuit Design



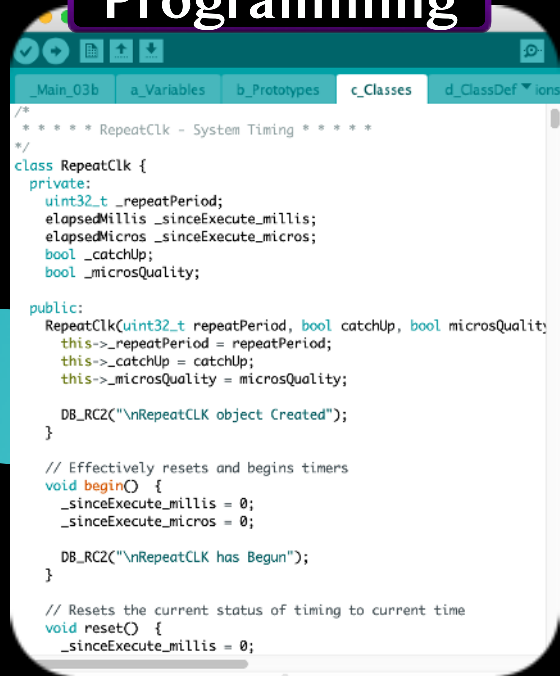
Ideation



Organisation



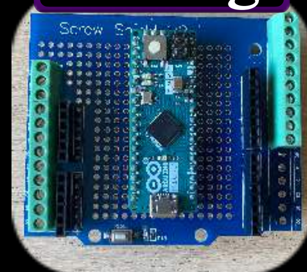
Programming




```
/*
 * * * * * RepeatClk - System Timing * * * * *
*/
class RepeatClk {
  private:
    uint32_t _repeatPeriod;
    elapsedMillis _sinceExecute_millis;
    elapsedMicros _sinceExecute_micros;
    bool _catchUp;
    bool _microsQuality;

  public:
    RepeatClk(uint32_t repeatPeriod, bool catchUp, bool microsQuality
      this->_repeatPeriod = repeatPeriod;
      this->_catchUp = catchUp;
      this->_microsQuality = microsQuality;

      DB_RC2("\nRepeatCLK object Created");
    }

    // Effectively resets and begins timers
    void begin()  {
      _sinceExecute_millis = 0;
      _sinceExecute_micros = 0;

      DB_RC2("\nRepeatCLK has Begun");
    }

    // Resets the current status of timing to current time
    void reset()  {
      _sinceExecute_millis = 0;
```

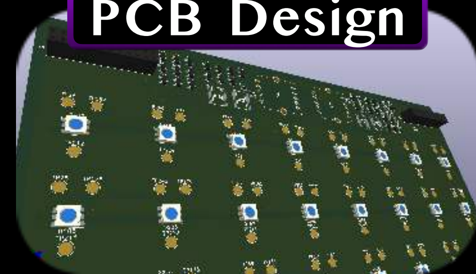
Prototypes

Testing



UI Design

PCB Design



Ideas Generation & Exploration of Existing Ideas 2.1

KEY - AREA OF EXPLORATION		
	DESCRIPTION	INTERESTING
	PROS	WHAT I'LL DO BETTER
	CONS	PRICE

ELEMENTS LIVID	MINE S SPECIAL WAVES	GRID INTECH STUDIOS	MIDILAR JACUB MUNDRAK
			
The Elements controller is a modular synthesiser in a user friendly form. It can also be MIDI interfaced with a computer	The Special Waves controller is a MIDI grid with rearrangeable components that can be customised and interfaced by the user	The GRID controller is designed as individual MIDI panels that can be daisy chained together as an expandable controller	The MIDILAR controller is a MIDI based digital synthesiser designed to work with modular synthesiser software for musical production
Great for quick custom synth build, simple, effective & aesthetic	Perfect for small scale customisable controls, fairly versatile design	Snap together & very simple, well executed & aesthetically great	Fairly customisable and perfect for MIDI modular synthesis
Only for very specific application, not highly customisable	Missing core components, small size panels, requires app	Not very customisable, missing many components	Only for very specific application, not highly customisable
Software support is discontinued, this product isn't supported	Requires custom application to connect to computer & set up	Very simplistic design & operation, great for simple usage only	Isn't commercially available, still in concept idea stage
\$650 - \$950 Full Device \$100 per module (4x4 controls)	\$399 - \$499 Full Device ≈ \$16 per module \$179 Base Plate	≈ \$100 per module (4x4 controls)	Currently unavailable for purchase
My controller won't require a special app. It will be customisable down to individual button level, instead of swapping whole panels. It will have different sized panels & a large range of modules so it will have a far greater usage scope than all above products. It will work for not only MIDI synthesis, but also DJing, Stage Lighting, Photo & Video editing, Gaming & Simulators and much more. It will cost less than all except the GRID when compared on a cost per button basis.			

Existing Solutions to the MIDI Controller Problem

There are currently a limited number of solutions to this problem, with the most applicable being detailed by the table on the left. These include the Mine S by Special Waves, Elements by LIVID, GRID by Intech Studios and MIDILAR by Jacub Mudrak. The Elements and MIDILAR controllers are both designed as modular synthesisers, and while they do run through MIDI, they **do not** solve this market need as they are **specifically for sound synthesis** and only offer a solution for this **small market portion**. These, along with the GRID controller all come as "**chunks**" of buttons and controls, **not actually allowing the user to rearrange them individually** but rather in groups. This results in only **a few possible combinations** and not being useful or practical for the overwhelming majority of users.

The Special Waves X does solve this problem by creating individual slots for each button etc, however it **brings its own series of issues**. Based on only **5 active components**, it is **missing key functionality** for **DJs, Loopers and many other users**. It also has **limited settings** and requires **specific software to work,** meaning it can only be integrated with **apps the manufacturer supports**, not allowing any user additions or modifications. To summarise, a large market gap still exists but **requires a breakthrough** that is **far superior to the minimalistic existing solutions**. Overall, the main problem is a lack of functionality and a far too limited usage scope.

Relation to Design Brief

These currently available products **fall short** from satisfying the **design brief** in the following areas:

- **Functionality** - These all lack comparable functionality to current standalone products
- **User customisation** - These have limited and/or far too few options to be effective
- **Effective for wide variety of uses** - These are only useful for specific niche use cases
- **Price range** - These are very expensive for their functionality compared to current products

As well as this, there are many other areas of these designs which I believe could be **largely improved on** to better fill this gap in the market. These current solutions simply don't get enough attention because they **don't fulfil the needs of the user** and act as more of an "optional extra".

Assessing the existing solutions in this section has been critical. The use of a table over other cognitive organisers such as a mind map or Venn diagram a strategic choice. Venn diagrams can be confusing especially when relating more than three products and mind maps are more effective for creative rather than comparative stages of design. By using a table, it is clear which elements are being compared and methodical research into all required areas of each product can be done.

By using a table that clearly compares and contrasts four of the best currently available solutions, it became evident what was required to properly fit this market gap. The flaws in these designs were often the same and all four seemed underdeveloped.

During the research of each of these devices, new issues, ideas and viewpoints came to light. These all encouraged the critical thinking and problem solving that went into the design of MIDIfier. Ultimately, the research into these areas provided understanding of the market, a comparative ground and insight into what MIDIfier should do better.

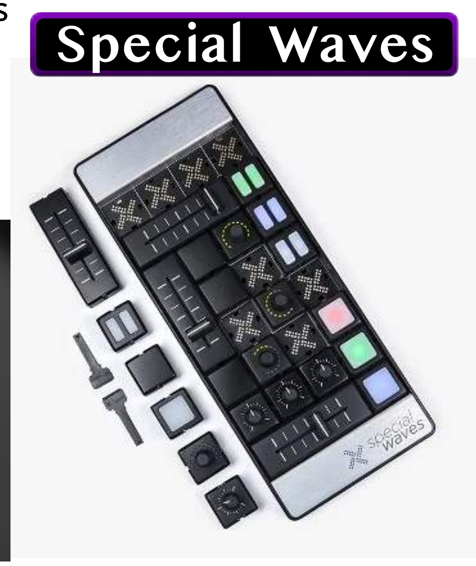
KEY FEATURES - MIDIFIER	COMPARABLE FEATURES - CURRENT PRODUCTS
- Universally Compatible - No Specialty App Required - MIDI Compliant (To current MIDI standards)	- Commonly Compatible - MIDI Compliant
- Full control of MIDI outputs - User controlled response curves - Customisable deadbands	- None Known
- Daisy-Chain design & expansion - Extremely flexible hardware customisation - Dual Latching Pins	- Limited Daisy-Chain Expansion - Latching Pins
- Large Touchscreen for user customisation - Smooth UI for easy navigation - Dedicated Graphics Processor for speed	- No inbuilt UI, proprietary application required
- Customisable theming of LEDs - LED Colour Response from inputs - FFT Equaliser Display feature	- Custom theming of LEDs through proprietary application - Limited LED colour response
- Full Components range for all purposes - New components can be easily added - Non manufacturer parts accepted	- Limited components available - Swappable components
- Hot swapping (Live swapping parts) - Unlimited Saved Setups - Re-Setup Assistant	- Unlimited Saved Setups through Proprietary application
- Bare Metal + Custom Operating System - User controlled refresh rate - Highly efficient, 100ma 5v CPU (0.5 watts)	- Relies on Host CPU - Modestly efficient, USB powered
- SD card saves, swappable to backup - Error checking UART + i2c communications - MIDI + Serial + HID + USB Audio capable	- Host Save - Host Backups - Proprietary Communications + emulated MIDI

MIDIfier's Degrees of Difference

The MIDIfier will have a **variety of differences** that separates it from the competition. These have been **outlined** in the table to the left in comparison to the **best features of existing market solutions**. By far, the most important aspect is the **fundamental level** of how MIDIfier is **designed to work**. It has its **own microprocessor, touchscreen display and user interface all in one.** This means **measuring, customisation and calculation** is **done onboard** and **does not require a host device** to do any processing. All the other controllers seen thus far **require a specialty program** to be installed onto every device intended for use. By making MIDIfier with its own processor, it becomes both **far more robust and simultaneously universal to any device** that is capable of receiving MIDI messages.

As well as this, the physical design of MIDIfier is **far more simple** than competitors such as Special Waves. This means it is very simple to **incorporate any button, sensor or module** into the ecosystem and make it compatible with MIDIfier. One of the biggest limiting factors with Special Waves is the **lack of support** for many **common sensors**, meaning it simply isn't a suitable replacement for standalone MIDI controllers.

Finally, MIDIfier is built on the principle of a **data "bus"** and **"daisy chaining"**. These two communication concepts are **well known** and are implemented as the **core communications** used in MIDIfier. This is what allows panels to be **"tacked onto"** and removed at the user's will. As well as swappable modules, the whole size of the setup can be **changed however is needed or preferred.**

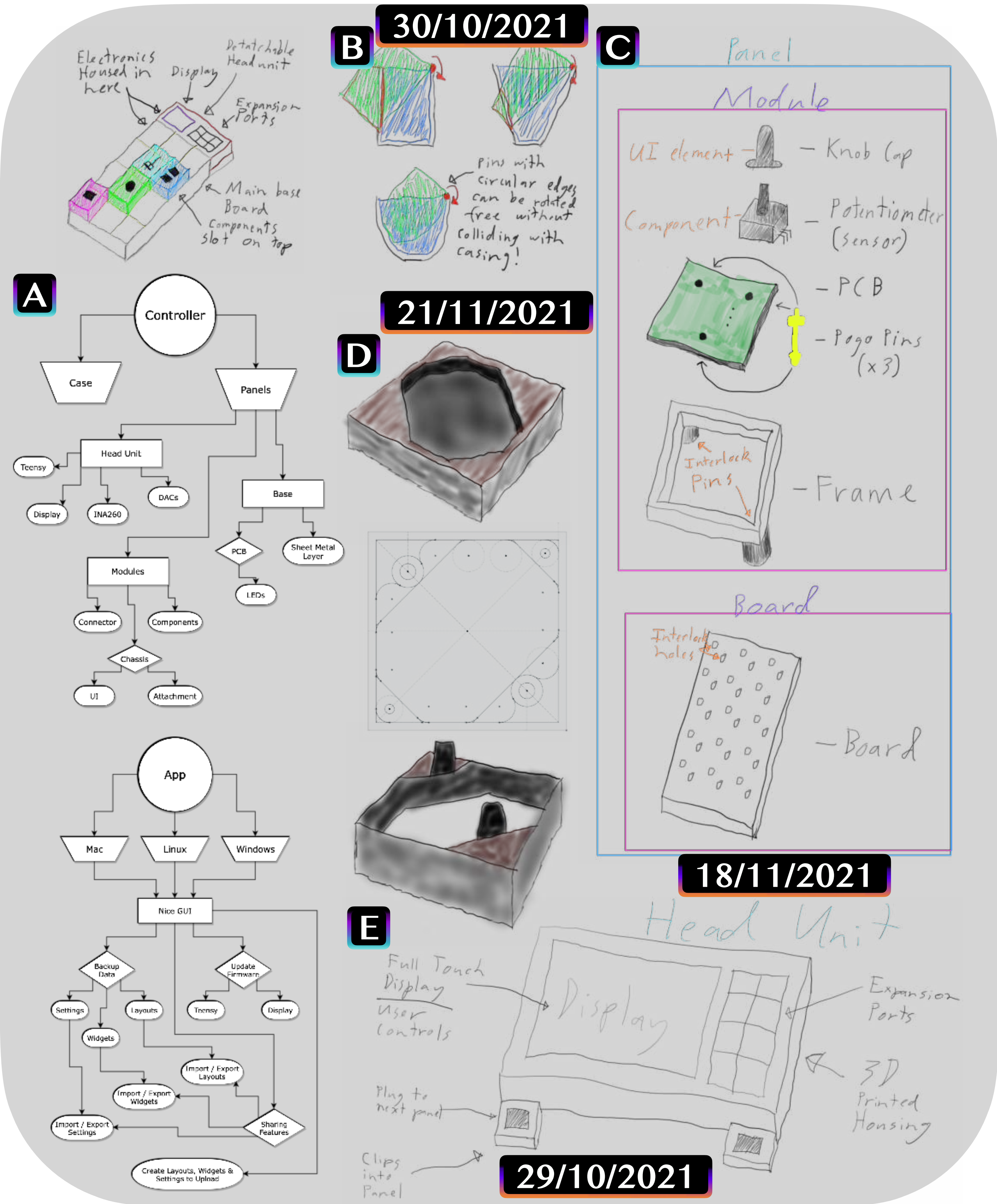


The degree of difference analysis on this page was done to explore in depth how MIDIfier is different from its closest competitor - the Special Waves X controller. This controller was born from similar ideas as the MIDIfier, however the biggest source for difference is a lack of development. As seen in the comparison, the Special Waves X is underpowered and lacks many key features of which the MIDIfier will be designed to have.

Having this depth of research is a massive advantage later on in the project. This is because not only does it give a list of features to ensure make the final design, but it also gives a clear list of features that can be harnessed during marketing of a final product.

Overall, this analysis has not been very useful within the scope of this major works, however overall to the project on its journey to becoming potentially commercial it is one of the most vital analysis steps.

Ideas Generation & Exploration of Existing Ideas 2.1



Sketching and the Assembly Flowchart

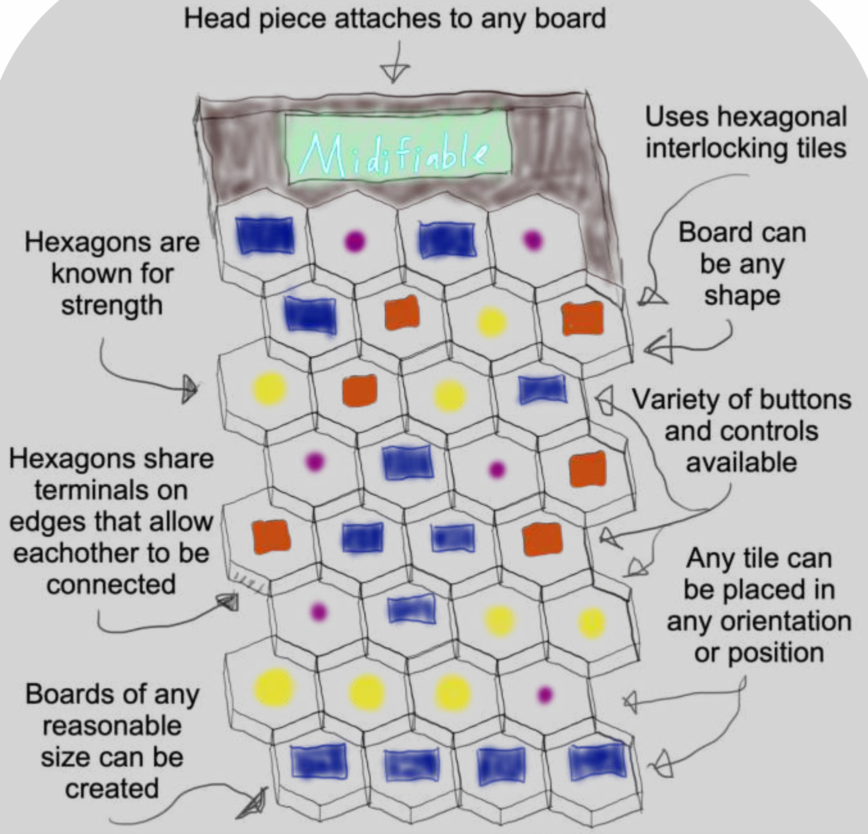
In order to break down this project into **manageable sections**, a flowchart was created to show how segments will be **interconnected** (A). The physical product as a whole is referred to as the "**controller**", similar to how a gaming controller or tv remote controller is referred to. This comprised of a **carry case** (still in concept phase, never prototyped) and **panels.** These Panels (C) are the basis of the **MIDIfier**, and a maximum of **16 panels** can be **linked together** to form a completed **controller**. Each panel is an assembly consisting of a base board which has slots to hold a maximum of **44 modules**. These boards contain all the required circuitry to communicate with the **Head Unit** (E) which is where the **Central Processing Unit** is. A module is the combination of a **sensor in a housing** that can be plugged and unplugged from **any available position** on a board. These can have **any type** of **analog or digital sensor**, including (but not limited to) buttons, potentiometers (linear or rotational). Modules have releasable pins (B) which are rounded allowing for **easy removal by pulling or rotating.** These pins have small magnets on the bottom which hold them in their corresponding slots on boards when put into place.

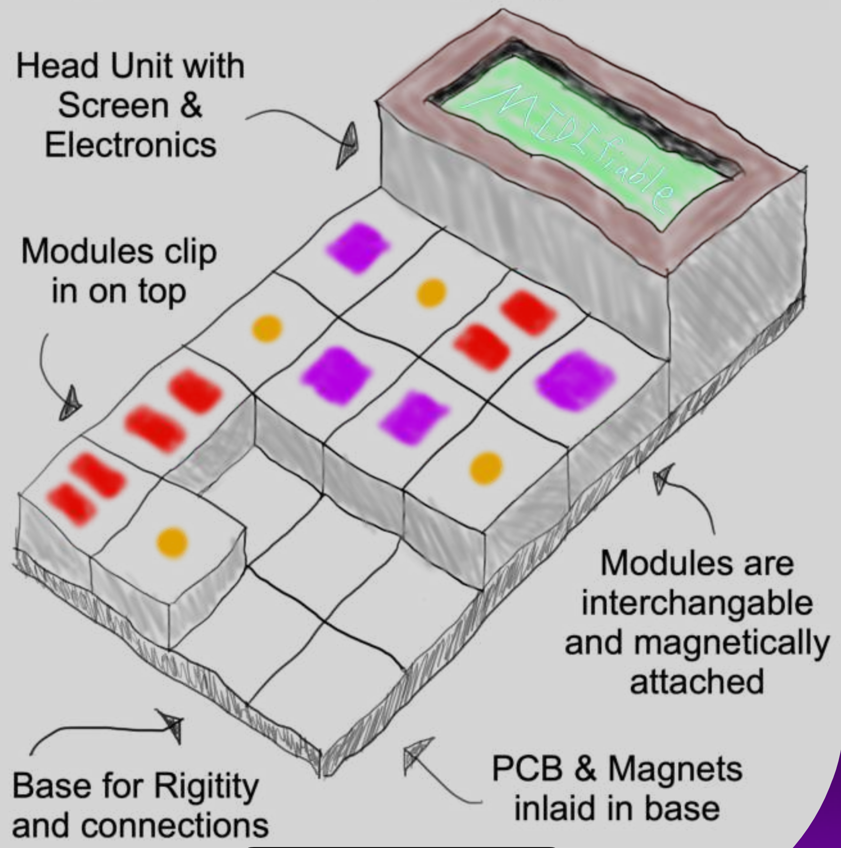
This modular design allows the MIDIfier to successfully achieve the project brief in concept form. By breaking it further down into **smaller segments,** this structure (A) can be carried through onto the further sketching stages in 3D as well as CAD design and assembly stages.

Further Sketching

Throughout previous years of Design and Technology, many hours have been spent understanding how to **best process ideas**. It has become evident that **digital sketching in CAD software** is **far more effective than hand sketching** for **more advanced concepts** as it allows prototyping in 3D instantaneously. Sketching in CAD opens the ability to see **both small and large details** that will or won't work **as** the design is being made, allowing a sound result much faster. With this being said, the most basic level of ideation is **often easier** and **more intuitive** to perform by hand, so **both methods** are used at different times.

On page 18, the second stage of sketching is shown with **digital CAD sketches** and their corresponding **3D concept models**. These reflect the ideation sketches on this page with **more detail** and **better consideration** of the connection each segment has to one another. This is especially important to this design as there are so many pieces that must fit together perfectly. **Simply jumping straight into 3D CAD design from the ideation sketching is not possible, so another more detailed level of CAD sketching is required.**





02/12/2021

	PLUS	MINUS	INTERESTING
HEXAGON CONTROLLER	- Aesthetically pleasing - Allows multiple rotations of components - Extendable in all directions	- Difficult to make stable electrical connections - Modules are offset, not vertically in line with each other - Difficult to pick up and move - Difficult to swap parts as they rely on each piece to stay together	Hexagons are typically a great shape for modularity, however they can present engineering challenges. In the case of this design, this adds unnecessary complexity and I shall not use this design to solve the modular MIDI controller problem.
RECTANGLE CONTROLLER	- Greater rigidity and structural integrity - Structurally simpler design - Electrical connections potentially more stable and secure - Easy to pick up and move - Reduces unneeded complexities - More structured approach for easier configuration	- Less aesthetically pleasing - Requires both base and components - Could become bulky	A square / rectangular based system with a base panel is the simplest of the design ideas generated. It effectively solves the problem and the structural & electrical simplicity far outweighs the potential aesthetic benefits of the hexagonal system. I will further develop this design idea for my major design project.

Structure of MIDIfier

To find the best overall structure of MIDIfier, I came up with two **tessellating patterns**. These were **hexagonal and rectangular prisms**. I then sketched an idea for each, comparing the positives and negatives of each in the table above. Overall, having a rectangular based controller is the **simplest** to design and implement as well as allowing for **larger sizes in multiples of the original dimensions** which makes it the **ideal shape for MIDIfier.**

The rectangular shape is similar to the Special Waves controller that already exists on the market. The Special Waves controller uses **both square and rectangular modules** and this is a **very strong aspect** of the design. There is **no currently known issues** with this layout and it seems to be the **most effective design** which is another supporting reason to use this for MIDIfier.

Special Waves

The Plus Minus Interesting (PMI) structure helps simultaneously compare advantages and drawbacks of two designs. By using this structure to compare two potential ideas, it is much easier to choose which will progress to further testing. Also, by then comparing these designs to existing market solutions, we are able to better understand why those decisions may have been made with existing products.

In this case, we were able to see the way the two designs would interact with pieces and why this may have been taken into account on existing solutions, all of which used the rectangular design. From there, the drawbacks of this more common design can be assessed, and if it still appears to be the superior solution, it will progress to further designs.

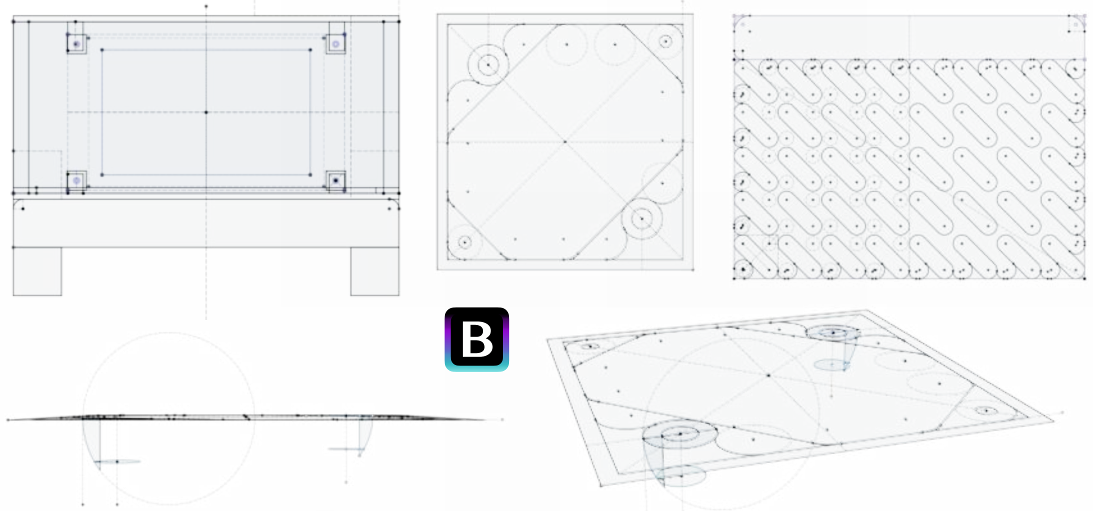
Ideas Generation & Exploration of Existing Ideas

2.1

A

Parametric Sketching with CAD

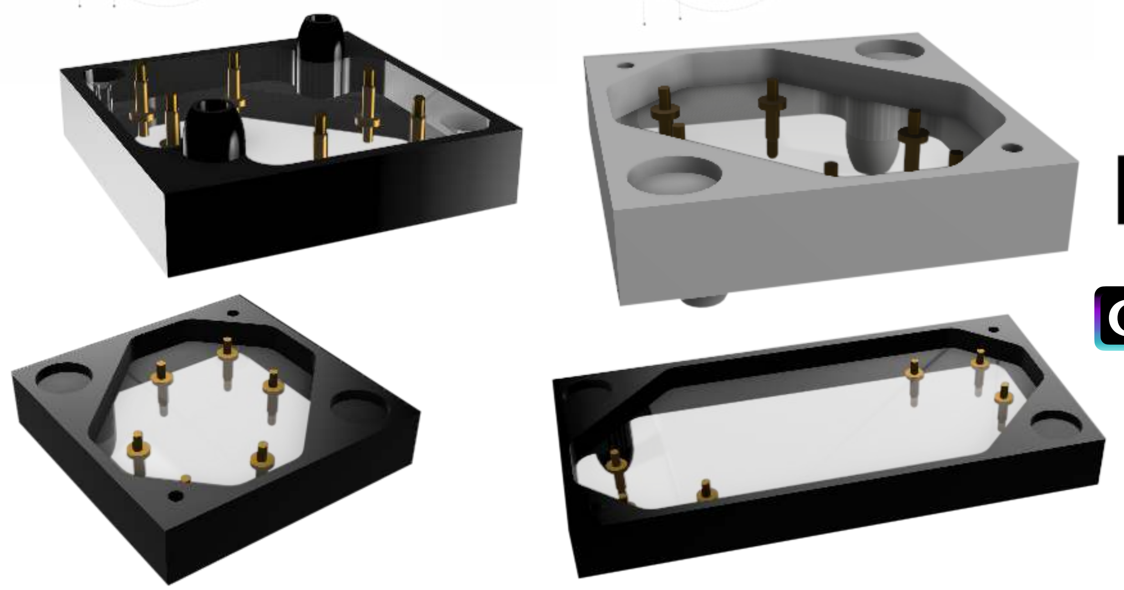
The second stage is to sketch these ideas **parametrically**. This is done with the help of **computer aided design (CAD)** software. This stage begins with a **rough copy** of the hand sketch in 2D using basic CAD shapes (B). Then, the **connections and relationships between these shapes** are defined with different **constraints**. This is the most important step to do correctly, as this is what allows **changes to measurements** to **update the entire model automatically**. These dimensions are then added, leaving a **dimensionally accurate two dimensional sketch** that represents the original idea.



B

Progressing to 3D

These 2D parametric sketches are the basis of the first stage of 3D modelling (C). This stage is not manufacturing ready but more for completing the **basic design stages**. This is because having a **dimensionally accurate 3D model** often reveals where parts will **intersect** or **otherwise not function as intended.** This is especially common with **complex designs** and is a **useful stage** as it allows these **fundamental errors** to be **detected** and **changed** before the **final 3D model begins to be designed.**



C

Visualisation with AR

The second benefit of creating 3D sketches such as these is the ability to **import** them into **augmented reality** capable software such as **Adobe Aero.** This software is still in **beta development stages** however is stable enough to use for this project. Putting this model into AR allows insight into how it will **look** when brought to life. It gives a **semi realistic** view on aesthetics and often shows which aspects are **more or less prominent than expected.** As seen in image (A), the MIDIfier 3D model is shown using augmented reality next to an existing laptop. The **QR code** in the **top right corner** can be scanned to **view this model in any space using a standard smartphone.**

This ideation phase was revisited multiple times throughout the design process as it is a key element of the design cycle. By breaking this phase into sketching, modelling and visualisation, often errors can be caught before progressing to the prototyping phase. This has been highly effective during this major works which is why this process involving Augmented Reality prototyping is highlighted. However, even with the use of these visual inspection techniques and scale accurate modelling, some changes were still needed after prototyping began. For example, after the completion of the first design, testing from a professional in the field lead to a change in the base size of modules, which meant revisiting this section of the design cycle was necessary. The changes to size were implemented in sketches and adjusted in the parametric 3D model. This model was then re-exported to an Augmented Reality compatible mesh file (FBX) which was imported into a new, revised version of the augmented reality prototype. This prototype seemed to solve the issues highlighted by the user testing, which was then confirmed as the new 3D printed prototype was made and tested.

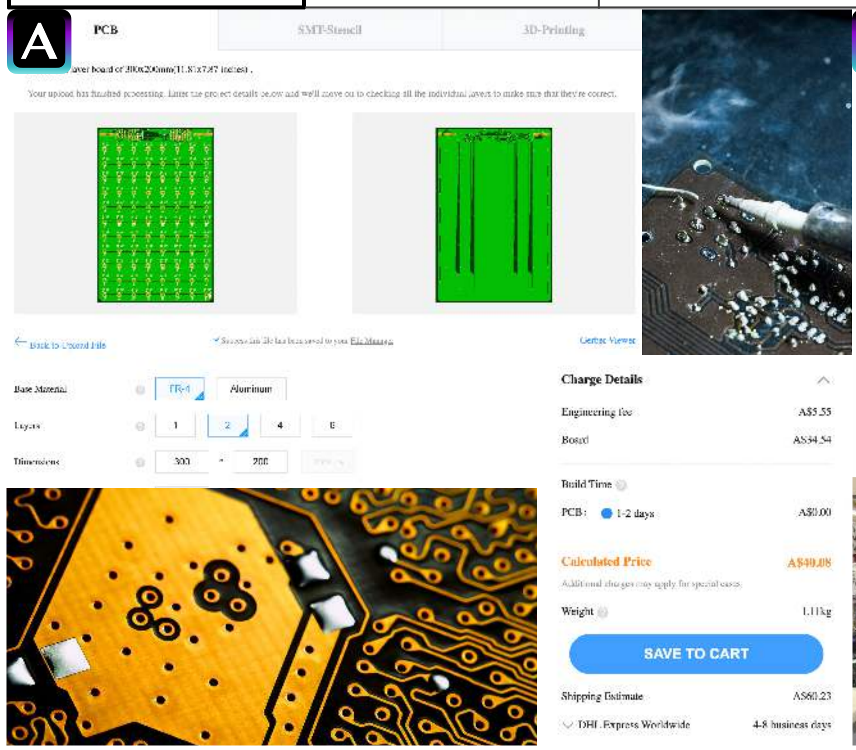
Consideration of Design Factors 2.2

DESIGN FACTOR	CRITICAL ANALYSIS	RELEVANCE TO MDP	PROPOSED EXPERIMENT	APPLICATION TO PROJECT
FUNCTION	This product must function to a very high standard as to be a suitable replacement for existing technologies. It must be effective in it's base technology - the interlock mechanism	The interlock mechanism allows the user to swap pieces which is the basis of a modular design. This is the core solution to the design situation and problem being solved by this project	Magnets & Connectors test (Page 22) Test the use of magnets to successfully interlock and remove modular parts. This will allow a magnetic rather than latch based system	**This experiment proved successful and was used as the basis of the design. This aspect of functionality can be seen on Pages 17 & 32**
AESTHETICS	This product must be aesthetically pleasing as well as functional. High quality aesthetics will influence the user to proudly use this product in any setting, commercial or personal	For a product to be successful in this market, it requires good aesthetics. In this design, aesthetics have been designed into the functionality, especially in the customisable LEDs	Lighting Experiments (Page 23) Testing different materials and diffusion techniques to find the best combination for indicator LEDs underneath buttons	**This experiment revealed that roughened clear acrylic is the most aesthetically pleasing. This lead to white filament being used in 3D prints to match seen on Pages 23 & 25**
ERGONOMICS	This product relies on the ergonomics design factor to achieve it's purpose - if it feels worse than single purpose alternatives, it simply will not be used as an "all in one" solution	The machining techniques used to make the modules should leave smoothed or even surfaces - they should not be warped or have burrs or sharp edges	Machining Experiments (Page 23) Experiment with 3D Printing, Laser Cutting & CNC milling to find the pros and cons of each	**This experiment revealed which machining techniques are best suited to each part, however it is evident commercial solutions may be better. Machining can be seen Pages 29 & 32**
QUALITY	This product must be very high quality in order to successfully achieve its purpose. To be modular and useful for a variety of purposes, it must be very durable and well designed	Especially when taking into consideration the modularity requires swapping and changing of components, high quality is essential to prevent breaking and failures	Designing in 3D to a high quality requires suitable software to assist. A variety of 3D CAD programs will be tested to choose the most effective for designing this product with	**This experiment allowed me to find the most suitable programs and allowed a relatively issue free 3D design process as seen on Pages 18 & 28**
OBSOLESCENCE	This product must be designed in a way that it does not easily become obsolete. This is due to its solution being useful for many areas. It would be useless if it became obsolete	This product will be designed in a way that is not only modular but also upgradable and repairable. This makes the product able to grow and change alongside emerging technologies	To design this modular & upgradable product, special consideration to circuit design is required. Testing to find the best circuit and PCB design software is essential	**This experiment allowed me to find the most affordable and suitable program to design my circuits and PCBs in. This is seen on Pages 21 & 30**
EXISTING SOLUTIONS	This product must take large consideration of existing designs as it must be both capable of doing the same while being modular and improved from the original products	The design of my product considers the variety of components available on existing controllers and allows an interface in which new components can be added and made compatible	Magnets & Interference (Page 22) In order to accomodate new components, the design must not gain interference as this will compromise it's ability to match existing products	**This experiment showed that electrical noise is low in this scenario and this product should perform effectively with changing components, seen on Page 30**

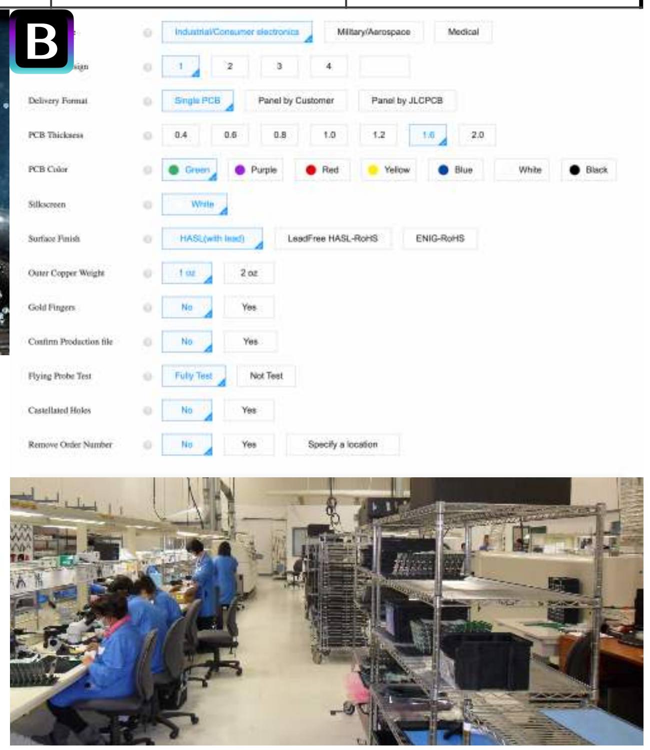
The intent of this table is to thoroughly assess design factors and find their correlation to this major design project. By finding this correlation through the "critical analysis" and "relevance to MDP" columns, an experiment could be proposed to further understand the mechanisms that would be used to achieve a desirable result in each area. After completing the experiments, in most cases I found that more related experiments needed to be completed in order to thoroughly understand what solution would be best. This highlights a weakness in the table structure, in that it can be hard to draw clear connections between further research or alternative ideas. It became evident that this section should have been a more creatively focused cognitive organiser such as a mind map or a flow chart which could be easily extended as the project progressed, therefore allowing more clear links to be identified, making it easier to draw conclusions from this information.

SUPPLIER	GENERAL	FABRICATION	COMPONENTS	FEASIBILITY
RUSHPCB	- Australia - Turnkey Fab - AOI + X-Ray - Flying Probe	- Rigid PCB - Flexible PCB - SMD + THT	- Small Library Available - Expensive prices	- Fair Time - Very High Relative Price
OurPCB	- Australia - AOI - Flying Probe	- Rigid PCB - SMD + THT	- Small Library Available - Expensive prices	- Long Time - High Relative Price
PCBWay	- China - Turnkey Fab - AOI + X-Ray - Flying Probe	- Rigid PCB - Flexible PCB - SMD + THT - PIP + Wave	- Medium Library Available - Fair prices	- Medium Time - Low Relative Price
JLCPCB	- China - Turnkey Fab - AOI + X-Ray - Flying Probe	- Rigid PCB - Flexible PCB - SMD + THT - PIP + Wave	- Large Library Available - Good prices	- Short Time - Low Relative Price
NextPCB	- China - Turnkey Fab - AOI + X-Ray - Flying Probe	- Rigid PCB - Flexible PCB - SMD + THT - PIP + Wave	- Medium Library Available - Good prices	- Short Time - Medium Relative Price

A



B



PCB Supplier Comparison

PCB stands for Printed Circuit Board and these are very common in electronics. They are useful for complicated circuits and when incorporating integrated circuits (ICs - a smaller chip) into a larger circuit. For the MIDIfier, the required circuits will likely be very complicated to allow high speed communications with numerous analog and digital components. A custom PCB will be required for both low level prototyping and a final product.

PCB Manufacturing is very complex and the equipment is very expensive and hard to use. After extensive research into this, it became evident that PCB manufacturing in Australia tends to be less common and more expensive than other places such as China. Of the many companies researched, all the Australian companies had minimum quantities far higher than suitable for prototyping, such as 100pcs minimum. This means for a prototype, when modifications need to be made, 100 boards may be wasted instead of just 5 as most of the Chinese companies offer. These minimum quantity requirements are both expensive and completely unviable for the project, ruling out RushPCB and OurPCB.

Of the remaining three services investigated, JLCPCB had the largest library of available components with most of the chips needed, while PCBway and NextPCB had low stock available. This was the biggest factor in choosing a manufacturer as hand soldering is not viable for the high amounts of soldering connections needed for moderately complex circuit designs.

PCB Ordering

After designing the PCBs (Page 29), the files were exported and uploaded to JLCPCB (A). Research into the correct options was done (B) and Surface Mount Device assembly was requested. Not all of the required parts were available and a request needed to be placed to source the missing parts (C). As only a small amount of boards were required, the request could take up to 6 months to be completed. After a month and many times contacting the company, it became evident that it could not be completed within the time frame this major works was required to be completed. PCBway and NextPCB have restrictions on minimum order quantity for custom sourced parts. This meant a custom PCB within the timeframe and budget of this major work was not possible.

C

	OPSCO Optoelectronics	2022-03-15 21:39	Rejected	Currently Unavaila...
C2909059	OPSCO Optoelectronics SK9822-EC20	SMD,2x2x0.65...	OPSCO Optoelectronics	

KEY		
KEY	OPEN SOURCE AND/OR FREE	GOOD
	BASIC FREE + PAID EXTRAS	AVERAGE / LIMITED
	PAID PURCHASE / SUSUBSCRIPTION	BAD / NON EXISTENT

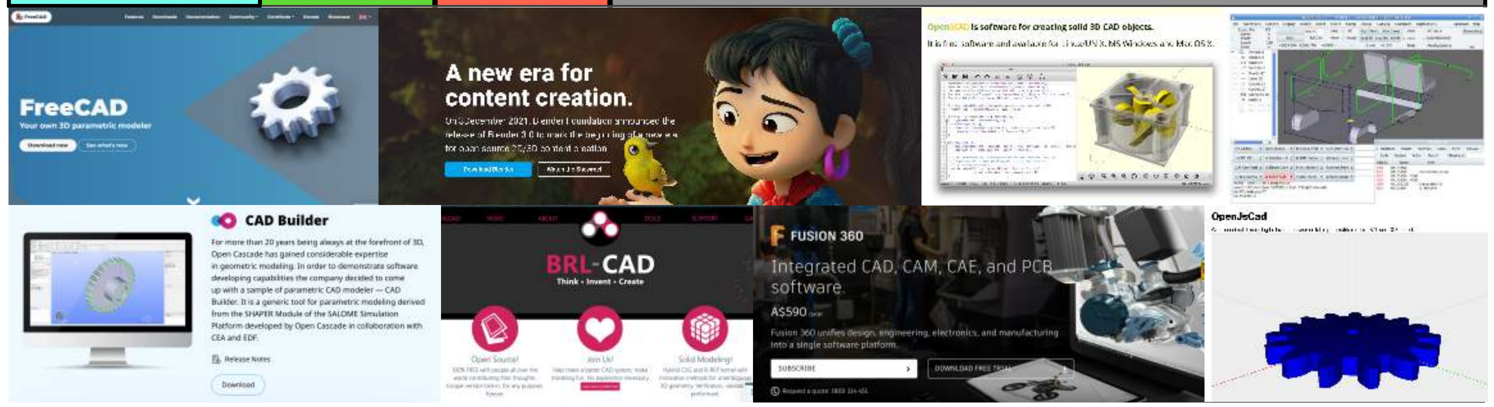
Software Experimentation (3D & PCB CAD Packages)

Aim: To determine the most effective 3D CAD package for complicated 3D modelling

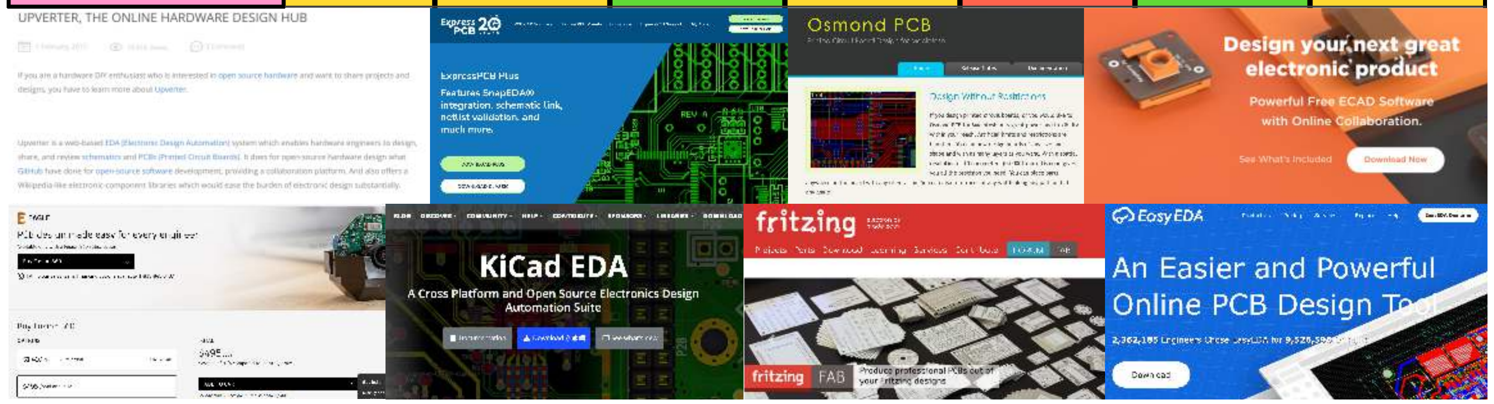
Method: Examine different programs' capabilities and test by importing a 500k polygon model

Conclusion: While Fusion 360 has been a 'go to' option previously, it struggles with complex models and can become highly unreliable. The workflow is forced to become convoluted and it does not work well with other programs. FreeCAD however, is open source, has all the necessary features and performs much better with higher degrees of customisation. However, as Fusion is used for many of the available tools, it may be used for tool-pathing in later design stages.

RESULTS:	PARA-METRIC?	USER FRIENDLY?	500K+ POLYGON	REFEREN-CE PARTS?	WORK-FLOW?	TOOLS?	SUPPORT MANUALS
FUSION 360	TEDIOUS	FAIRLY GOOD	LAGGY + CRASHES	BAD DESIGN	SLUGGISH + TIMELY	LOTS	GREAT SUPPORT
BLENDER	NO SKETCHES	COMPLEX BUT GOOD	RELIABLY	ONLY BY COPY	NOT IDEAL FOR CAD	BEST RANGE	GREAT SUPPORT
FREECAD	GOOD SOLVER	AVERAGE INTERFACE	RELIABLY	GREAT	GREAT	UN-LIMITED	GREAT SUPPORT
CAD BUILDER					RELIES ON EXTERNAL	EXPORTS LIMITED	GOOD SUPPORT
BRL-CAD			THESE PROGRAMS: - USE DIRECT CODE BASED MODELLING (REQUIRING USER TO CREATE 3D OBJECTS THROUGH CODE RATHER THAN GRAPHICAL INTERFACE) - ARE LIMITED IN FUNCTIONALITY - HAVE A STEEP LEARNING CURVE - HAVE LIMITED COMPATIBILITY WITH OTHER PROGRAMS				
OPENSCAD / OPENJSCAD							
GCAD3D							



RESULTS:	UI	PCB LAYERS	TOOLS	SPEED	ADDONS	PARTS LIBRARY	SUPPORT DOCS
EAGLE CAD		16					
KICAD		32					
FRITZING		2					
EASYEDA		34					
UPVERTER		16					
EXPRESSPCB		4					
CIRCUITMAKER		16					
OSMOND		16					



Aim: To determine the most suitable PCB CAD for learning schematic and printed circuit design

Method: Research options & trial the programs that offer the required features

Conclusion: Many of the available options were either high cost or very lightweight, online and limited in functionality. CircuitMaker is similar to Altium designer which was excluded due to commercial range costs, however Eagle CAD is not far behind. However, CircuitMaker is very limited in functionality, as is expressPCB, Fritzing and Osmond. EasyEDA was a viable option, however it offers essentially the same as KiCAD which is a fully free and open source project with a large community, many commercial users and well developed features and documentation. It also allows for any plug-ins, built in python scripting and does not have limitations on usage (or claim copyright over) produced PCBs such as EAGLE CAD does. For this reason, I will continue to learn circuit design using KiCAD.

KEY	ANALOG SIGNAL WIRE LENGTH
	DIGITAL SIGNAL WIRE PROXIMITY

Mechanical Experimentation (Magnets & Connectors)

Aim: Determine if a stronger magnet can easily override weaker magnetic connection

Method: Place magnet on sheet steel, hover stronger magnet 5mm above and observe transition

Conclusion: A stronger magnet will easily remove the weaker connection due to the exponentially increasing strength of magnets with proximity (C). Required magnet strength can be calculated with this website: https://www.kjmagnetics.com/calculator.asp, making this a viable solution for use in my designs.

Electrical Experimentation (Sensors & Interference)

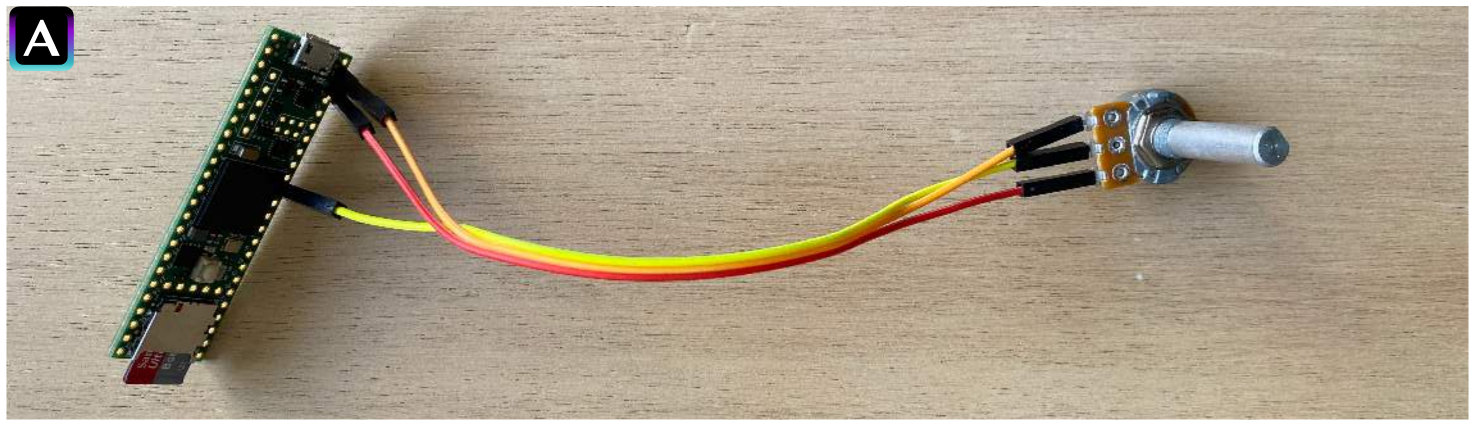
Aim: To test the noise generated by the length of analog wires and proximity to digital signals (A)

Method: Attach varying lengths of wires to the microcontroller and analog sensor. Test three times each and repeat bringing active digital signal into closer proximity with the controller. Record noise levels & peak spike values

Results: The noise observed by increasing lengths of wire was proportional but fairly insignificant (B). The proximity of digital signals did not have much effect, so this will not need to be accounted for in the PCB design

Conclusion: In the PCB Design, routing to the analog sensors will be prioritised, however reducing proximity to digital signals will not be considered as a priority. Code will also be developed to take multiple readings and average them so that any small amounts of noise will be filtered out.

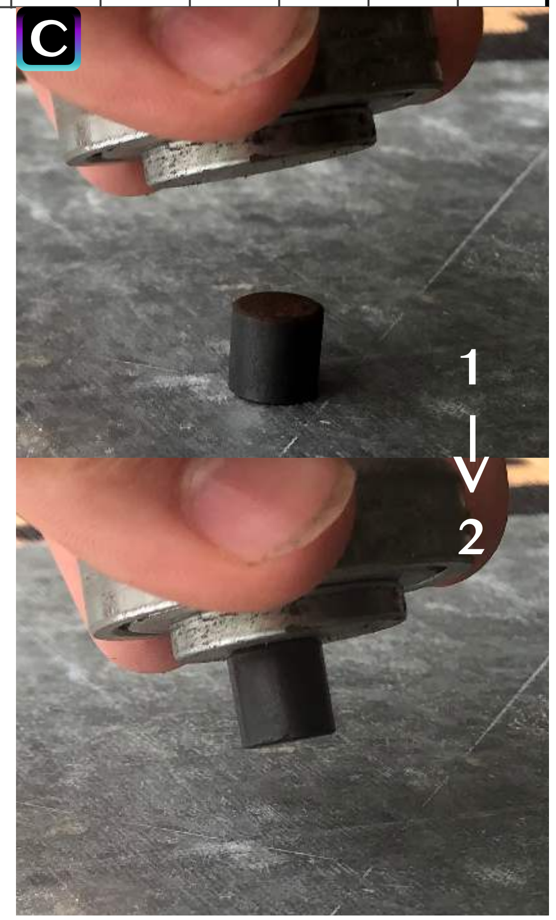
A



	0MM			100MM			200MM			300MM			400MM		
∞MM	2	2	2	3	2	3	5	5	4	4	5	5	5	6	5
20MM	1	3	2	3	3	3	4	5	4	5	6	4	5	5	5
10MM	2	2	1	3	2	4	5	5	5	5	5	4	6	5	4
0MM	2	3	2	3	3	4	5	5	5	4	6	5	5	6	6

B

C



The research, interviews, experimentation and testing completed in this section has been essential to the project. The research into PCB suppliers and ordering of custom circuit boards was completed fairly early on and had a large impact on the project as it posed many problems. By learning early on that custom PCB fabrication was a timely and expensive process, the project had to be reduced to various working prototypes of individual aspects rather than a consolidated final product. Due to the sheer complexity of the electronics involved in this design, using custom printed circuit boards was unavoidable and thus this obstacle caused a reorient of the project.

The software experimentation resulted in having the right tools for the project which proved to be highly valuable especially as designs became increasingly complex. The mechanical, electrical, tooling, lighting and reliability experiments all played fundamental roles in giving insight into the specific areas of the project in which they were related to. The target market testing resulted in useful feedback and redesigning the basic module to be a more suitable size. This fundamentally influenced the design for the better.

Research, Interviews, Experimentation And Testing 2.3

Tooling Experiments (Fabrication Techniques)

Aim: Determine the best tool to create prototype component frames with

Method: Create a prototype using the laser cutter, 3D printer and CNC machine

Conclusion: Each technique had positives and negatives, however 3D printing was the simplest and most effective. CNC cutting was marginally more accurate however small enough milling bits are not available to cut the holes for the magnets (D). Laser cutting is limited to 2D, however can be done in 3D with advanced engraving techniques. This, however, resulted in bowing of the material due to the heat produced (A) and took approximately five times longer to complete than 3D printing. This resulted in 3D printing for the frames (C) and laser cutting for top 2D pieces.

Lighting Experiments

Aim: Determine the most visually appealing material for the top face of components to allow RGB LEDs to shine through

Method: Place an RGB LED under a variety of materials including engraved acrylic and make a personal judgement on the most aesthetically appealing (B)

Conclusion: While white acrylic looked fairly appealing, it blocks a fair percentage of the light meaning it will make the product fairly inefficient through wasting most of the light produced. Clear acrylic showed a distinct glare from the LEDs, causing a distraction to the user. Roughened clear acrylic (laser engraved) produces a uniformly diffused light which is perfect for this product.

Target Market Testing

Aim: Determine if this product is applicable and practical for a user from the target market

Method: Provide a sample of interlock mechanism (E) to a DJ and request their opinion on the feel, usability and sizing of modules and panels

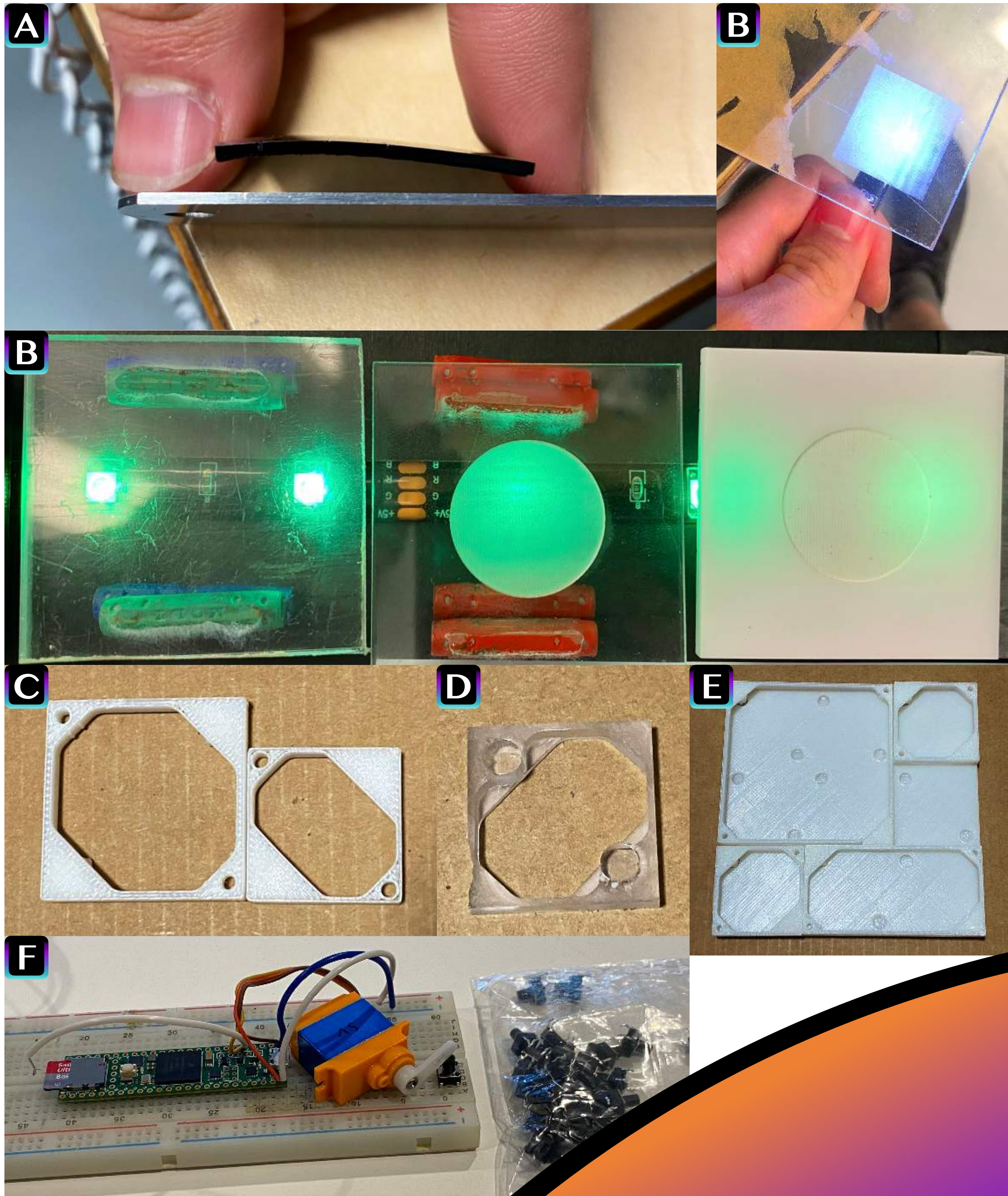
Conclusion: A DJ in the local area gave the feedback that the modules should be slightly bigger. This lead to further prototyping with modules that are based on multiples of 33mm rather than the originally prototyped 25mm modules (C)

Parts Reliability Testing

Aim: Determine if the parts purchased are suitably reliable for this use case

Method: Create an automated button clicker rig (F) to press a sample of the buttons 100,000 times and ensure they still function reliably

Conclusion: After over 100,000 button presses (2 presses per second, 100000/2/3600 ≈ 14hrs) the sample of buttons tested still functioned as new. This confirmed that this particular part would be suitable for use in the final product. Similar tests were done for other parts that were used in MIDIfier.



Structure of Code & Functions

The structure of a program is possibly the most important foundational element. After extensive thought into the structure required, an extensive set of flowcharts was created to organise the program structure. (A) This allowed tasks to be clearly broken down and to function cooperatively.

System Monitoring

A system monitoring function was implemented to keep track of power, ram, cpu and other usage parameters in order to satisfy USB power limits.

Timing & Execution of Functions

Timing was a fundamental challenge in this code. Many methods were tested in order to find the most suitable, with the result being a cooperative multitasking system where tasks can take turns utilising resources. This allows task deadlines to be met as well as avoiding the use of interrupts. Many modern computers use real time or general purpose operating systems with interrupt based time sharing, however this is too complex for this purpose.

Settings & SD Card Interface

Many settings are required for this project and saving these settings between power cycles was difficult. This is because the microcontroller has limited non volatile memory (memory that remains between power cycles). The solution was to use an SD card which required a large amount more code.

Multiplexor Reading & Writing

Reading and writing to the multiplexors that are connected to the different components was fairly straightforward. The use of multi-dimensional arrays and matrices along with nested “FOR” loops allowed this to be completed efficiently. These advanced techniques are highly effective once perfected.

LED Control & Response

Control of the individually addressable LEDs was achieved using the FastLED library alongside similar multi-dimensional arrays and FOR loops as above.

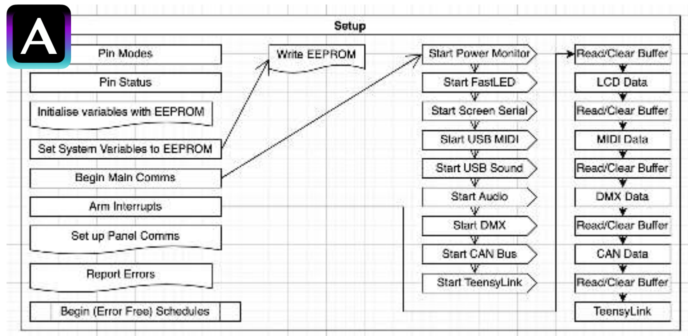
MIDI & Communications

To interface the Teensy controller with a computer, a multi protocol system was set up where both MIDI & Audio data could be sent simultaneously. (B)

Other Functions

Many other functions were created and tested to allow expansion with other controllers, DMX lighting and staging, CAN bus communications, I2C modules and much more. These were not essential to the design but very helpful to experiment with and will be great for expansion in later stages.

A



B

A very large amount of coding was needed for this project as it solely uses software to interpret user arrangement and take necessary action. However, by having this working code, the concept can be tested and proven without the need for fully developed hardware. With the difficulties of custom PCB fabrication for small scale projects, being able to create functional code has been essential as it has allowed me to make working prototypes of various elements of the project even without completed hardware prototypes.

Also, the way this code is able to operate modularly on its own means that once hardware is developed, this code will require minimal changes in order to operate properly. Parameters such as saved settings can easily be changed on the SD card and will work instantly. Modules can be easily added to the multitasking environment that would make any required changes simple to implement and work smoothly alongside all the other functions. On top of this, the code has been divided into seperate tabs that allows for a developer to easily skip to the section that needs changes and make the required modifications. This has been a massive time saver as the project has progressed from this testing phase to more finalised versions.

Device Safety

The MIDIfier must be safe to operate, even in the case of a fault, failure, damage or misuse. For this reason, the two operating voltages used are 3.3v and 5v (D). Five volts is what USB devices operate with and has been proven to be harmless in almost all cases even when a catastrophic failure occurs. To quantify the associated risk, the conductivity of my index finger was used for calculating the electrical current that would flow through my skin if 5v was applied directly to the surface. The measured resistance was around 3.117 mega-ohms (C). Using Ohms Law, Voltage = Current * Resistance. Solving for Current, 5.14v / 3117000Ω = 0.000001649A or 1.649 micro amps. Even in a high voltage setup such as a Van De Graaf generator, more than 50 micro amps are required before any human sensation is felt.

This experiment is incomplete as it does not account for the distance between probes, moisture of the skin or many other factors. However, it does show that the electrical risk is far below what can be felt even in a catastrophic failure such as a short circuit, and it is even farther below any levels that are harmful to humans. For this reason, 5v will be the operating voltage and will be safe for all users.

PPE During Manufacturing

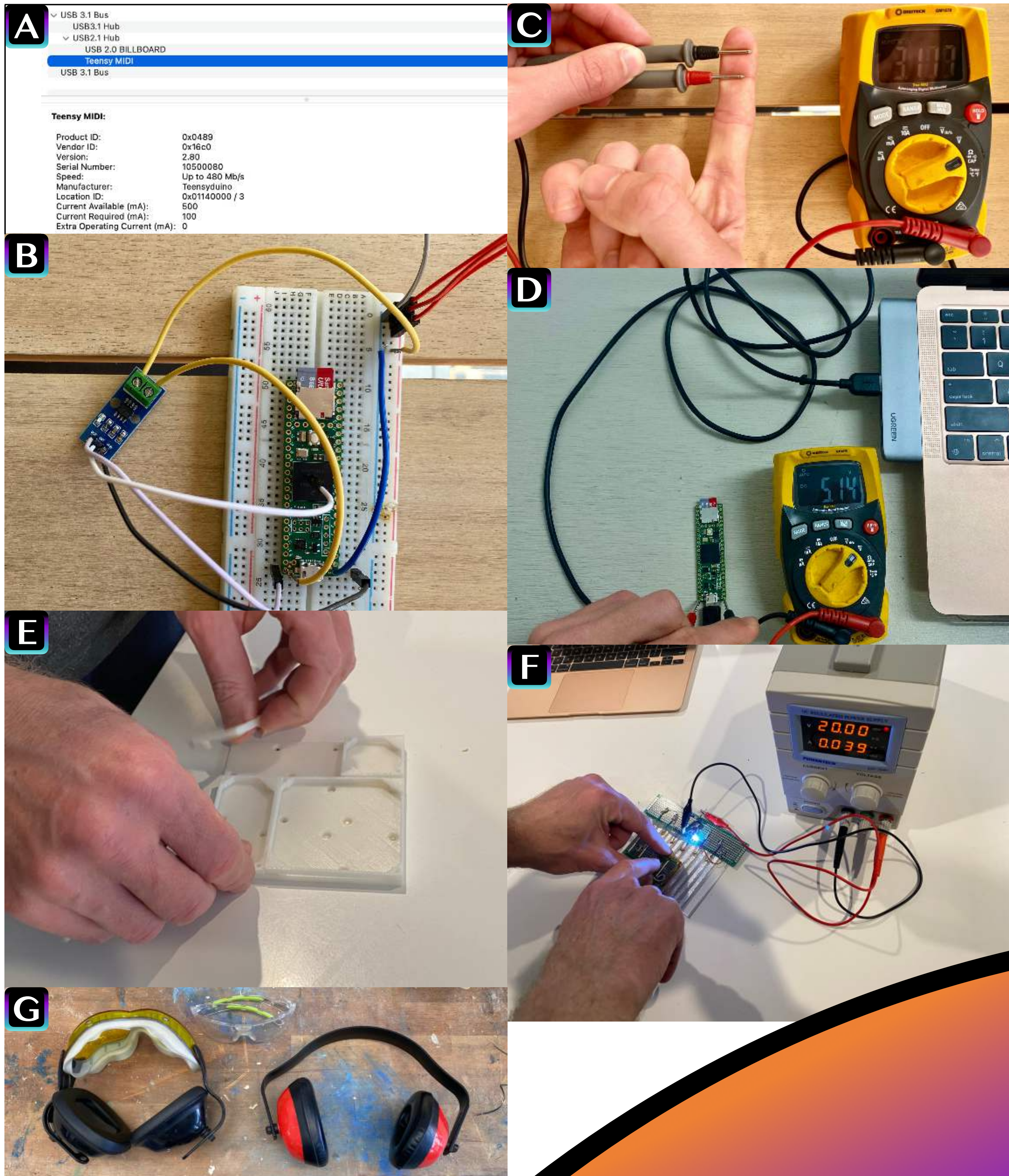
Many machines used in the manufacturing process required Personal Protective Equipment (G) due to inherit hazards. For example, the Computer Numerically Controlled Router requires Earmuffs and Eye Protection to be worn. I measured this machine to have an average sound level of 92db when cutting which can be damaging if heard for more than half an hour a day or more than 4 hours over a week. These measurements confirm the need for hearing protection such as ear-muffs or ear-plugs. Eye protection is essential as the machine cuts by using a high speed router bit. As well as the risk of loose parts becoming projectiles, the material being cut will form shards that can be sent flying in all directions during the operation. For safety, the operator must always be carefully monitoring the job, however eye protection is absolutely necessary.

End User Testing

After initial prototypes were completed, a local DJ was invited to test two aspects of functionality. This was the part swapping mechanism (E) and the electronic hot-swap configuration (F). This testing left me with useful feedback that will be explored further in this folio.

Device Compliance with Existing Standards

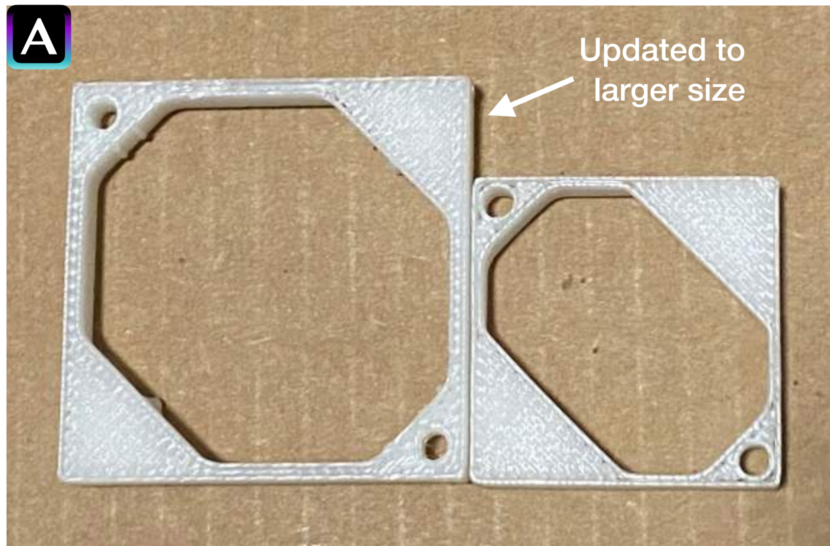
The Universal Serial Bus (USB) protocol allows for devices to consume a certain specified amount of power, as well as negotiate for more power allowance if needed. By implementing a current sensing module (B), MIDIfier is able to dynamically adjust settings to reduce power usage. That can include things such as LED brightness and CPU speed. As seen in (A), even when operating at maximum load, the Teensy chip running MIDIfier adheres to the 500ma limit and only requires 100ma to operate.

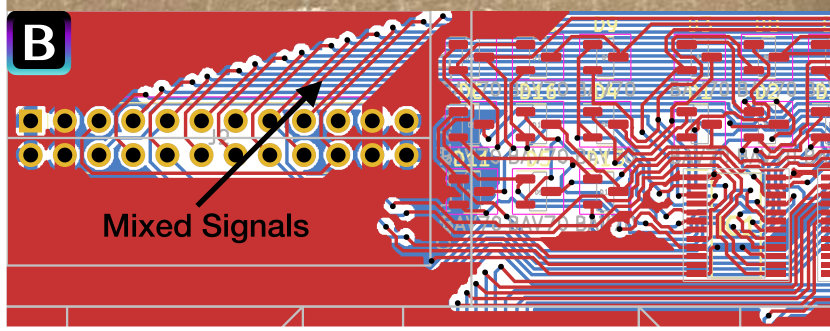


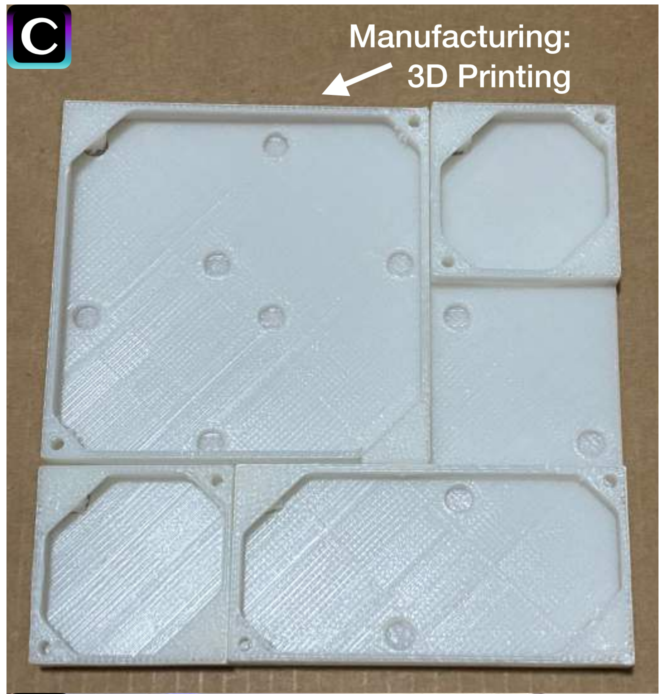
EXPERIMENT	APPLICATION
PCB SUPPLIER COMPARISON	- Revealed the most suitable supplier - Had an effect on (Page 29) where the PCBs were designed. Tolerances and other manufacturer specific requirements were adhered to during the design of the circuits.
SOFTWARE EXPERIMENTATION - 3D CAD	- Revealed the limitations and advantages of various CAD packages - Can be seen on (Pages 18, 27, 28 & 31) where parts were sketched, designed, rendered and machined using the chosen CAD packages
SOFTWARE EXPERIMENTATION - PCB CAD	- Revealed the limitations and advantages of various Circuit Design and PCB CAD packages - Can be seen on (Pages 29 & 31) where circuits and PCBs were created and prototyped. Having 3D viewing helped greatly and this functionality would not have otherwise been available
(E) - MECHANICAL EXPERIMENTATION (MAGNETS & CONNECTORS)	- Confirmed design ideas to be an effective solution - This takes effect all throughout this project. Wherever 2D or 3D CAD has been used, the design of the interlock connectors has been based on the results of this experiment
(B) - ELECTRICAL EXPERIMENTATION (MAGNETS & INTERFERENCE)	- Showed a measurable and predictable interference level that can be safely ignored now that it is quantified - Has taken effect by heavily influencing the PCB routing on (Page 29, fig D) as it allowed close proximity digital and analog wires without worrying about interference
(C) - TOOLING EXPERIMENTS (FABRICATION TECHNIQUES)	- Allowed effective selection of appropriate tooling techniques for each part - Can be seen on (Pages 28 & 31) where various tooling techniques have been used for different parts
(D) - LIGHTING EXPERIMENTS	- Allowed for a value judgement to be made regarding aesthetics and choosing the best material - Can be seen throughout the design as this experiment impacted the materials and tooling techniques used
(A) - TAGET MARKET TESTING	- Gave insight into the direction of the project - This is a core element of this project as it lead to underlying features such as sizing being changed to better suit the user. This has a roll on effect to the entire project

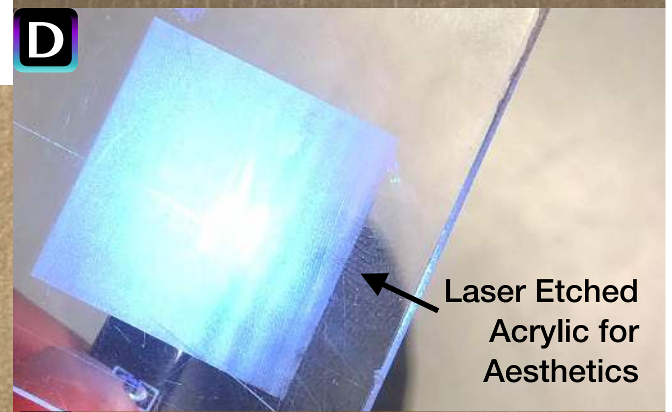
Experimentation & Application

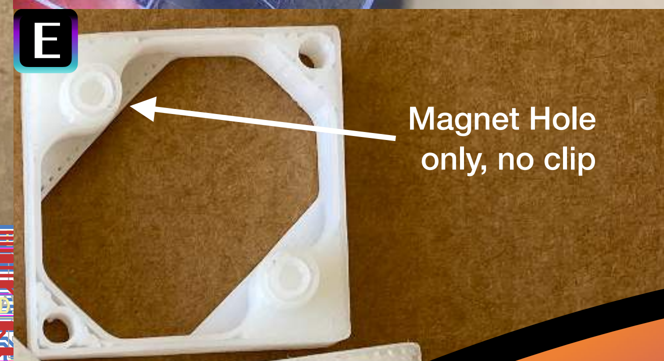
A **very large range of experiments** were undertaken for this project. The reason for such a large number of experiments is due to the **overall complexity of the project.** Each element needed to be **tested thoroughly**. The areas in which the software related experiments were applied aren't shown visually as they were simply the **underlying foundation** for the project. Having the right tools is **essential** and these software experiments helped find these tools. Overall, the experiments were **very effective** in **guiding** the project in the **correct direction** and without these experiments, research, testing and interviews this project **wouldn't successfully head the right way.**



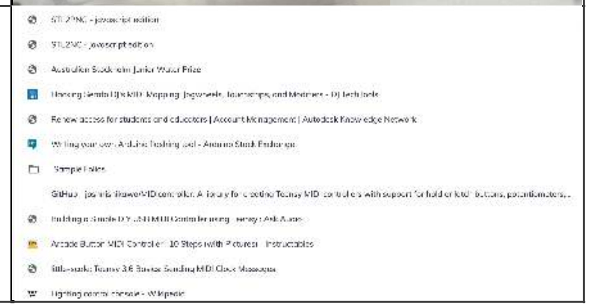




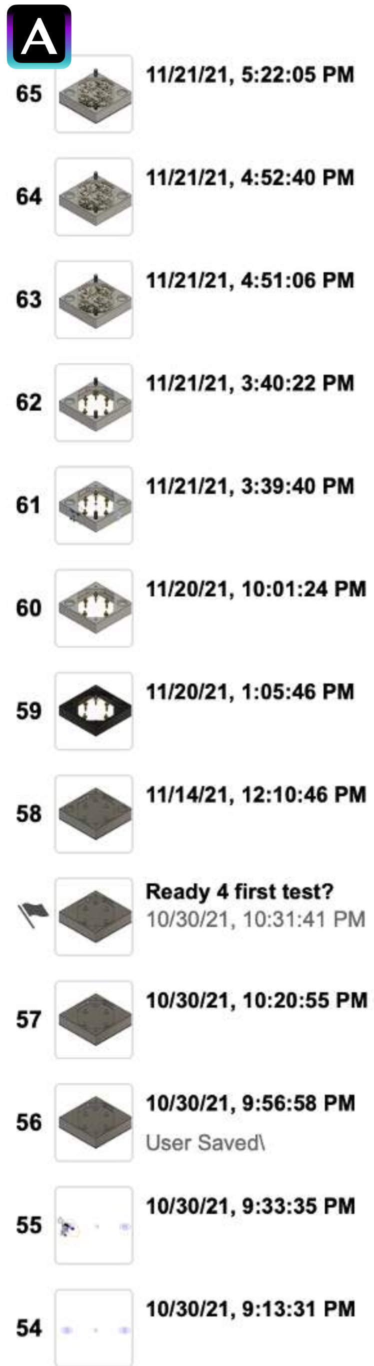


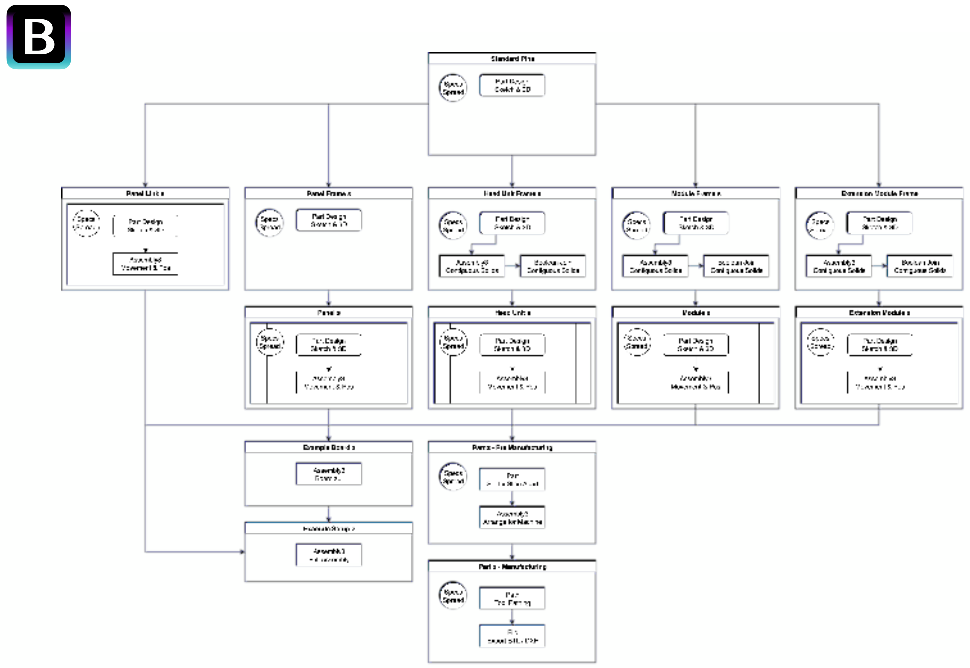


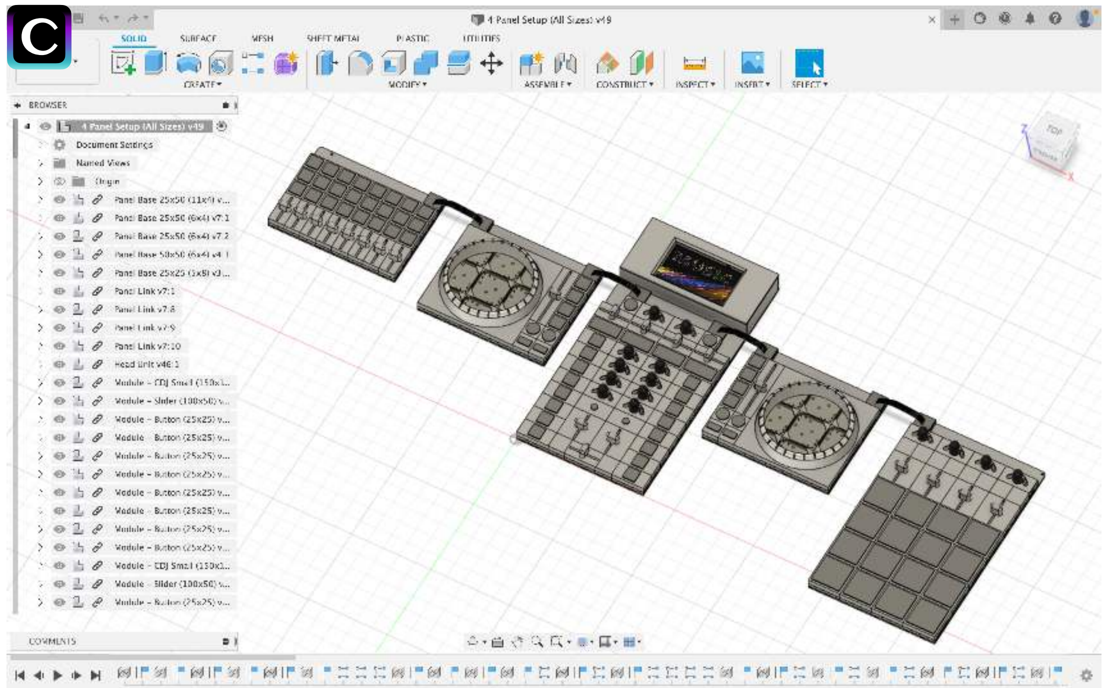
Identification & Justification of Ideas And Resources Used 2.5

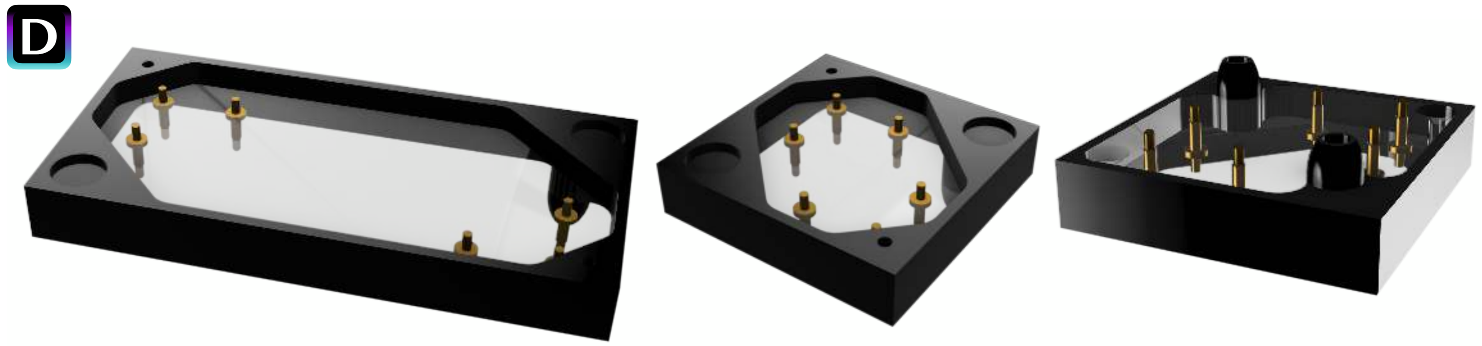
TYPE	RESOURCE	JUSTIFICATION	REFERENCE	IMAGE
PEOPLE	- ************ - Design & Tech Teacher & Safety Advisor - ************ - DJ & Civil Engineer - ************ - DJ & Audio Engineer - ************ - DJ & Backend Developer - ************ - Creative Writer & Grammar Expert - ************ - Interior designer & Colour Expert - ************ - Axiom CEO and Entrepreneur	************ helped greatly with maintaining workplace safety and sourcing materials. The three DJs helped with feedback, testing and improvements after each revision. ************ and ************ gave advice on colour schemes, presentation, grammatical corrections and clarity of the folio and display. ************ gave extensive insight into further steps to complete and commercialise this project.	The feedback and revisions are seen in sections 2.4 - 2.6. The colour schemes are seen throughout the entire project, presentation and supporting video	
HARDWARE	Teensy 4.2 Microcontroller, Arduino Micro, Arduino Uno MacBook Pro & Air Laptop, Workstation Desktop Bench-top Variable Power Supply & Multimeter Soldering Iron, Laser Cutter, CNC Router, 3D Printer Knife, Screwdrivers, Wire Strippers, Other Hand Tools iPhone, Printer, Guillotine, Scissors, Glue	The extensive use of electronics and IT in this project has been fundamental. The many microcontrollers were used for experimentation and the numerous computers were vital in allowing me to create 3D models & renders of the project. The hand tools and power tools allowed for rapid prototyping and quick testing and optimisation.	3D Models & Renders are seen throughout the folio and display. Microcontrollers and coding is seen in sections 2.4 - 2.6	
SOFTWARE	Karo Graph, Medibang Paint, Adobe Illustrator, Draw io Fusion 360, FreeCAD, KiCAD, Blender, Adobe XD Final Cut Pro, Handbrake, Logic Pro, Mixxx, Midi Monitor Pages, Numbers, Keynote, Vectornator, TextEdit Google Chrome, Preview, Kap, Notebook Teensyduino, Atom, Platform IO, GitHub, Simulide	A very broad range of software allowed this expansive project to take place as lots of time went into finding “the right tool for the job”. Through various CAD packages to many text and graphics editing programs, code editors, note taking and management systems, this project was efficiently completed due to these optimised programs.	The programs used are evident throughout this project in everything from assets to the quality of folio & video produced and displayed	
MATERIALS	PLA 3D Print Filament 3mm Clear Acrylic, 4.5mm Clear Polycarbonate Aluminium foil, Wires, Solder, General Electronics Microcontrollers, Sensor Modules, Breadboard, Perfboard Neodymium Magnets, Screws, Super Glue	Various plastics were used due to their compatibility with different manufacturing techniques. The use of electronic components was large as this formed a basis for the project as well as the extensive use of microcontrollers. Various other items such as screws and magnets were used too.	The usage of these materials is seen from sections 2.3 - 2.6 as well as in all the prototypes created and displayed	
WEBSITES	https://www.kjmagnetics.com/calculator.asp https://github.com/joshnishikawa/MIDIcontroller https://en.wikipedia.org/wiki/MIDI_Show_Control https://github.com/ImpulseAdventure/GUIslice https://octopart.com/search?q=INA260 https://github.com/mitxela/kicad-round-tracks https://www.pololu.com/product/3089	Over 75 websites were used and bookmarked for important information and research in relation to this project. The sample shown here highlights the variety of sources from wikipedia to proprietary calculators as well as code resources from Github. Vast research was done into each section of this project as the complexity and ideation required lots of accurate information.	The research performed is evident throughout the project, especially in section 1 where ideas are explored and supporting information was found	

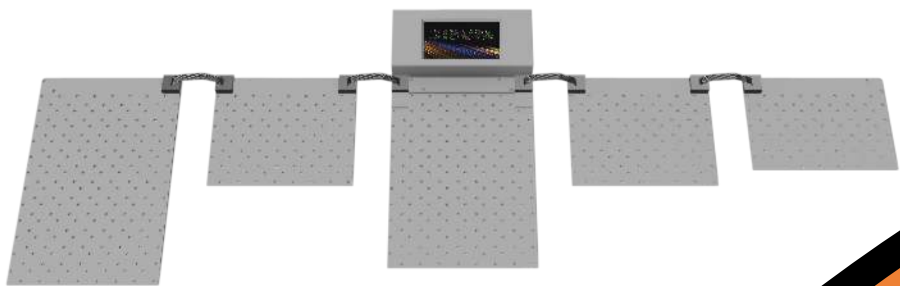
The identification of resources used has been shown in a table for simplicity and clarity. This section hasn’t been beneficial to the projects progress, however, it is an important process to identify these resources. By categorising them and justifying where and why each was used, it is clear to viewers where much of the information and tools was from and may be helpful for others with similar projects. This is especially the case with the software section, as lots of the software used was found only after thorough research, experimentation and testing. This folio isn’t the ideal location for information on these sources, especially the website references as far more were used that could not be displayed. For future projects, I will look into ways to document and record supporting resources and information for future reference.











3D CAD - Planning

3D design forms a **very large aspect** of this project. Knowing this, care was taken into **properly planning and preparing before beginning CAD work.** The initial controller breakdown (Page 15, fig. 1) was revisited and expanded into a **low level plan** (B). This low level plan breaks each component of the design into the **structural processes** which are needed to create it. For example, a **base sketch** that is **revolved** to create a **conical interlock pin.** This low level plan also details how components should be **inter reliant** on one another. This is because with such a complex design, it **should not** be fully **placed in a single file.** Each component should be a seperate file which is **linked** to any other required files. In doing this, a **base feature can be updated** and the whole design will **recorrect itself**, rather than a small change requiring a complete redo. This also allows the design to become more flexible if the required parts aren't available and a slightly different variant is required.

3D CAD - Organisation

After the low level plan was completed, a **file structure** was developed to allow for **correct saving and versioning** (A). Each version can have a description if required, and if not it will have the **date and time the modifications were made.** This is an **essential organisational structure** that will prevent this project from ever being **lost, corrupt or otherwise confusing.**

3D CAD - Design

With a detailed plan and proper organisation established, 3D design could commence. This **consumed many hours** and a **large percentage** of this project's time budget due to the **complexity and considerations** that had to be made. While the initial 3D models were being made, not all the material testing had **yet been completed**. This meant that it was **unknown** whether the final product would be **laser cut, CNC routed or 3D printed.** This was later decided after the materials and tooling experiments (Pages 23 & 29), however before this, **consideration had to be taken** with the **possibility that CNC manufacturing may be required.** This is due to the fact that a CNC router with a standard flat end mill bit **cannot produce sharp internal corners.** The smallest tool bit available for the router was 1/8" size, **meaning no corner sharper than around a 1/8" diameter circle could be made.** The entire design was made with this in mind, leading to the **more fluid and curvy inner designs** for modules.

Evidence & Application of Practical Skills to Produce Product 2.6

Materials

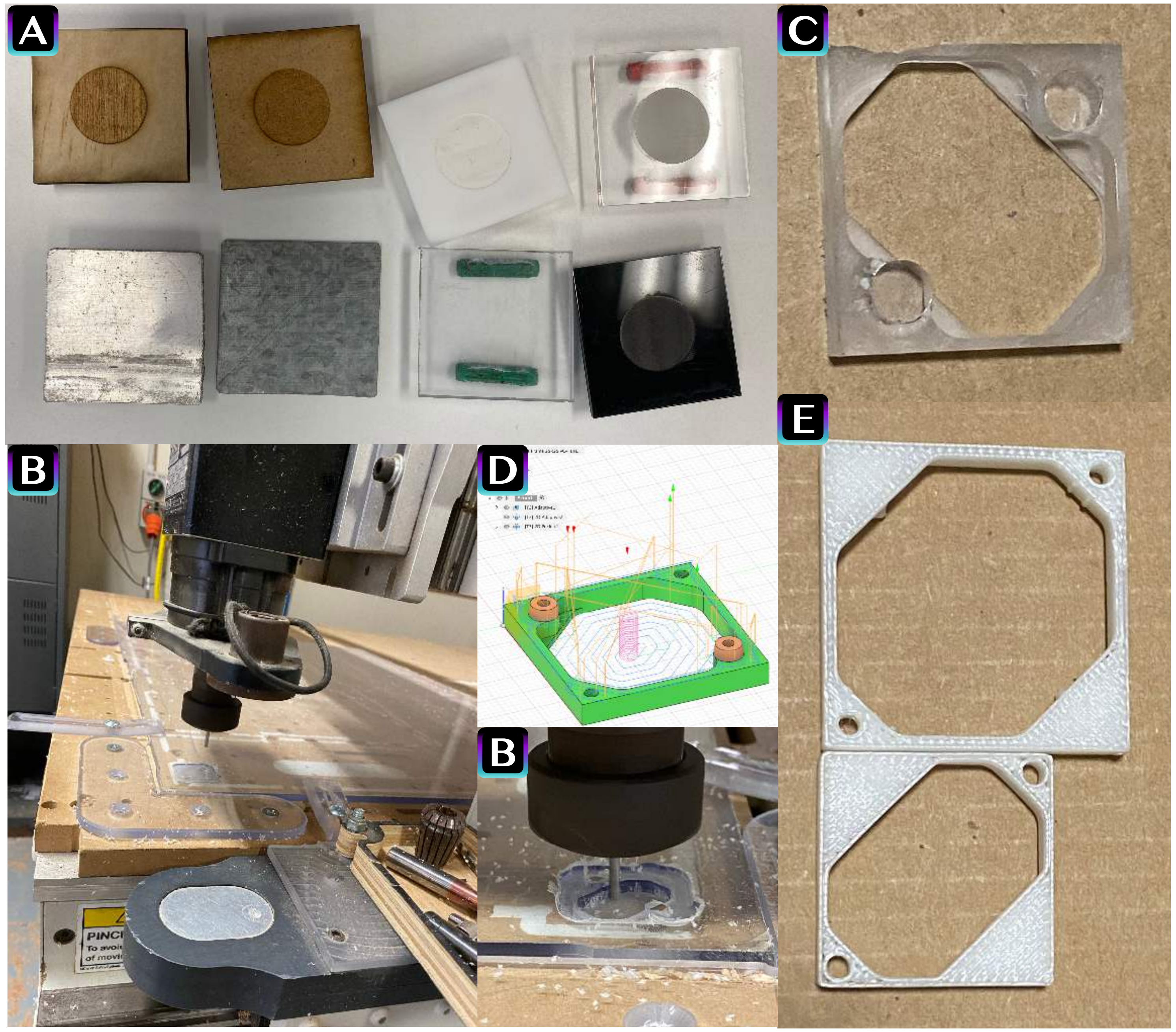
Many potentially suitable materials were evaluated based on their **structural integrity, aesthetics, function and compatibility with available tools and skills** (A). The main structure of this controller has **very fine tolerances and small parts,** so timber won't be ideal. While timber was considered for face panels and aesthetic elements of the design, **bowing, staining and variability** are likely to be common issues. On top of this, there are e**xtra complexities involved** with using a wider than necessary variety of materials making timber **unsuitable for MIDIfier.** Steel and aluminium have **exceptional structural qualities**, however can be more difficult to machine and require tools that are not currently available to me. It is **possible to outsource** some of these jobs, however it is **unnecessarily complicated** for small added benefit. Cast acrylic comes in a variety of colours and opacities. It can be laser cut **easily and accurately** however it shatters if used with a CNC. Polycarbonate is the opposite of acrylic for machining. It cannot be laser cut, but cuts flawlessly in the CNC. For these reasons, I will use acrylic for the sections that can be laser cut. If any CNC milling is used, polycarbonate will be the best option for those parts.

Machining & Manufacturing

CNC machining (B) was the **first method tested** to manufacture the models. The tool pathing required (D) was **rather complex** and very time consuming due to **so many operations on curved surfaces.** There also is not a tool available for this machine that is small enough to cut the holes for the magnets, **seen missing in the part in image** (C).

After these issues were discovered, it was **back to the drawing board.** The model was **updated** to have **thicker walls to allow for 3D printing**, which had **much finer accuracy** (E). 3D printing these parts was **slightly less strong** than the polycarbonate version, however this could be solved in a commercial setting by **injection moulding** or other **mass production methods** so for a prototype, **3D printing is sufficient.**

Finally, laser cutting was used to make the top panels of modules from the clear engraved acrylic in the top right corner of image (A). This is simply as due to the lighting experiments (Page 23), it is the **most aesthetically pleasing** material for the job and can be used in 2D parts.

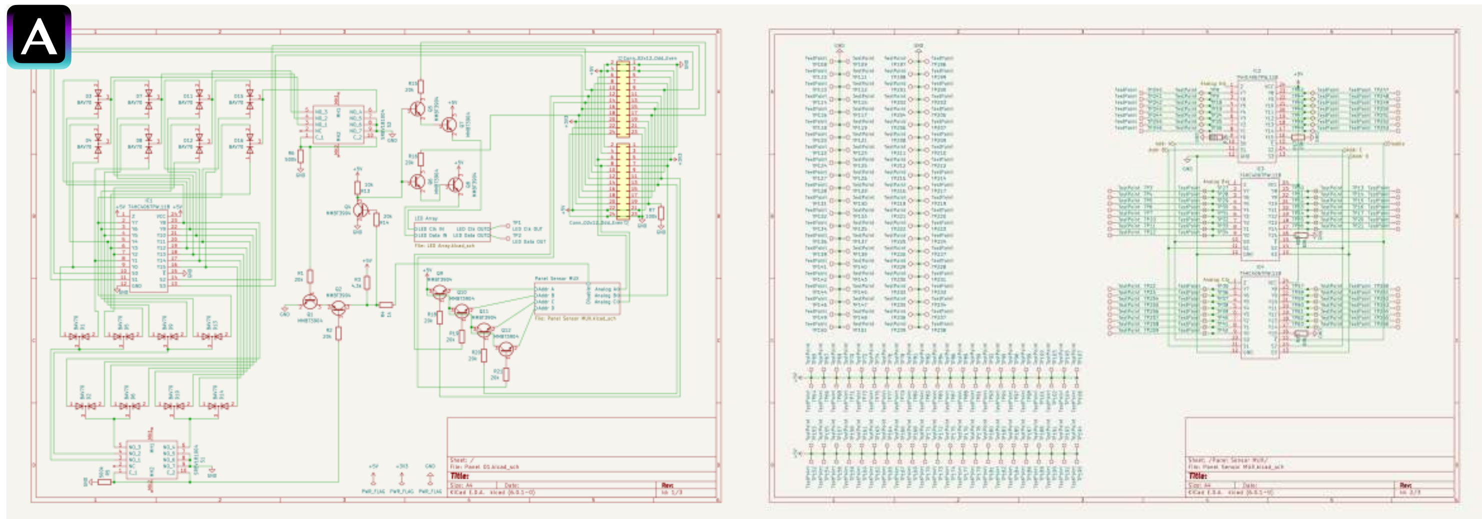


Machining and manufacturing of the various prototypes, experiments and other elements of MIDIfier was an extensive process with many mistakes and revisions made. As often is the case with advanced machining, many lessons were learnt through trial and error, especially with tool pathing for the Computer Numerically Controlled machines. For the CNC Router, the first mistake was not "tabbing" the job, meaning that as the final cut was made, the piece moved and was damaged by the still spinning bit. On the next operation, small tabs were inserted into the design which held the piece in place throughout the job. At the end, these were cut by hand with a utility knife to remove from the stock material. Many similar learning curves occurred in the processes of 3D printing and Laser cutting, all of which overall developed my knowledge and understanding of these tools and fabrication techniques. In the next project, this section could be improved with more thorough photography and videography to better show the manufacturing process, failures and changes.

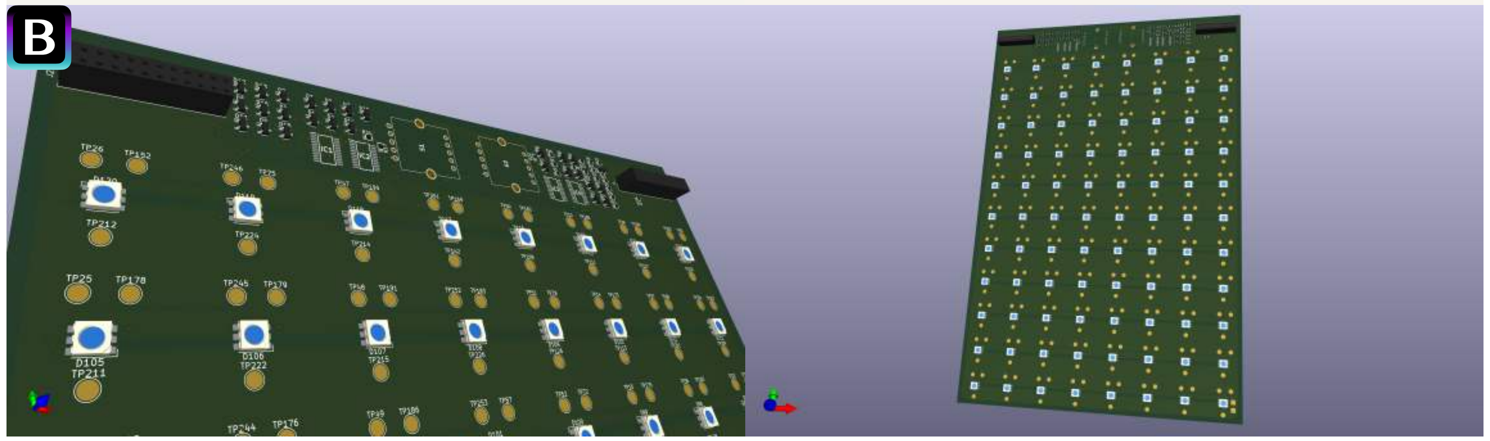
Electronics & Circuit Design

Circuit Design is a **major element of MIDIfier.** This is because of the **inherent complexity** with making such a **large scale system.** In this design, each MIDIfier Head Unit can be connected to a maximum of 16 panels, each of which can hold up to 44 modules. Each module slot has two individually addressable LEDs, each of which can display approximately 16 million colours (256^3). This means there is a **maximum of 704 analog signals** and **1048 LEDs** that need to be read and written to. For an ideal analog refresh rate of 1ms for all components, this can mean components need to be read in **close to 1 microsecond each.** The LEDs should be updated at 120Hz, requiring (64*120) + (32*1048*120) bits per second, **approximately 4Mbps** or a clock speed of greater than 4Mhz. Overall however, this means a **well designed circuit** is required to support this, far more than is achievable by hand. At these speeds, **wire length and resistance** play a large part and thus should be made from **copper tracks** set to specific desirable widths and lengths. The top level concept of how the laptop and core parts of the circuitry should be connected (C) were **sketched in Karo Graph**, a simple drawing utility. The full detail designs were done in **KiCad** as it is **free, open source** and allowed for schematic design (A), PCB design (D) and 3D previewing (B).

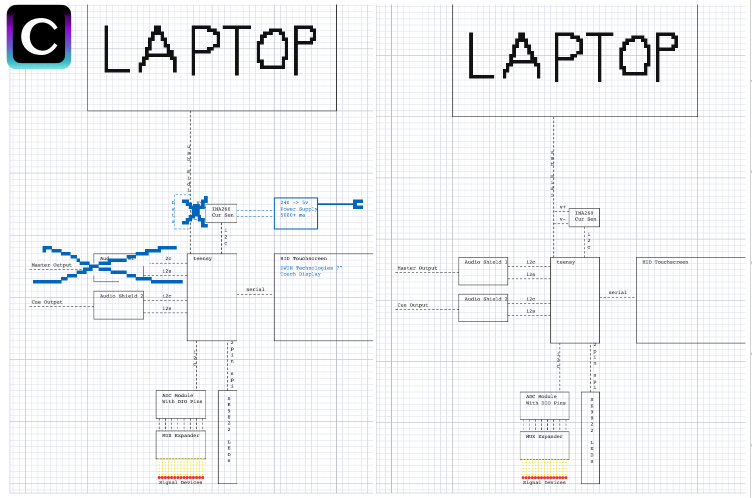
A



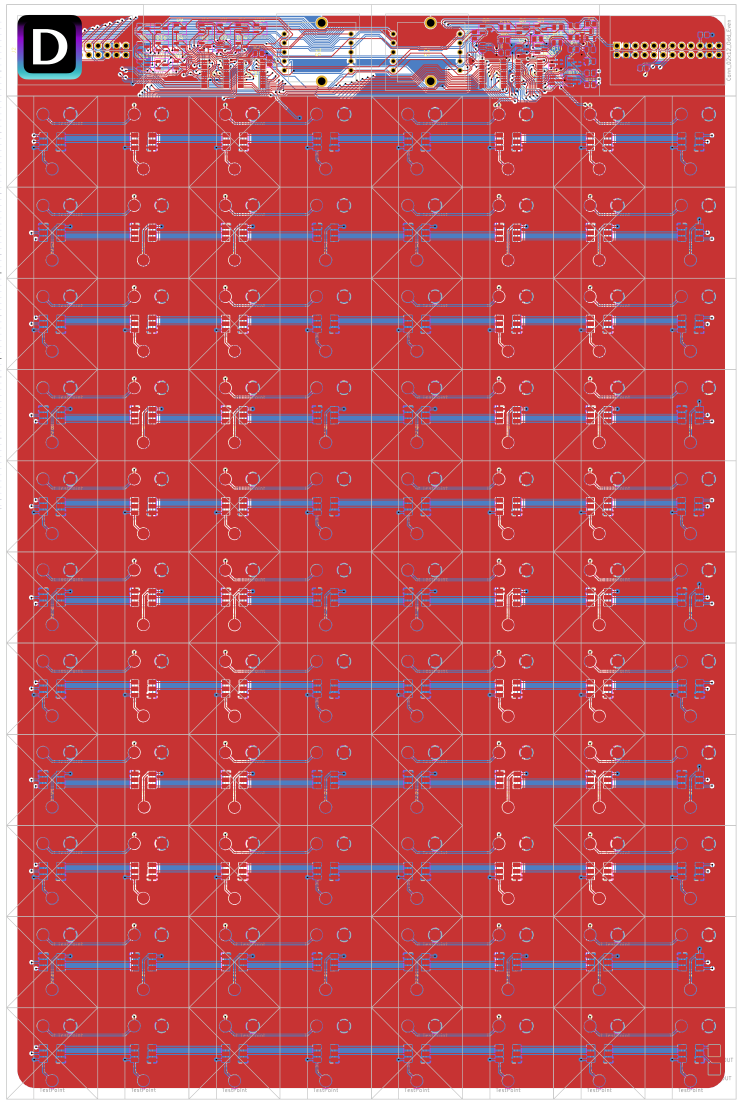
B



C



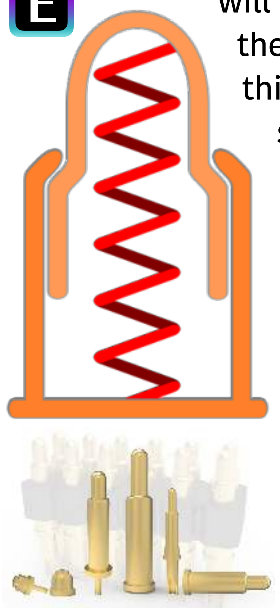
D



PCB DEVELOPMENT

The circuit for the panels is broken down into **two main sections** - the **attachment area** and the **addressor**. The addressor is the very top bar seen at the top of fig (D). This part is responsible for **only allowing connections** to the Head Unit when the **correct address is selected**. It works by having **two selection knobs** the user sets to a **unique channel combination** (ie, positions 2 & 5). This will activate only a **single channel** from a **16 channel multiplexer.** This multiplexer will allow a signal through when the three address pins are set to the corresponding pin the switches are set to. In this way, each board will only receive and respond to signals on the channel its switches are set, meaning **all 16 panels** can **take turns talking** on the **3 wire bus without interfering.** The attachment area is the rest of the board. It contains **exposed copper pads** wherever a component slot is available, as well as **evenly spaced LEDs** in a **grid underneath all slots.** The LEDs allows for **complete colour control** of every component individually at very high refresh rates. The copper pads facilitate a connection between the panel and the interchangeable components, each of which will have it's own **smaller circuit board** with the sensor (button, knob etc) and pogo pins (E) to connect to these copper pads.

E



Code Editor

As this project progressed, it became evident that the default (D) Arduino Integrated Development Environment (IDE) **was not sufficient** for the volume of code being produced. **A switch** to the **open source ATOM editor** (A) with the PlatformIO plugin (B) allowed **better handling** and **management of large code bases** as well as some **time saving features** such as **pre-emptive typing.**

Usage of Libraries

Many libraries were used to interface with different sensors and components. Some of these include InternalTemperature.h, RTClib.h, SdFat.h, FastLED.h to name a few (C). These assist with temperature monitoring, real time tracking, SD card communications and LED operation respectively. By using these **community built** and **open source libraries,** these operations could be achieved **efficiently** with **minimal extra code required.**

Assembly of Modules & Compute Power

As the **independently tested** sections of code (E) for doing various things **proved effective,** the time came to assemble these into the **one functional program.** In doing so, it became evident that the **cooperative multitasking system** could be **overloaded** by a single task taking too long. To solve this, a new system had to be invented that would use the **CPU clock cycles** to work out **how long each task took** so an analysis could be later performed. This led to an **extensive bug tracking system** being implemented later on.

Bug Tracking

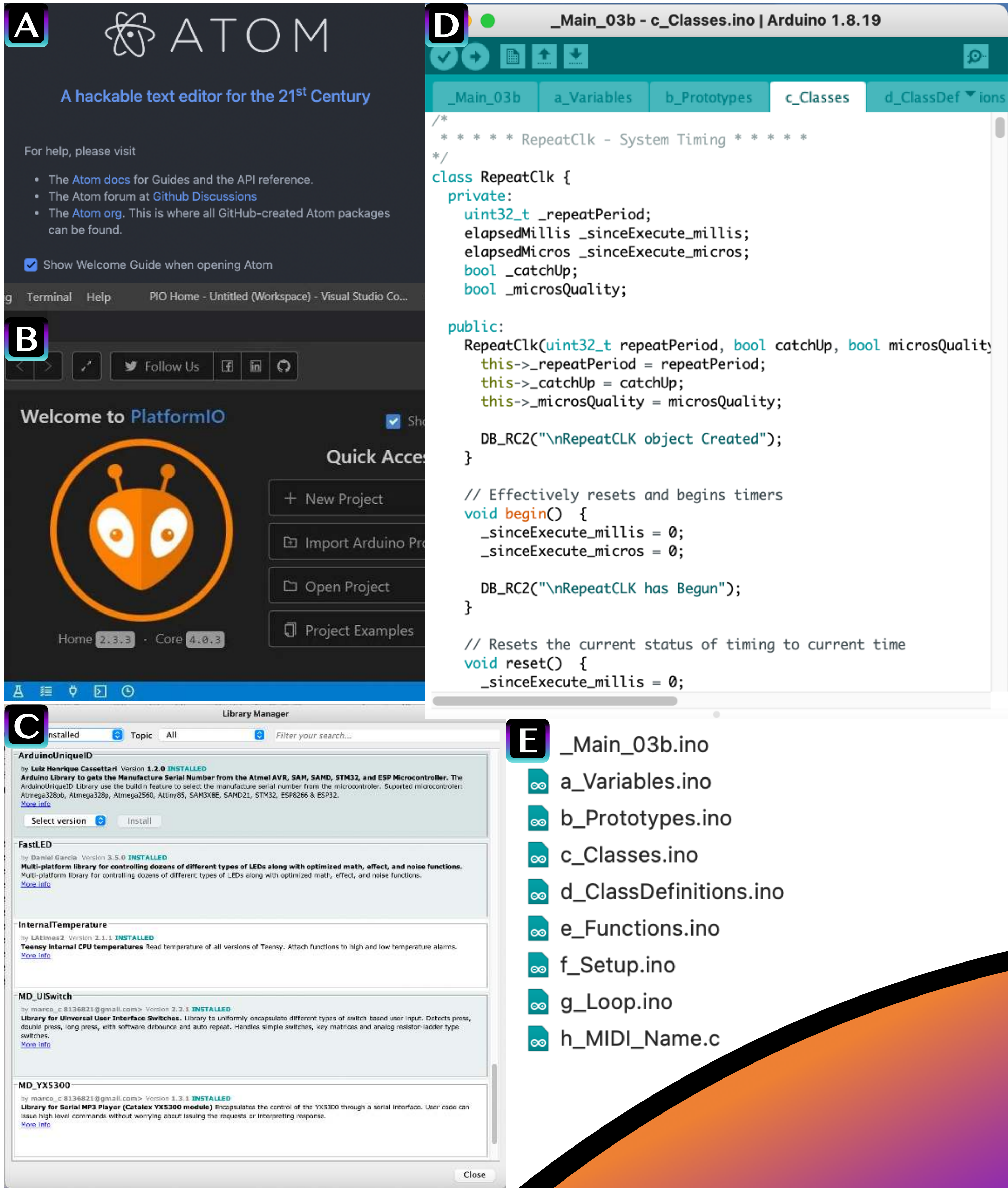
As the complexity of the program increased, simple methods of bug tracking using “print” statements **started to fall short.** Instead, a **universal bug tracking system** was created which used **macros** to tell the compiler where to copy and paste de-bugging code when needed. This **saves lots of development time** and **allows debugging with greatly simplified commands.**

Usage of Classes

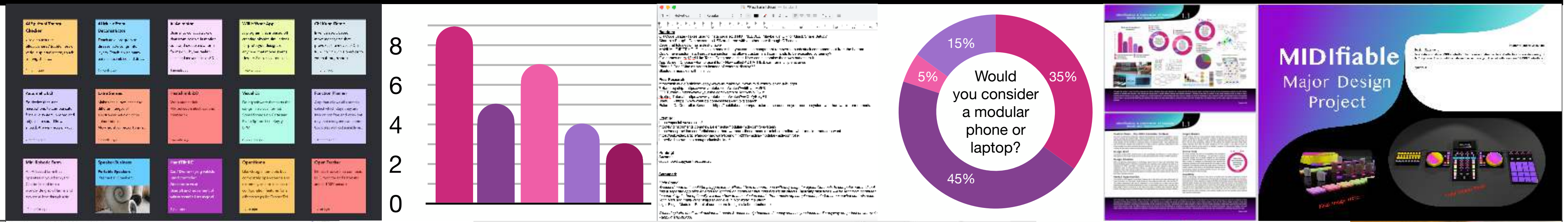
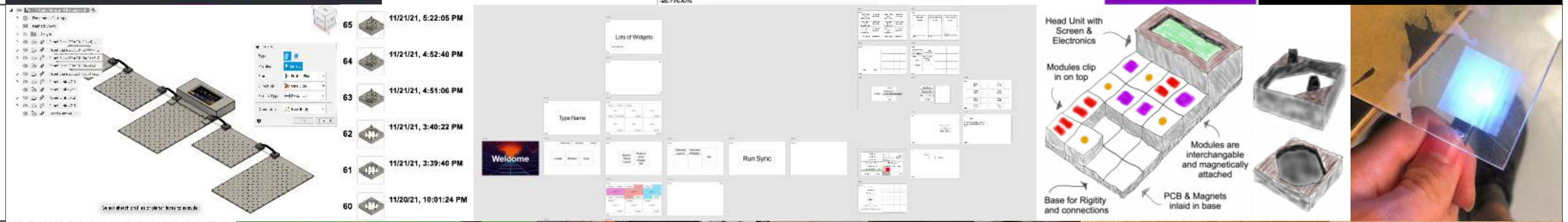
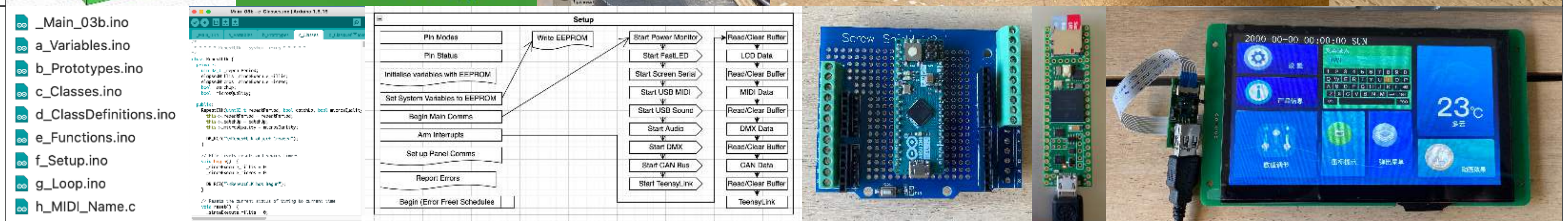
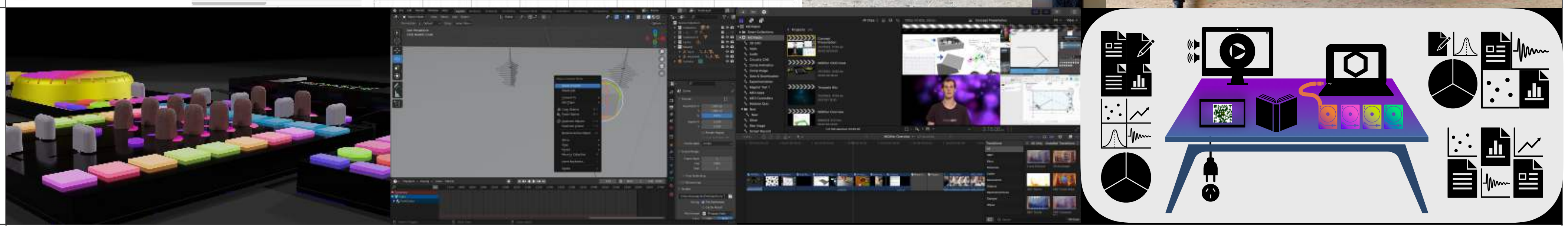
A **learning curve** with this program was to utilise “classes” which are segments of code and variables that can **have many copies created and destroyed at will.** Previously **I had never used classes** so **learning this was a challenge,** however it **greatly improved the code efficiency** and simplicity once implemented.

Final Status

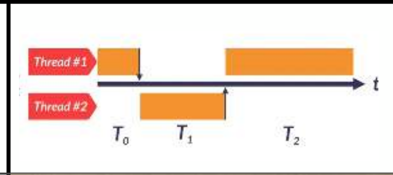
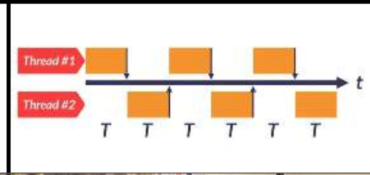
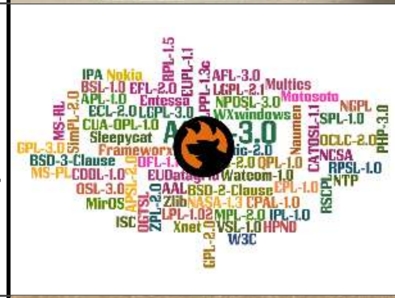
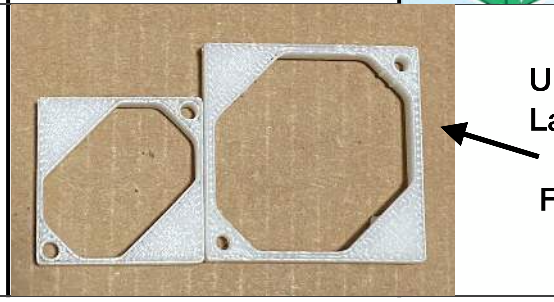
After these various changes and improvements were implemented, the final status of the code leaves a **fully functional program** that is **ready to be implemented** and adjusted to a variety of custom hardware. **It functions standalone for various tests and prototypes** as needed and is **overall the most thoroughly completed component of the project.**



Evidence & Application of Practical Skills to Produce Product 2.6

TASK DESCRIPTION	TIME TAKEN	EVIDENCE
PLANNING, COMMUNICATION & DOCUMENTATION: THIS INCLUDES DISCUSSING IDEAS, IN CLASS ASSESSMENTS, PRIMARY AND SECONDARY RESEARCH AND FOLIO WORK	**91 Hours** **15** Ideation **4** Discussion **6** Primary **6** Secondary **60** Folio	
SKETCHING, DESIGN AND TESTING: THIS INCLUDES ALL DESIGNS UP TO MANUFACTURING POINT AS WELL AS EXPERIMENTATION WITH TOOLS, MATERIALS AND TECHNIQUES	**182 Hours** **18** Sketching **80** 3D CAD **45** PCB **17** UI / UX **22** Testing	
TOOL PATHING, FABRICATION & ASSEMBLY: THIS INCLUDES CREATING TOOL PATHS, SETTING UP MACHINES, PURCHASING MATERIALS, CONVERTING DESIGNS & MAKING TWEAKS AND ADJUSTMENTS	**34 Hours** **7** Tool Paths **6** Setup **9** Materials **12** Tweaks	
PROGRAMMING, TESTING & ANALYSIS: THIS INCLUDES PROGRAMMING, TESTING FEASIBILITY AND IDEAS, TESTING CODE, UI & UX, ANALYSIS AGAINST ORIGINAL INTENT AND EXPLORATION OF REQUIRED CHANGES	**113 Hours** **56** Coding **12** UI / UX **27** Testing **18** Mods	
PRESENTATION & DEMONSTRATION: THIS INCLUDES SETTING UP DISPLAY PRESENTATION, DEMONSTRATING AND CREATION OF SUPPORTING CONTENT (VIDEOS & ANIMATIONS)	**51 Hours** **30** CGI **13** Video **8** Display	

This section of the folio has been extremely interesting as it neatly summarises the work of the entire project. This is possibly the most elegant and useful table in the project, clearly and visually showing both the numerical information as well as reference images that clearly identify the tasks completed. In a future project, it would be great to include a graph comparing time spent on each aspect so that viewers can visually understand the information.

PRODUCTION TECHNIQUE	APPLICATION IN PROJECT	ORIGNAL	MODIFICATION
QUALITY CONTROL	The programming for MIDIfier was very complex and required thorough testing to ensure it was up to the highest quality. To do this, parameters were incrementally increased to stress the scheduler to its limits. In doing this, it became evident that the scheduler was not able to correctly prioritise and manage tasks when a single task had a long waiting period, as it was able to hold up the entire program. To fix this, the scheduler was re-written to dynamically track task execution time and halt it if necessary.		
SAFETY ISSUES, SOP, MDS & PPE	Many potential risks have been assessed and mitigated throughout this project. This includes correct operating procedures for all machinery used (Laser cutter, CNC Router, 3D Printer) as well as supervision from a trained professional. Material Data Safety Sheets were also taken into consideration so that laser cutting was limited to certain materials to prevent toxic by-products being produced. Similarly, certain materials like acrylic could not be cut using the CNC router as it tends to shatter and cause sharp shards to be produced rather than cut smoothly with harmless pieces being cut off. All laser cutters were fitted with closed cutting chambers and extractors which were used during every cut. The 3D printers used have an enclosure to prevent accidental bumps and burns however do not have extractors, so they were used in an open place with plenty of airflow. Even with the correct Standard Operating Procedures, inherent risks with machinery are always present and the appropriate PPE was used at all times. This included protective eyewear and ear protection when operating the CNC Router. Safety for the final user has been considered in many aspects such as low operating voltage and short circuit protection.		
LEGISLATIVE ISSUES	Two main legislative concerns were considered during this project. For all electrical appliances in Australia, complying with Regulatory Compliance Mark and Mandatory Approval Certificates is required before selling to an end user. The research was completed in order to know what would be required for a final product, however as MIDIfier is only in the prototype stage, no action was required so far. Another consideration was the Intellectual Property rights for the development environment (Arduino IDE) and the bootloader of the microcontroller. All of the systems used are licensed with different open source licences, commonly GNU v2 or MIT. This can have implications requiring the source code for MIDIfier to also be open source, however provided the licence agreements are met selling this product should be legal. When a final product is achieved, a professional will be consulted.		
MODIFICATIONS	Many modifications have been made during this project, however the most fundamental change has been the decision to revise the size of the modules. By changing the base size, all modules and mechanical parts were affected and needed to be redesigned to suit the new sizing. As big of a change as this was, it became apparent how important it would be after the spacing of controls on a standard DJ controller was assessed. This idea to change the size of the modules was instigated from the testing performed with professionals in the field. The feedback of the interlocking mechanism was that the modules were "too small and finicky" and would be "better if they were larger with stronger magnets and a more secure hold, even if modules were not as compact". Ultimately, this design modification has proven to be an essential step forward into producing a more ergonomic solution.		Updated to Larger Size after DJ Feedback

The final production of MIDIfier was fairly limited due to a few reasons discussed further in section 3, however, the production techniques used in manufacturing of the prototypes has been an extensive undertaking. This section has been effective in demonstrating the extensive attention to safety that has been evident throughout all manufacturing of the project. It has also given an opportunity to display the research that was completed around legislative issues and considerations, initially which were researched out of curiosity rather than necessity as this product is far from consumer ready. This section was fairly brief in that I was not able to fully explain all the modifications made, especially relating to the programming. Many of the programming issues are specific to developers and generally are hard to explain to general audiences without extensive explanations of the mechanisms in place behind the workings of the code. For this reason, I found this section frustrating to complete as there is much more I wish to include but do not have the space to.

Use of Communication & Presentation Techniques

2.7

KEY	
	HIGHLY SUCCESSFUL
	SUCCESSFUL
	SATISFACTORY

COMMUNICATION TECHNIQUES	APPLICATION	JUSTIFICATION	EVALUATION
USE OF TEXTS, COLOURS AND FONTS	A specific style was chosen that included a matching range of fonts, colours and shapes	Maintaining a specific style is aesthetically pleasing as well as neat and presentable	The theme was coherent and personally I am extremely satisfied with it overall
POSTERS & CONCEPT BOARDS	Concept Boards were used especially during ideation phase as an effective cognitive organiser	Concept boards allow the exploration of ideas as well as being effective to communicate to others	These were very effective and if given more time I would make more for each stage of the project
SURVEYS	A survey was used to gauge user opinion and understanding towards modularisation	This survey was essential in gauging the quality of the original idea early in development	This survey was fairly insightful and it would have been useful to complete another later on
SKETCHES	Digital & Hand sketching was used especially with ideation and CAD design	Sketching is fundamental in bridging between ideas and concept and has been thoroughly used	Finding a bridge between CAD and hand sketches could greatly improve the efficiency of this
CAD	3D CAD design has been fundamentally used for creating all parts of the models	3D CAD is currently the best way to create models that can be produced by CNC machines	The 3D work associated with this major works has been efficient and essential
GRAPHS AND CHARTS	Graphs and charts have been used to show visual data from surveys and similar data sources	Visual representation of comparable data is usually easier to understand than numbers	The graphs used in this major have been effective and well placed to best serve their purpose
AUDIO / VIDEO	A supporting video presentation was created to better show video animations and other graphics	Video is often able to intuitively show movement and relationships better than photos	The 3D animation has been difficult but highly valuable in explaining MIDIfier to an audience
PHOTOGRAPHS	Photographs have been used extensively throughout this major as a way to share info	Photographs are able to visually show and prove the work being described throughout this folio	Photos caused large file sizes and other issues but overall have been highly effective
POSTERS	Posters are used as a visual representation of design processes and ideas that were undertaken	Posters are able to display and highlight important concepts that need attention	Posters have been great for portraying information at first glance to an audience
MODELS & PROTOTYPES	Physical models and prototypes were made to test various components and mechanisms	Models and prototypes are effective for understanding and improving mechanics	The variety of prototypes have been essential to progressing with the development of MIDIfier
WRITTEN EXPLANATIONS	Written explanations are used to convey information that isn't otherwise clear or known	Written explanations provide a way for thoughts and ideas to be explained	Overall, the text content is extensive and detailed however writing is not my strongest skill
SIGNS / LABELS	Labels are used in the presentation setup to clearly mark experiments and prototypes	By using clear labelling, it is easy to cross reference from the folio to practical application	The labelling system has been effective in keeping an organised demonstration
TABLES	Tables are used frequently as a structured way to represent and organise information	Tables are a very structured and clear way to organise information which is perfect	In many cases, it made most sense to use tables extensively throughout this folio
MIND MAPS / FLOWCHARTS	A variety of cognitive organisers have been used as a way to manage ideas and concepts	Cognitive organisers help with creative processes such as ideation and flow charts	The range of cognitive organisers used has been effective in organising and developing ideas
FINAL DISPLAY SETUP LAYOUT	The final display is set up in a way to best show the progress of this project	Having a physical display set up gives users tangible prototypes to interact with	The final display was very effective in presenting and explaining the concept and prototypes

This section of the folio seemed to add very little value to the overall project. This is because in my opinion most of the information presented should already be evident. However, by summarising and justifying the techniques used, it is clear to any viewer that the techniques were intentional and deliberate in order to achieve the quality of project and presentation desired. As well as this, it provided a fairly valuable chance to reflect on the effectiveness of each communication technique, most of which were highly successful. Of course, this opinion is subjective and is a self judgement, so viewers may disagree. For this reason, in future projects I will look towards using similar tables as learning diaries to assess what can be improved upon, rather than as a displayable reference of the work completed.

Presentation Setup Plan

Posters & Concept Boards will be displayed **alongside** my project. These concept boards were **used during the ideation stage** of my project to **collect and explore possibilities.**

The 6 minute video created to **support my folio** will be **playing on repeat** on a large computer to **give visual insight** into the project **at a glance**, as well as **provide more details than pictures alone can.**

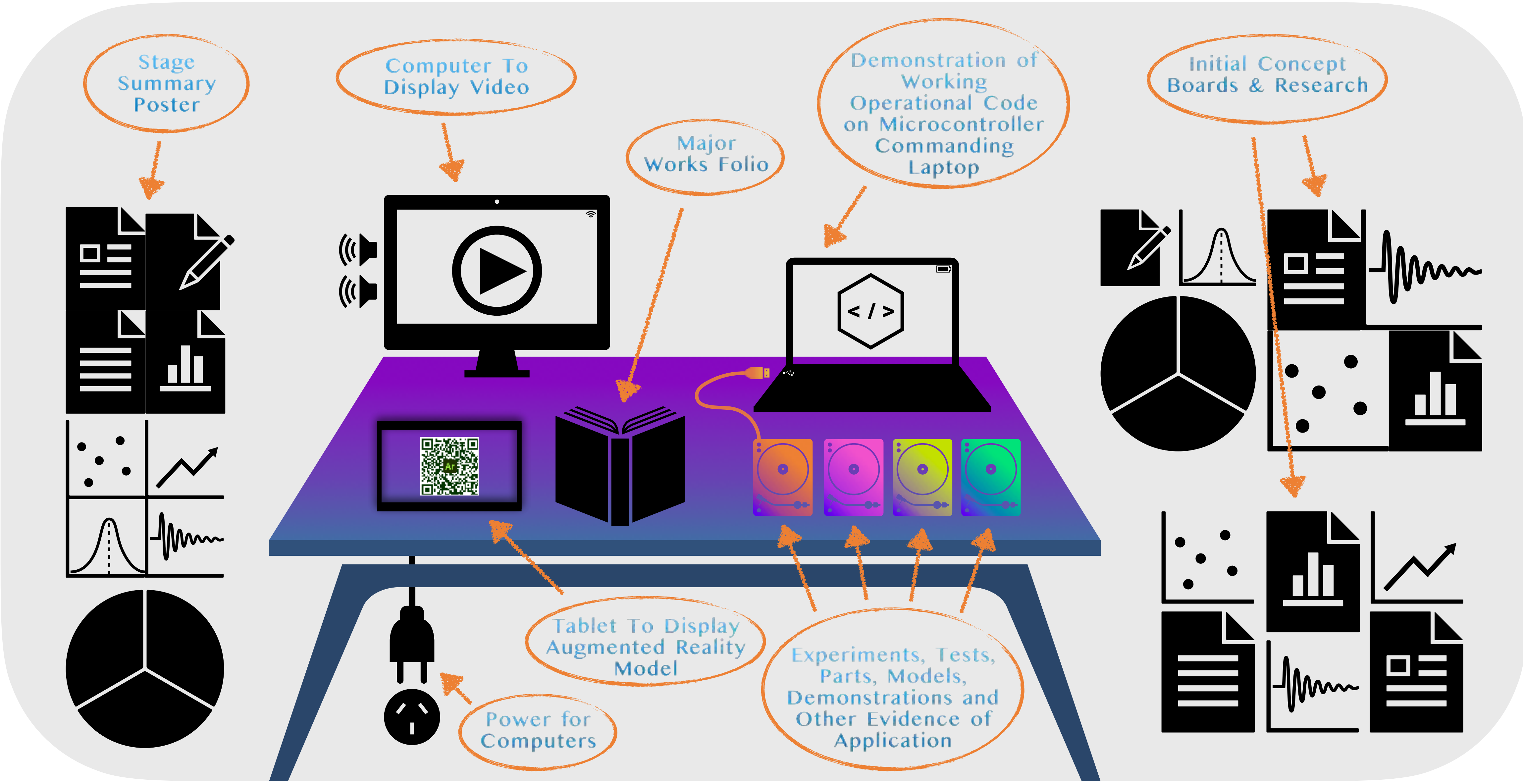
The Major Works Folio will be at the **front of the desk** and easily accessible for anyone wanting to read it. It will be printed in **A3 size and be 40 pages in total length.**

An iPad will be set up with the **Augmented Reality model** of MIDIfier that was used for prototyping. This will provide viewers with the **opportunity to explore the design at their own pace.**

The full set of **all Experiments, Tests, Prototypes, Comparisons, Materials and other physical elements** of this project will be displayed on the front right side of this table. These are listed below.

Signs made from **laser cut two layer plastic** will give **brief descriptions** on different parts of the exhibition and what they relate to. This will allow the user to **link understanding** of the folio and display.

The exhibition setup will be indoors as reflection of sunlight can make computer screens hard to see. This will also **eliminate any risks of weather events** causing adverse effects such as knocking over or wetting electronics and parts. The setup will require power and a large table.



Evidence of Application

The constructed elements displayed will include:

- Magnet **Experiments**
- Lighting **Experiments**
- Machined Product **Tests**
- Material **Tests**
- Target Market Experiment **Changes**
- Code **Experiments**
- Hot Swap **Prototype**
- Re-arrangeability **Prototype**
- Microcontroller **Prototype**
- Multiplexor **Prototype**
- Display **Prototype**

3. Project Evaluation

Analysis of Functional & Aesthetic Aspects of Design

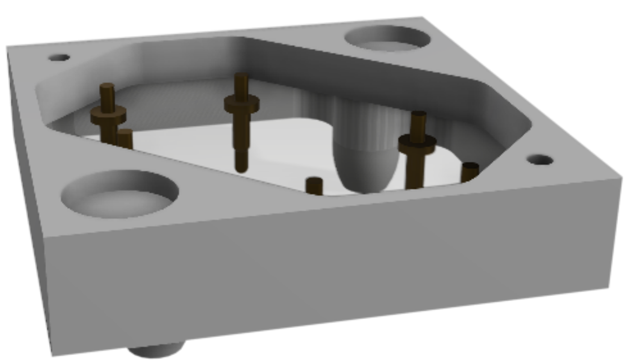
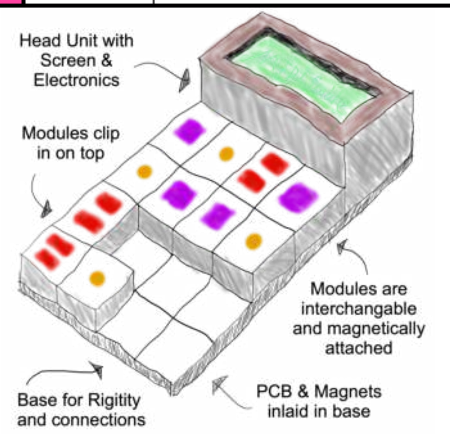
3.1

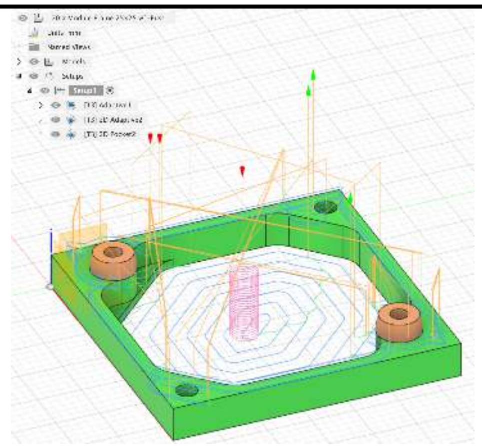
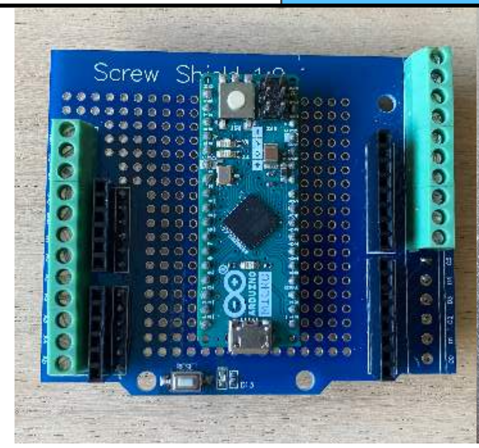
DESIGN PROCESS	PAGE NUMBERS	CRITICAL EVALUATION OF EVALUATIONS
IDENTIFICATION OF GENUINE NEED	6, 7	Throughout this major works, critical evaluations have been completed in the **purple boxes** at the bottom of various pages. The pages where critical evaluations are located can be found in the "page numbers" column. Critical evaluations are an **important reflective process** that should occur **at all stages** throughout the design cycle. By critically evaluating the **success and efficiency** of a completed process, mistakes can be **identified and rectified** before progress continues. Also, by evaluating how effective a process has been, a designer is able to **improve on their techniques** for the next project. Commonly throughout the MIDIfier folio, I have found certain structures, tables or cognitive organisers to be **cumbersome or confusing** to use for various purposes and types of information. These critical evaluations have allowed me to **learn from this** by considering other ways in which the information could be presented and structured for future projects. Evaluations have brought up many questions throughout this project. For example, the evaluation on the table comparing MIDIfier to Special Waves X helped consider how valuable it was to have a large degree of difference from existing products on the market. These evaluations helped alter the course of the project for the better. However, I feel that for larger projects, this level of evaluation is not deep enough to consider the overall impact of each design stage. After completing this Major Design Project, it is evident when looking back that many of the critical evaluations uncovered valuable ideas and questions that needed to be explored in more detail. Maybe it is possible or necessary to deeply explore the results of each section through further experiments or tests. For example, the critical evaluation regarding code experimentation evaluated the swap to a more organised "tabbed" code structure. This could have lead to further research or experimentation on the best methods to keep code organised. If this had been done, more efficient ways to organise code may have been discovered, thus leading to a more efficient code base.
IDEAS GENERATION	8	
INVESTIGATION OF IDEAS	9	
PLANNING & MANAGEMENT	10, 11, 12	
DEVELOPMENT OF CHOSEN IDEA	14, 15, 17, 18, 19	
RESEARCH AND EXPERIMENTATION	22, 24	
PRACTICAL APPLICATION	27, 29, 32, 33	
PRESENTATION	34	
EVALUATION	Section 3	

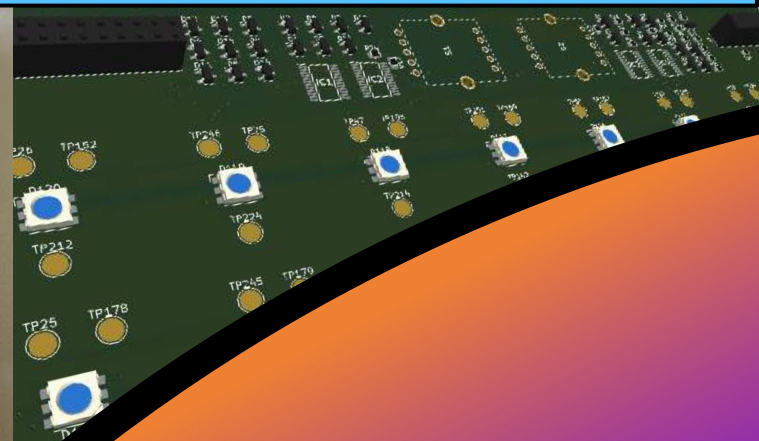
Relationship to the Project Proposal 3.2

KEY	SATISFACTORY
HIGHLY SUCCESSFUL	INCOMPLETE
SUCCESSFUL	UNKNOWN

SPECIFIC CRITERIA TO EVALUATE SUCCESS	SCORE	TESTING METHOD	SUCCESS / IMPROVEMENT
ABLE TO ADJUST PHYSICAL ARRANGEMENT OF CONTROLS TO SUIT THE USER	7/10	I will continually test to confirm the product is fully user adjustable during the process.	All prototypes were fully adjustable, however code settings should be more easily changeable which would require development of a GUI
ABLE TO CONFORM TO MIDI STANDARDS & MIDI ASSIGNMENT IS ADJUSTABLE BY USERS	10/10	I will connect controller to a variety of applications to make sure it works as expected with them all.	The program written for the Teensy worked fully with various MIDI messages and programs functioning exactly as expected
ABLE TO BE USED FOR VARIETY OF PURPOSES THAT MANY MIDI DEVICES ARE USED FOR	4/10	I will continually test the controller for different MIDI purposes throughout the project, primarily during programming stages	Working prototypes were achieved for each functional aspect, however a completed product to test with was not yet created
BODY SHOULD BE SMOOTH PLASTIC WITH EASY TO GRIP CONTROLS TO AVOID MISS-CLICKS	5/10	I will survey people who use MIDI controllers, asking them to test my prototype and make a judgement on surface and ergonomics.	The materials chosen had a very satisfactory finish after machining however an end product was not achieved so this could not be tested
COLOURS MAKE IT EASY TO DIFFERENTIATE BETWEEN BUTTONS IN LOW LIGHT	0/10	I will place the controller in low light situations and try to utilise it, comparing my results to normal lighting conditions.	Lighting tests were limited as this area was less vital and would consume a lot of time to program. This could not be properly assessed
DESIGN IS SLEEK, MODERN AND CLEAN FINISHED. SUITABLE FOR A HIGH CLASS PARTY	?/10	I will survey people who use MIDI controllers, asking them to test my prototype and make a judgement on design and look.	Surveys and feedback was mainly about functionality so this aspect is hard to assess
AESTHETICALLY PLEASING AND COLOUR SCHEME CAN BE MODIFIED BY THE USER	6/10	I will use RGB LEDs and if time permits, will program features that will fulfil this need. It should have user accessible settings.	Programming was implemented to allow these customisation features. It works well in testing but was not yet implemented on a prototype
MUST BE FUSED, LOW VOLTAGE AND WON'T EXCEED POWER LIMITATIONS FROM USB PORTS	10/10	I will thoroughly test my circuitry with a multimeter and lab power supply while simulating usage to ensure specifications are met.	All regulations, standards and conventions for USB and general Australian Electrical Appliances were successfully met
MUST NOT HAVE DANGEROUSLY SHARP EDGES OR HAZARDOUS MATERIALS	9/10	I will thoroughly inspect product to ensure no dangers have been left over from manufacturing.	Manufacturing processes allowed smooth cuts and high quality finishes that do not have hazards for the user
INDIVIDUAL COMPONENTS CAN BE SERVICED OR REPLACED BY THE USER AND ARE UPGRADABLE	10/10	I will ensure all vital parts are designed with ease of access. I will ask my peers to test and confirm this is achievable and user friendly.	All prototypes of all functions successfully allowed hot swapping, changing and replacement of any form
DURABLE DESIGN AND QUALITY MATERIALS WILL BE USED TO ENSURE LONG WORKING LIFE	6/10	I will perform durability tests on all materials and parts of my product through usage simulations and scenarios such as being dropped.	Durability tests were performed on bought components, however most prototypes were not thoroughly tested
COST IS AROUND THE SAME AS THE AVERAGE COMMERCIALLY AVAILABLE CONTROLLER	?/10	I will make a budget plan, perform research and ensure the final product meets this regulation.	Financial measurements are still estimates at this point due to varying product prices and unknown final product design
INDIVIDUAL COMPONENTS CAN BE PURCHASED FOR REASONABLE PRICE	?/10	I will design a simple financial plan and examine the cost of producing each component and find the price of selling them	Costs seem to be very reasonable however this cannot be confirmed as the project has not had enough development of a final product



Impact on the Individual User

The MIDIfier has the potential to have a **large positive impact** on the user overall. It has the potential to create a **more efficient medium** between humans and computers, known as the **Human User Interface (HUI).** Ultimately these improved control systems can **carry through** even with emerging Virtual and Augmented Reality devices, as human interfaces are **still necessary** in many of these systems.

By having a modular, rearrangeable controller, an end users life is made better by **providing a system that can be tailored to their needs.** However, this begs the question, **"What if we have multiple uses for the one controller?" "Does it need to be manually rearranged each time?"** This is one possible fundamental flaw of the design, in that it increases the **possibilities available** to a user but doesn't necessarily **make them more convenient.** This ultimately brings the idea full circle back to the start of the design cycle. Maybe in future times, this project can be **revisited with this question in mind,** reconsidering the problem and creating an **even more suitable solution.**

The modular technology concept is a **proven successful concept** to improve the quality of life for many people. It allows the user to have **full control over their own device, ease of repairs, unlimited customisability and smooth integration.** It is for this reason that MIDIfier would be able to **strike the balance** between **consumers and producers,** providing a product and business model that **does not require planned obsolescence to function.** Consumers have an expandable product and producers are able to offer upgrades and repairs that can be chosen at the users discretion.

As well as these benefits, by providing a platform that can **grow alongside a user,** MIDIfier is also a **learning companion.** It is able to **facilitate learning through experimentation,** as well as **inspiring curiosity, exploration and growth.** It is for these reasons that the MIDIfier concept has a **positive overall impact on the user,** even if it is not yet developed to be the ideal solution to cater for **modern convenience wants.**

Impact on Society

MIDIfier has potential to affect society in many ways if widely adopted. This is because it enforces a **completely different business model** and **product design structure.** Currently, many products are designed with **planned obsolescence to satisfy the business model.** This is often the case with technology such as smartphones, which are **mostly non upgradable and difficult to repair. This is done intentionally, knowing that new technology will be created** and if users want access to this, they will need to buy an entirely new device. As profitable as this business model can be, it is also **wasteful** as many fully functioning devices are thrown away and most aren't recycled due to the **complexity required** to **extract raw materials again.**

MIDIfier takes on a similar design concept as early computers used. **Critical parts are upgradable and interchangeable,** meaning the user can **change components as technology advances.** This strategy has in many cases reached its limitations in computing due to the **proximity of parts having an effect on performance.** Computer chips can often function at higher speeds when they are all tightly integrated into the same package or motherboard. However, **this is not a limitation Human User Interfaces commonly experience** so it makes sense to utilise this structure for MIDIfier.

Overall, this impacts society positively by promoting the **repairable and upgradable ecosystem.** It also promotes **customisation & exploration** which leads to **deeper understanding and learning.** This in turn will allow **productivity to increase,** meaning as a whole society has the opportunity to become more **efficient when working with technology.** Conversely, this level of customisation can **reduce the ability for shared tools,** as each one will be set up to suit the owner. For example, a DJ won't be used to using the same DJ setup as "Club Mixers" use, commonly Pioneer Dual Deck setups. DJs will need to **rearrange the setup or bring their own,** reducing their compatibility and increasing setup time and effort. This could also make **connections between DJs more difficult** because they won't have common hardware to work with or perform together on. However, this diversity could **promote discussion about different methods and habits** which will promote a **deeper understanding of a variety of possible ways to DJ.** Ultimately, the effect on society is **positive with a shift in focus towards more environmentally and logically designed technology.**

Impact on the Environment

MIDIfier has **both negative and positive effects on the environment.** Short term, MIDIfier is yet another product that is manufactured with **plastic and electronics.** However, due to the business model, **obsolescence will be reduced to a minimum.** This means that long term, **wastage will be minimum** and MIDIfier will be **able to adapt and accomodate for new and changing technologies.** In the long run, the materials MIDIfier is made from can be updated to **more renewable and environmentally friendly alternatives,** however by having a long lasting and updatable structure, even with the use of highly processed plastics, **MIDIfier has a far better overall effect on the environment than most modern technologies do.**

Final Evaluation of Project 3.4

Analysis

In my opinion, MIDIfier is currently a **successful but underdeveloped product.** The idea and concept has been **thoroughly explored and researched.** All aspects of the design have been **prototyped and tested** to various extents, however a **final product has not been produced.** Ultimately, this comes down to two main reasons, time and resources.

The scale of this project was **very large** to begin with, **possibly too ambitious.** Assessment of the time that would be needed to complete it was **fairly accurate,** however I **greatly underestimated the amount of time actually available to do this.** This is because I **underestimated the time required for my other HSC subjects, study and assignments.** Holiday time had to be **distributed between these** and ultimately a lot less time was actually available for Design and Technology.

Secondly, time estimations **didn't accurately account for outsourcing manufacturing** of things like custom printed circuit boards. This was a flaw of "not knowing what you don't know", making the assumption that just because it was a commercially available procedure that I would be able to **access those resources when I needed.** To solve this issue for next time, it would be **ideal to complete the research and experimentation phase (Section 2.3) BEFORE project management** (Section 1.4). Unfortunately, in many larger projects, time for research and testing will need to be accounted for, so future projects may require **two research phases,** one of concepts and another of more detailed research to do with individual aspects. Regardless, this has been one **learning experience** and next time **more time allowance should be left for unexpected delays.**

Finally, parts availability caused unexpected wait times. Many of the proposed purchase locations became unavailable in a short period of time, meaning **alternatives needed to be sourced** from locations with **considerably longer postage periods.** This led to **delays in experimentation and manufacturing,** however the effects were **far more manageable than the many months wait time on outsourced PCB manufacturing.** I am not sure how to reduce this issue in small scale projects, however it could be less of an issue once the product is being mass produced and suppliers are available on contract rather than just for one-off purchases.

These issues are a reflection of my **ever evolving understanding of the design process.** Unfortunately they have meant that the final state of MIDIfier is still **as prototypes rather than a completed product,** however I feel they have **clearly demonstrated, tested and proven the concept** and made the **path for further development clear.** For this reason, I deem MIDIfier to be a **successful concept, working set of prototypes and developing final product.**

Critical Evaluation

Overall, MIDIfier **fails to achieve the goal** to be a fully functioning modular MIDI controller. This is because it isn't completed to the standard of final product desired. MIDIfier is able to successfully achieve **many individual aspects** through many prototypes, however it **doesn't satisfy** the design brief in its current state. The action statement of the design brief was **"To create a modular MIDI controller that is user customisable and effective in a wide variety of MIDI systems."**

After **thoroughly researching** this project and creating time management plans, a **more thorough evaluation** could have revealed the necessity to **modify this design brief to suit the available timeframe.** If the brief was **"to design" rather than "to create",** this project could have been completed to its fullest extent **without the issues of supplying parts, outsourcing manufacturing etc.** Unfortunately, this hasn't been realised until this point in the project, which is why overall, **MIDIfier in its current state does not satisfy the design brief.**

> If the [design] brief was "to design" rather than "to create", this project could have been completed to its fullest extent. MIDIfier in its current state does not satisfy the design brief.

Personal Judgement

I feel that MIDIfier has been a **successful project even though it did not satisfy the design brief.** This is because MIDIfier proved the **capability to achieve almost all of the "criteria to evaluate success" through the research, testing and experimentation.** Future projects should focus on **improved time management, increased research into manufacturing tools & techniques, better evaluation of suppliers and more allowance for inevitable errors.** Originally, I was worried about **scope creep** for this project as I often have **lots of new ideas along the way** that I get excited about and want to include in the project. **However, this was not the case.** Instead, I simply **set the bar too high** without knowing exactly what would be required to complete this project. In the end, that's another learning experience and my personal judgement on the project remains. **It is a good idea that has been thoroughly explored and with more development will one day become a great product.**