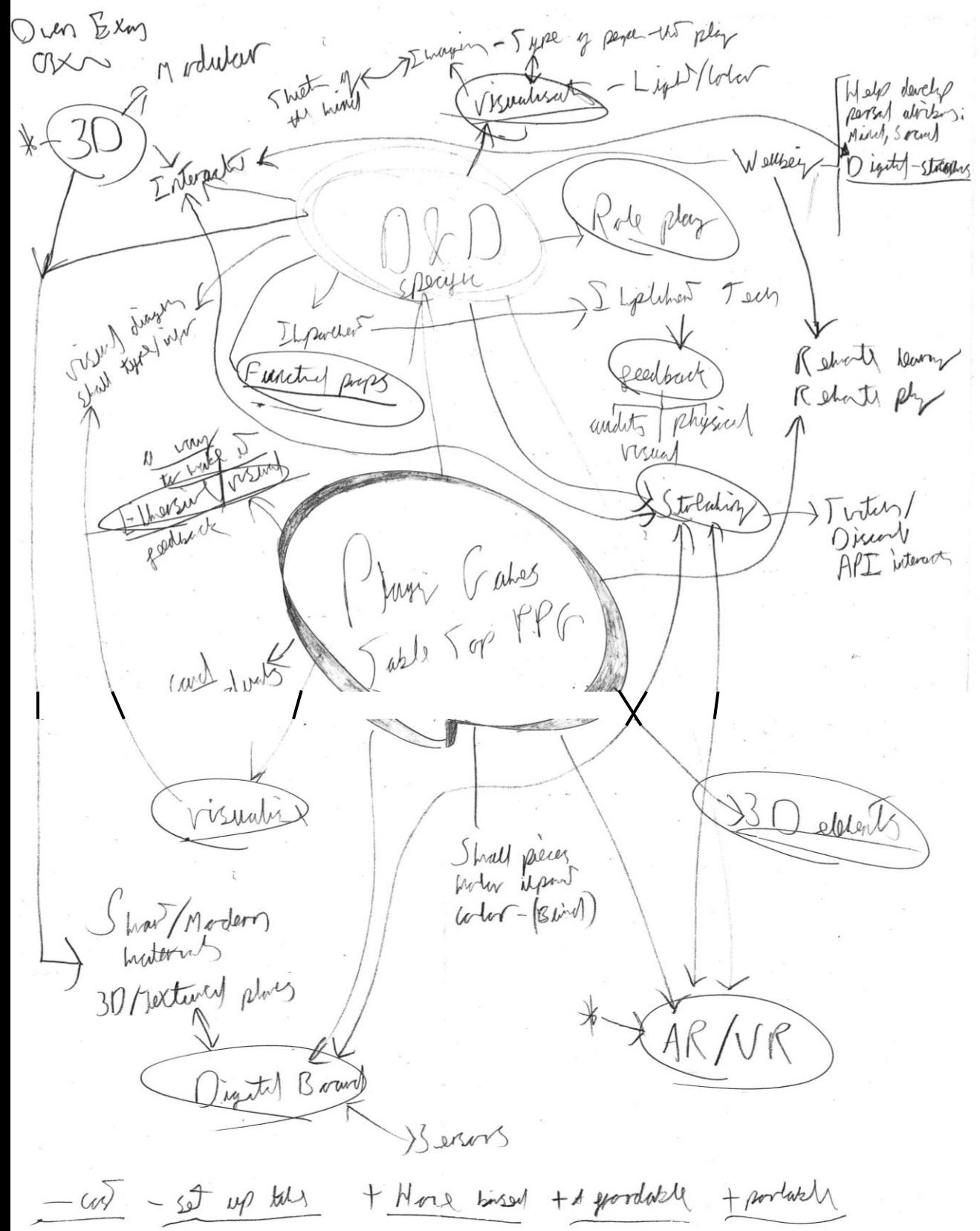
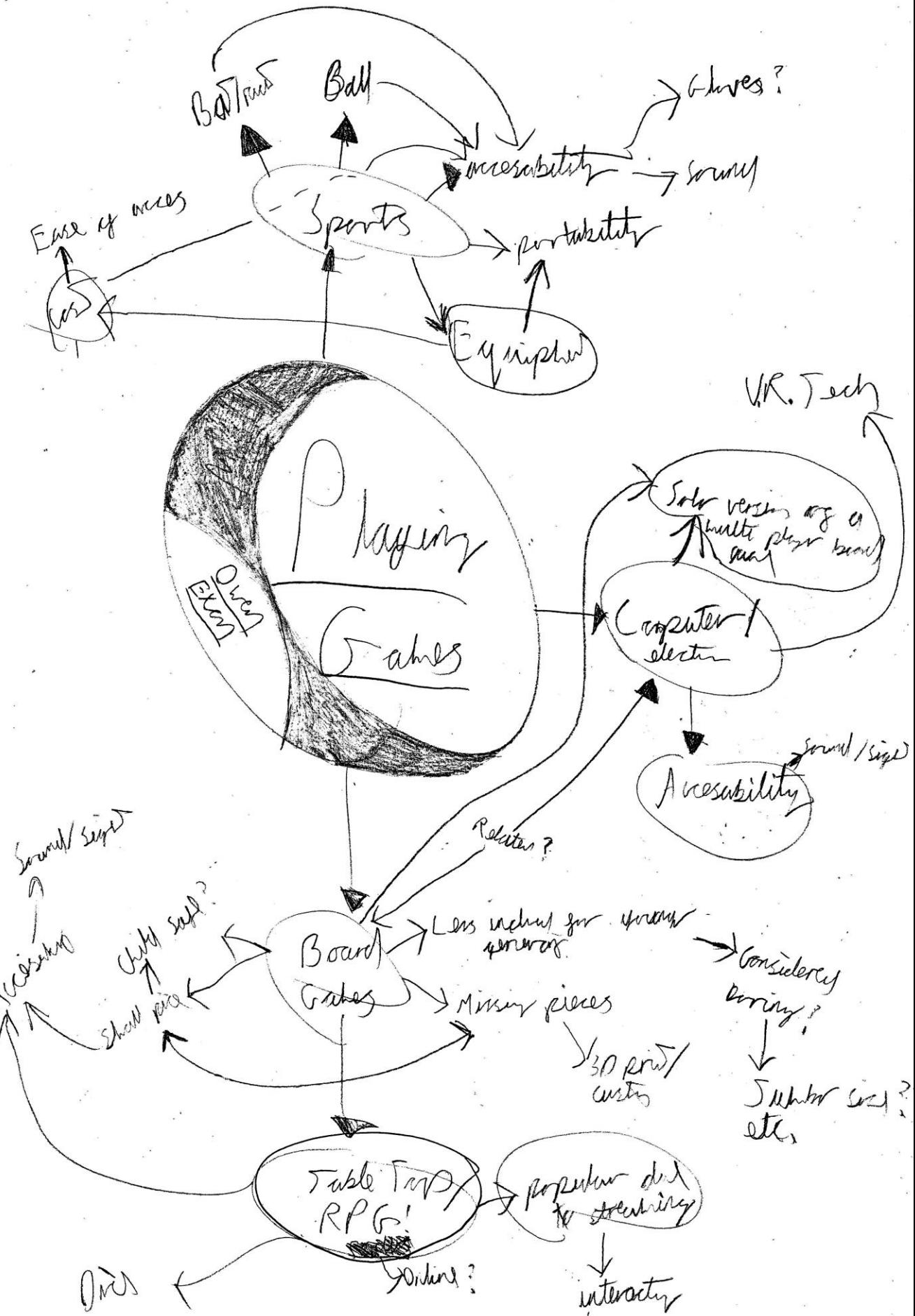


D&T NEA

Chosen context: *Playing games*

Owen W.B. Exon: **2071**

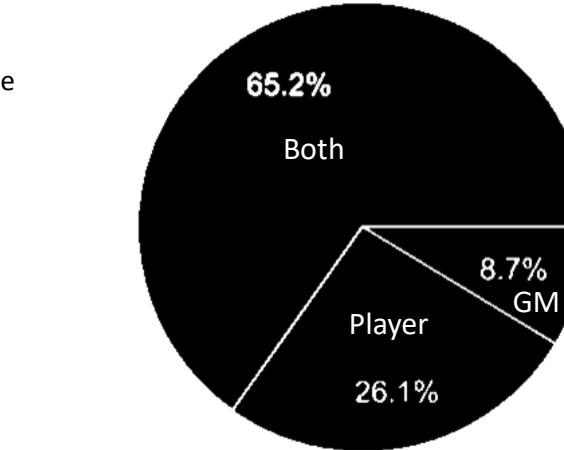
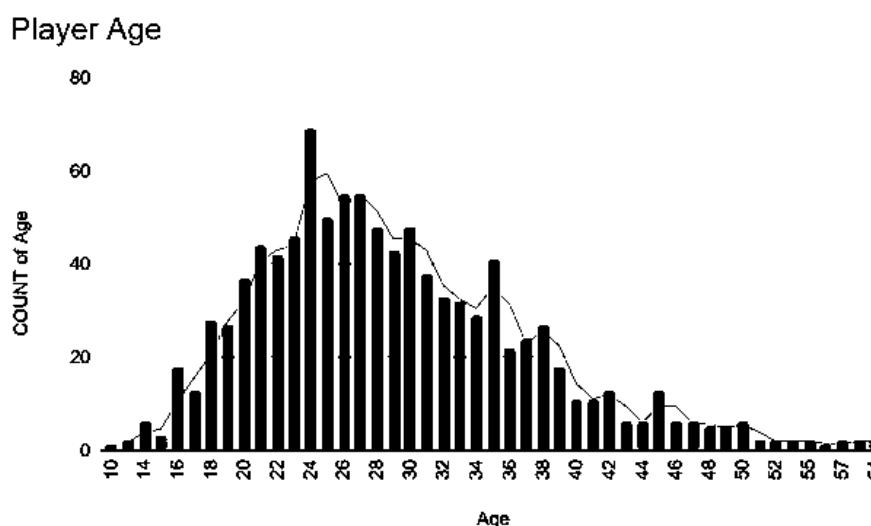
Droitwich Spa High School: **24055**



Research

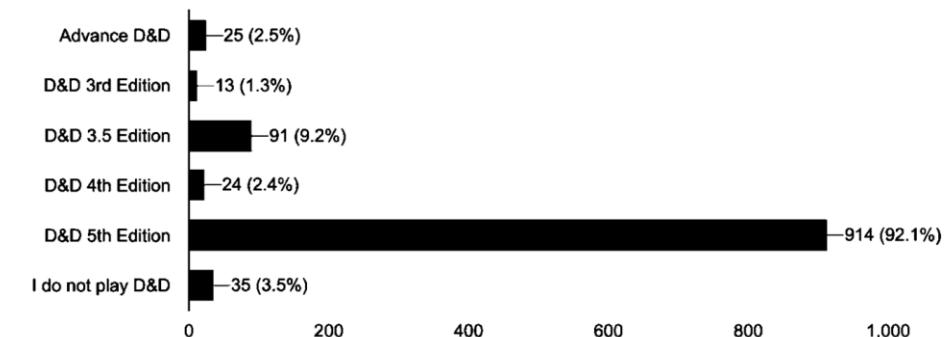
Looking at the articles below these are the insights that I've had: (not all points will be relevant to every idea but they are things to consider.)

1. Focus on DND 5e (5th edition) as it is the most popular TTRPG system.
 1. Use the 5e ruleset
 2. Look at pre-existing 5e ideas
 3. Or ideas that can be applied to DND and different TTRPGs
2. Ideas should focus both on players and DMs as more people are doing a mix of both.
 1. Help DMs remember the rules.
 2. Tools for DMs visualise and aid the players
 3. Enable DMs to plan and recall easier.
 4. Help Players remember the rules/state of play.
3. Focus on ideas for new players as most players are quite young so are more likely to be new.
 1. Show the State of play.
 2. Aid in remembering/following the Rules.
 3. Character management/Character abilities.
4. Visualisation is a key part of the game. So, it could be a good idea to link ideas to that.
 1. Show Combat
 2. Show Dungeons (Or similar)
 3. Can link to the World the players are in.
5. Remembering rules can be challenging so it should aid with that.
 1. Specifically, Character abilities.
 2. Conditions/Resistances during combat. (Already exists)



You play Dungeons and Dragons (D&D), which version(s) are you currently playing?

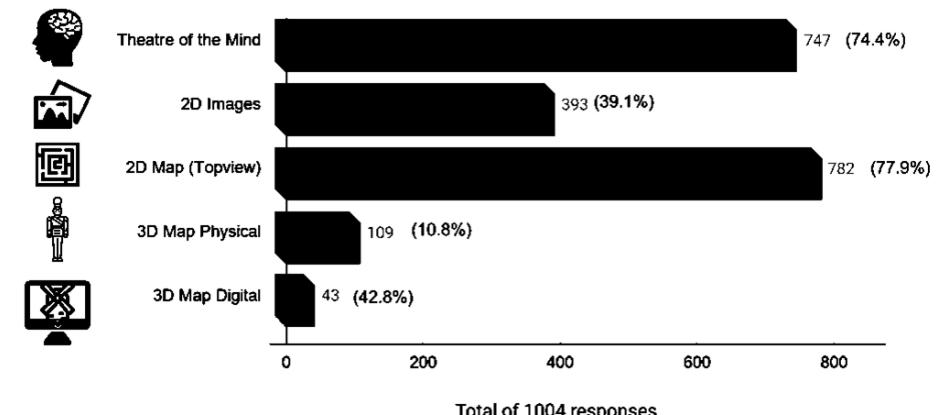
1 responses



Top 10:

1. Dungeons and Dragons (94.3%*)
2. Pathfinder (17.9%)
3. Call of Cthulhu (11.5%)
4. Vampire: The Masquerade (7.6%)
5. Warhammer RPG (6.4%)
6. Star Wars RPG (6.1%)
7. Shadowrun (4.3%)

How do you visualize your game?



Articles:

Therapy & RPGs: How Tabletop Role-Playing Games Benefit Our Mental Health:
<https://www.medievalcollectibles.com/how-ttrpgs-benefit-mental-health/>

The Surprising Benefits of Role-Playing Games
<https://lifehacker.com/the-surprising-benefits-of-role-playing-games-and-how-1684582789>

Learning the rules.

<https://screenrant.com/dnd-players-learn-rules-session-zero-resources-kick/>

D&D research:

<https://www.dndresearch.com/#/>

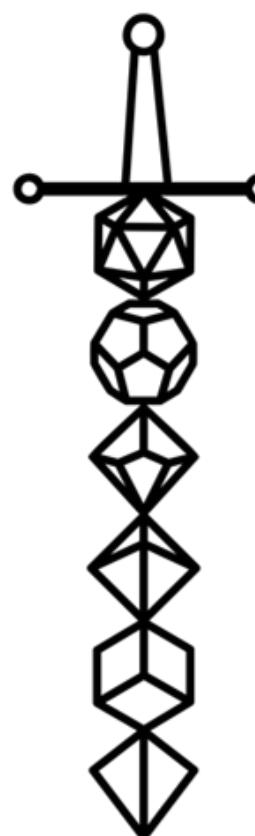
<https://www.dndresearch.com/blog/#/>

[https://www.dndresearch.com/blog/2020-survey-result-update-1-demographic-of-ttrpg-players#/](https://www.dndresearch.com/blog/2020-survey-result-update-1-demographic-of-ttrpg-players/#/)

[https://www.dndresearch.com/blog/archives/12-2020#/](https://www.dndresearch.com/blog/archives/12-2020/#/)

[https://www.dndresearch.com/blog/archives/01-2021#/](https://www.dndresearch.com/blog/archives/01-2021/#/)

[https://www.dndresearch.com/blog/archives/02-2021#/](https://www.dndresearch.com/blog/archives/02-2021/#/)



[https://www.dndresearch.com/blog/2020-survey-result-update-1-demographic-of-ttrpg-players#/](https://www.dndresearch.com/blog/2020-survey-result-update-1-demographic-of-ttrpg-players/#/)

Dungeons & Dragons (D&D) in a nutshell

Dungeons and Dragons is a Tabletop Role Playing Game (or TTRPG for short). The game is composed of 2 types of people: the players and the Dungeon/Game Master (DM or GM for short.) The DM builds a world, narrates the events in it and speaks through non-player characters (NPCs for short). The players each have their own character, detailed on either a physical or digital character sheet. (Bottom-right) This shows everything about their character. Like health, abilities and items. The players play within the world created by the DM. Often speaking in character. A set of polyhedral dice (notated by "d" followed by the number of sides e.g. d20) determine how successful most actions are. Actions from attacking someone, to picking a lock, to persuading someone to let them pass.

There are different editions of D&D, usually abbreviated to the number followed by the letter "e." The newest version is 5e, but 3.5e is also quite popular

Each player has a set of ability scores. These change what they add to dice rolls for each skill. (each skill is tied to an ability. E.g. Athletics (skill) is based on strength (ability)) You add an additional bonus if you are proficient in that skill.



The D20

If your character attempts a task with an uncertain outcome, you need to roll a twenty-sided die (**d20**) to succeed. There are three main types of d20 rolls: **attack rolls**, **ability checks** (which include your skill proficiencies), and **saving throws**. They all follow the same principle:



$$\text{add your relevant} + \text{Ability Score Modifier} + \text{Proficiency Bonus}$$

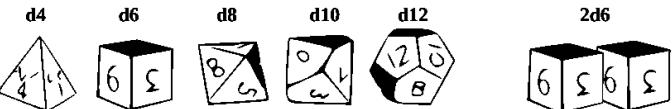
such as from Strength, Dexterity, or Charisma

only if you have proficiency in the weapon, skill, or save.

If circumstances grant you **advantage**, roll two d20s, and use the *higher* roll:
If circumstances grant you **disadvantage**, roll two d20s, and use the *lower* roll:



The target number that you need to meet or exceed is the **armor class (AC)** or **difficulty class (DC)**.



The Other Dice

The other dice are most commonly used to deal damage after a successful attack roll or to heal damage. Weapon **damage rolls** add your Strength or Dexterity modifier to the result depending on the weapon.

Turns in Combat

Your character can often speak and act freely, but during a fight, participants take turns. On your turn, your character usually just **moves** and performs one main **action** at any point before, during, or after moving, but you can do each of the following in any order you wish:

Move up to your speed, including jumping or swimming	Act using the attack action or the cast a spell action
+ Speak up to a short sentence while acting	+ Interact with one minor object, like drawing your weapon or opening a door
+ Take a Bonus Action only if you have a bonus action ability	

Other important actions you can choose to take are the **dash**, **dodge**, **help**, **hide**, and **ready** actions. Sometimes you may also take one **reaction**, like an opportunity attack, when it is not your turn.

Each player can also have various conditions and defences. Conditions are things effecting that character. For example, they could be poisoned or invisible. Defences are things that change if a condition affects you, or how much damage things do to you. For example, resistance to fire damage means it is halved. But immunity means it is ineffective.

There are a variety of ways to visualise the game, here are the most common:

Theatre of the mind: With this method, the DM describes the environment and the players imagine it.

2D-Image: This uses a set of images made by the DM in advance.

Topview: This is a 2D birds-eye-view map of the surrounding environment showing the characters location.

Topview Digital: Topview but digital.

3D Physical: Using model 3D terrain often with miniature characters.

3D Digital: (See above, but digital)

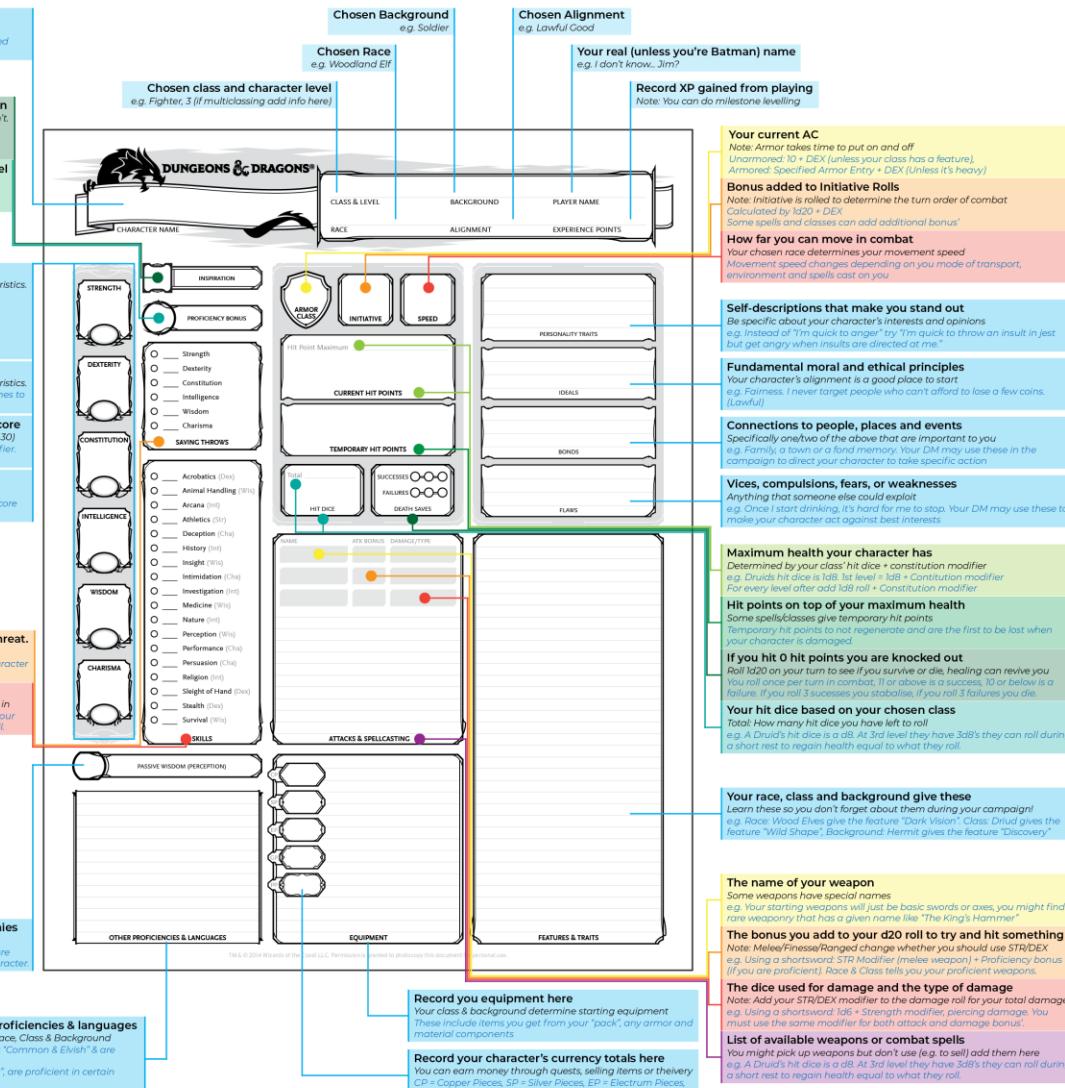
There are 3 main pillars of the game: Roleplaying, Exploration and Combat.

Roleplaying for social and conversational aspects of the game. This can occur between players, or between a player and an NPC. This normally happens in real time. (1 real-second = 1 game-second)

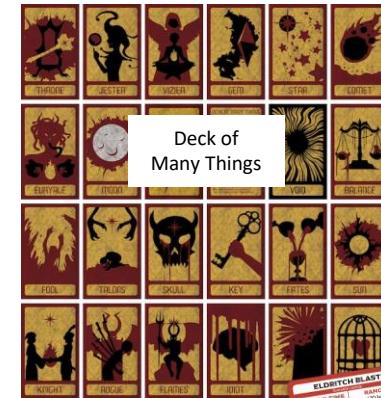
Exploration is when players are looking round a space or dungeon crawling. This can involve physical or mental maps/map making. This usually happens in accelerated time. (1 real-second is > 1 game-second)

Combat is the most complex part of the game. As the game is broken into 6 game-second chunks called rounds where each player takes their turn. And can do various things (see bottom-left) before the next person goes. (1 real-second is < 1 game-second)

This is some quick background information about D&D so some of the other terms I use in this portfolio make sense. If I've missed anything, it can likely be found at:
<https://donjon.bin.sh/5e/quickref/>



Pre-existing products



Deck of Many Things



Deck of Many Things



Source Books



Player Character	
Armor Class	
Spell Save DC	
Passive Perception	
Condition Afflicted?	
Conc. Spell Active? Yes • No	Yes • No
Inspiration? Yes • No	Yes • No

Player Stat Crib Sheet

CONDITIONS	
1 Blinded	7 Incapacitated
2 Charmed	8 Invisible
3 Deafened	9 Paralyzed
4 Exhaustion	10 Petrified
5 Frightened	11 Poisoned
6 Grappled	12 Prone
	13 Restrained
	14 Stunned
	15 Unconscious



Initiative Tokens and tracker



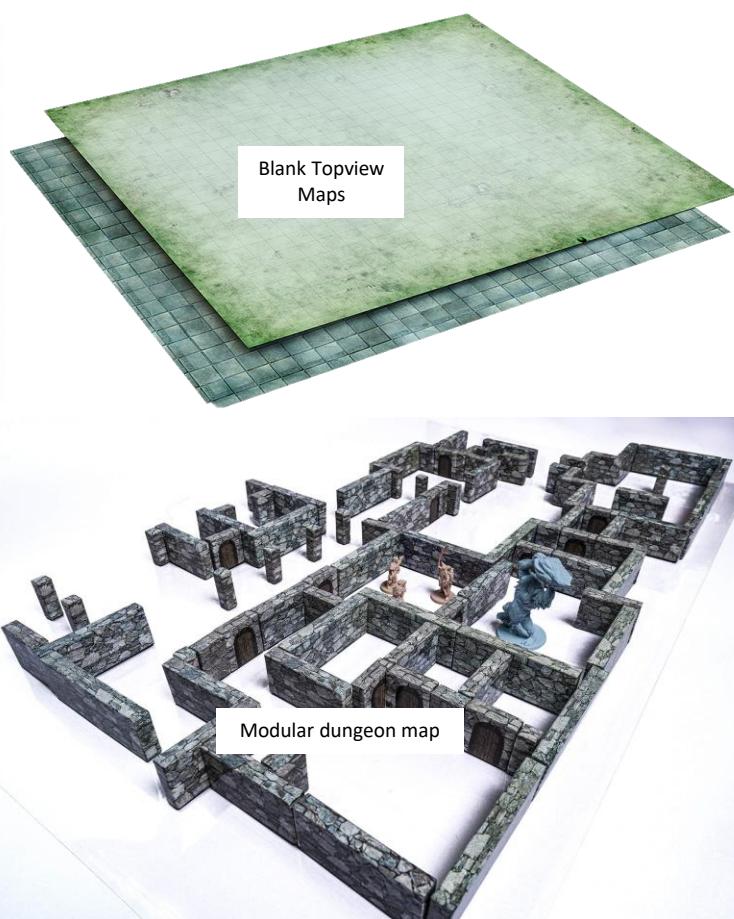
Class Ability Card



Mass transport



Combat props



Blank Topview Maps



Modular dungeon map



Modular dungeon master screen



Dice Tower



Dice Tower

Product Analysis

Combat Grids



Modular Dungeon (~£40-£50)

These are quite a fun addition to a D&D game. They allow for you to build up dungeons/ruins using modular pieces making combat and exploration far more interesting by allowing you to realise the environment in more detail (and often in 3D) than either theatre of the mind, or with alternate physical methods (see below). The one pictured has some kind of gentle adhesive on the base so it will remain on the plastic sheet. (Even when knocked)

Pros and Cons:

- + Fully Modular (Can be used until it breaks)
- + 3D (More degrees of freedom = more fun)
- + Aesthetic (Decorated)
- Limited by pieces: (Can't change shapes, limited number of specific pieces (doors etc.))
- Can't change appearance (Premade theme & colour)
- Holds together (Even when knocked)

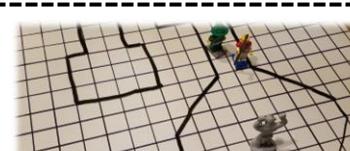
Top-view Book (~£30-£40)

I have a personal dislike of these kind of books, but none-the-less; I admit they can be useful. This is because they are cheaper than many alternatives but also still are very aesthetically pleasing. The books shown are designed to be able to be laid out together in different combinations allowing for more permutations than just 1-per-page. My dislike comes from the lack of customisability (despite what I just said) because you are tied into this set of maps and can't necessarily add your own elements.



Pros and Cons:

- + Somewhat Modular
- + Comparatively cheap
- + Aesthetic (Decorated)
- 2D (limits some of the most fun elements by included with 3D)
- Lack of customisation.
- Not necessarily durable.



Blank Top-view (~£15-£30)

This is the type of battle-map my groups currently use, despite it being constrained to 2D, it makes up for it in sheer freedom and the fact is it significantly cheaper than any other option. The plastic can also be used with whiteboard pens to add temporary features such as traps or other environmental effects. They are also very portable as they can be rolled up and stored.

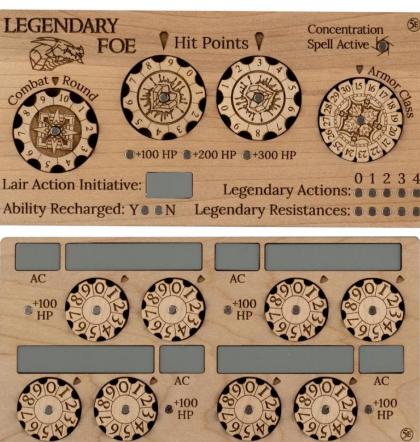
Pros and Cons:

- + Customisable
- + Quite cheap
- + Portable
- 2D (limits some of the most fun elements by included with 3D)
- Will stain over time. (Whiteboard pen)
- Not necessarily durable.

Things to note

- The more modular & customisable the better.
- Often the cost is very high (try to avoid, could be a focus)
- 3D is more fun (by could increase cost too much, could be a focus)
- Aesthetics is not required but is ideal.
- Making it Durable and Portable should be a primary concern

Quick Reference/trackers



Monster Trackers (~£24 each)

These are very useful. They act as a quick reference guide to the state of the monster, and also let you keep track of what they are doing in combat. The small metallic circles are magnetic and can be used to attach a ball-bearing. The grey rectangles are whiteboards and so you can write information on. The tiles can also be stuck (magnetically) to a sheet, On the DM screen below

Pros and Cons:

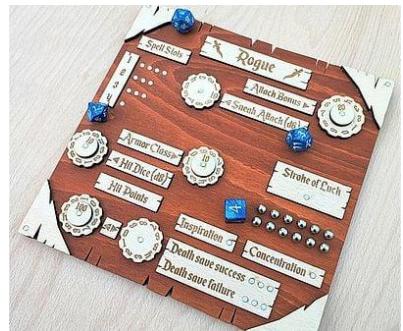
- + Laser Cut Aesthetic
- + Portable
- + Durable
- Expensive in bulk
- Could get cluttered if you have a lot

Player Trackers (~£50 each if custom)

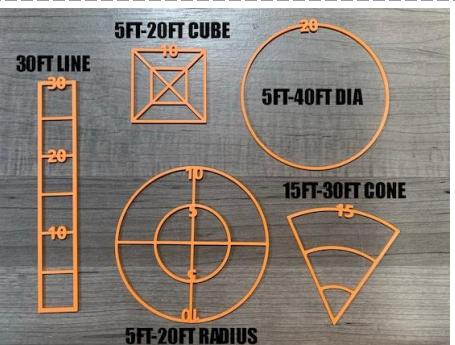
These are an overpriced method of character tracking. Especially because they don't allow for the tracking of full character sheets. This problem has already been solved by online services such as D&D beyond and Roll20. And solved far more effectively. Also even if you don't use an online service, a paper character sheet is still suitable.

Pros and Cons:

- | | |
|--|---|
| <ul style="list-style-type: none"> + Aesthetic + Portable + Durable | <ul style="list-style-type: none"> - Very Expensive - Not effective - A solved problem |
|--|---|



Accessories



Distance Measure (~£35-£40 For a set)
These can be used alongside a combat grid to measure the areas of effect for spells and also for any other time that distance is relevant and can't be easily counted on the grid. This one's pictured appear to be 3D-printed. Causing the cost to be greater than necessary because they are slower to manufacture.



Telescopic Miniature Riser (~£16 each)

These are a very well-designed tool for gamers. They allow miniatures to be raised in combat for if they are flying or falling. Or to raise them onto some kind of invisible platform. (Created by a spell or other arcane effect) Because they are telescopic, they can be used at any height, and are easy to store. They also have magnetic elements so can be stuck to things (I'm not sure why?)

Pros and Cons:

- + Portable
- + Very Effective
- Expensive (If used in large quantities)
- Possibly fragile
- Magnets could damage electronics



DM's Backpack (~£160)

This is a very expensive backpack designed for storing and carrying all of a DM's tools, resources and game-elements. This includes a laptop, books, mini's, paper and/or a battle map. The many small pockets mean many other things (such as mentioned above and more) can be made less cluttered and more organised. There is also risk of damage if you have too much in the bag

Pros and Cons:

- + Makes things more Portable
- + Very Effective
- Very Expensive
- Risk of Damage



Modular DM screen (~£350+ Total)

This is a very cool set of modular products that allow you to build up any combination of elements to aid in running sessions. This includes towers for storage. And magnetised panels for paper and monster trackers. All the pieces are magnetic so hold together without annoying physical joints.

Pros and Cons:

- + Very Aesthetically pleasing
- + Fully Modular
- + Durable
- Very, Very Expensive
- Could get cluttered if you have a lot
- Hard to store (though it does disassemble.)

Things to note

- The more modular & customisable the better.
- Some problems have already been solved. (Don't fix it if it isn't broken)
- Making it Durable and Portable should be a primary concern.
- Often the cost is quite high (try to avoid, could be a focus)

Things to note

- Making it Durable and Portable should be a primary concern.
- Often the cost is quite high (try to avoid, could be a focus)
- Organisation is key for DMs
- The more that can be automated/made easier the better.

Design Brief

This will be a product to aid players and game masters when playing tabletop role playing games. With availability for a range of people and to act as a purpose made item for dungeons and dragons, specifically 5th edition

Problems

Convenience

This can be problematic for players and DMs, Because the setup for DM's can be quite long, and players need to take their stuff with them. There is also quite a lot of stuff to store, such as dice, combat grids, props, note-pads and character sheets (digital or physical.) DMs also have lots of pre-session preparation to do so the more convenient everything can be made the better.

Rules

Sometimes it is hard to remember and enforce the rules, so it would be good to try to focus on helping with this. There are also many things to remember such as resistance to types of damage (such as taking half damage from fire) and conditions (such as being blinded or deafened). The many rules also don't help with learning them.

I would like to investigate how I could possibly create a system to help both GMs and players remember the more forgettable or complex elements.

High-end purpose-built tables

Most tables are either designed to be multifunctional, to allow it to become a normal table, or designed specifically for streaming/televising (And hence are far bigger than required for most groups due to the need for added space for cameras and microphones). But there doesn't seem to be any/many that are purpose built, exclusively for games like D&D but are not for streaming.

Accessibility

Different disabilities can affect the experience of playing D&D. Considering how visual a lot of the game is I could experiment with ways to aid the blind and partially sighted. This could include use of braille or tactile elements to allow a better experience without too much added complexity. People who are deaf or hard of hearing may struggle as part of the foundation of the game is a DM/GM describing the world and speaking through the characters in it. This is not a problem though, because there are already preexisting solutions like real-time subtitles.

Cost (+3D)

This is a simple one: everything for D&D is just so expensive. It would be a very good idea to look for ways to keep cost as low as possible. Particularly because new players may not be willing to spend more. Specifically for 3D combat. Because It is more fun to play in 3D but currently, it is very expensive either because you need to get terrain custom made, or you need to buy many modular terrain elements (each one quite expensive)

Solutions?

Make Things Modular

By making things modular you need to carry less stuff and could reduce (the effective) cost because things would be multipurpose.

Use Tactile Elements

By introducing tactile objects, the visual parts of the game (e.g. dice/combat grid) blind and partially sighted people would be able to enjoy a wider aspects of the game, not just theatre of the mind.

Crib sheets/quick reference

This would help DMs as then they can think less about memorising the rules and more about storytelling with the players in-front of them. Additionally, it could be something to provide quick reference information in relation to the game-world.

Aesthetics

This product must fit the fantasy theme of most D&D campaigns (While ideally being versatile enough for other themes.) While still looking good in a home. It would likely be made of rustic materials. I would like to have a clean product that is avoids more modern elements/peripherals being visible. e.g. Strip lights, cables etc.

User

This product needs to support a wide range and variety of numbers of people. This is so different sized groups can use it regardless of whether the group has 2 players, 6 or more.

To achieve this, I could have adjustable and/or scalable elements. Or not have the product linked to any specific group size.

Cost

This would likely be a purpose-made, high-end product. Or a low cost, cheaper alternative. The cost (for both) could be reduced/split by making the product a set of smaller modular pieces. The manufacturing cost would either be high due to the high-quality materials and likely complex nature of the product. Or low due to the use of cheaper materials. To reduce the cost further, existing component should be used where possible.

Function

This product must provide a way to play that will aid in remembering and enforcing rules, particularly rules that are easy to forget. Such as conditions or resistances (see page 4) This could include additional functionality for GMs as they must deal with many more rules and keep much more in the front of their mind. Alternatively, or additionally, it should provide functionality to visualise the game world. Or allow the game to be easier for those that struggle with accessibility.

Design Specification

Ergonomics

This product must be comfortable for a range of people and therefore adjustable or usable by all, without any one set size. This will also be used by people of all ages so it must allow people of all ages to use it comfortably.

Size

This product could be scalable to allow for a range of numbers of people. Or not to be tied to one size. (See user for more details)

Materials/Components

The materials must be strong enough to allow extensive use over time, so the product would last for a long time without needing to be replaced. And if there is a chance people would be putting their weight on it, it should be strong enough to support that. It would ideally be able to be wiped clean, in case food or drink was dropped/spilled on it.

There could also be some mechanical components to aid its function. I would attempt to make these parts replaceable in case they broke.

Safety

There should be no places in any mechanics that things could get trapped in. If there is any built-in storage, it should be easily accessible. And the same for any electrical components. If applicable, it should be light enough to lift without strain.

Sustainability

I would aim to make the product out of sustainable/recycled materials. That can be recycled again at the end of its life. This would include FSC timbers, recycled boards/papers and polymers that will decompose when the product has finished being used. Alternatively, it just needs to be long lasting.

The User

The users are a wide range of people. But the people who play D&D are mostly people in their 20s to 40s. They are likely both a DM and a player. Other than that, it could be basically anyone. Including being used with different sized groups from only 1 DM and 1 Player (called duet D&D) up to groups of up to about 8 players. The scenario this product will be used in is also just as varied as its users. But many people will just be using it on a dining table or other similar surface as most people won't have a specific D&D table. (Though some people may) On the flip side, it could also be that this product could be used by groups of people like Critical Role and Dimension 20 (Both large actual-play groups) but I will focus more on the everyday consumer than on televised games. Some of this is according to D&D research

(<https://www.dndresearch.com/blog/2020-survey-result-update-1-demographic-of-ttrpg-players/#/>)

And all of this comes with the caveat of a likely WEIRD bias. (A phenomena plaguing psychological studies where the people surveyed are most likely: Western, Educated, Industrialised, Rich and Democratic)

As my clients, I will use 3 teachers in my school that all play DND 5e. All are relatively experienced players, with one being slightly newer than the other two. They all play the game in different ways so I can get a variety of viewpoints when talking to them about the project. Additionally, I talked to a separate client who doesn't play DND 5E, but does enjoy TTRPGs, and so could provide a more general insight when needed.



Tactile Map

(Accessibility) This would be a combat grid that would allow for the blind/partially sighted to use as well. The pieces could lock in place to allow for them to be touched without fear of moving them. And tokens to represent conditions could lock onto those.

Functional Props/ Tokens

(Convenience, Immersion) This would be a set of props designed to enhance immersion and make playing easier. E.G. health potions with the correct number of dice in. There could also be a set of tokens to represent different aspects of the game.

Shifting Grid (Combat & World Scale):

(Cost, Convenience) I would make a 3D combat grid where each tile can move to different heights so you can make 3D terrain on the fly. This could include lights (or different colours) to show different types of terrain, and there could be different versions to allow for a square combat grid or a hexagon world-scale grid.

Combo Dice storage and Roller

(Convenience, Cost, Rules) This would be a box to store dice that also has a space to roll them. This could be an old looking chest or a themed box and the space to roll could be in the lid. This would be good for hiding dice rolls and storing a large number of dice.

Top-view Props.

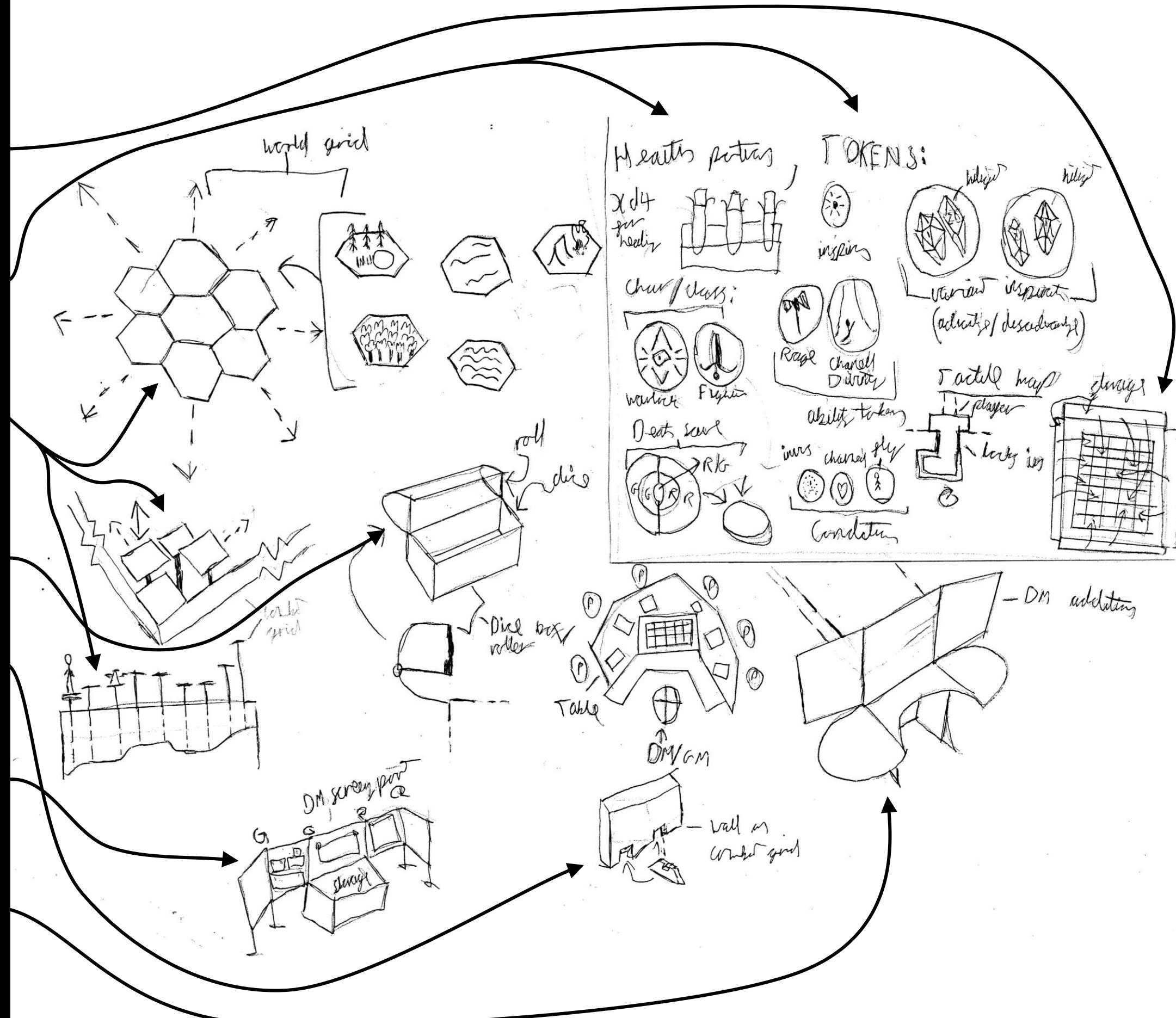
These would be a set of simple props to go on topview maps to give a small aspect of 3D to the game, when true 3D terrain can't be used.

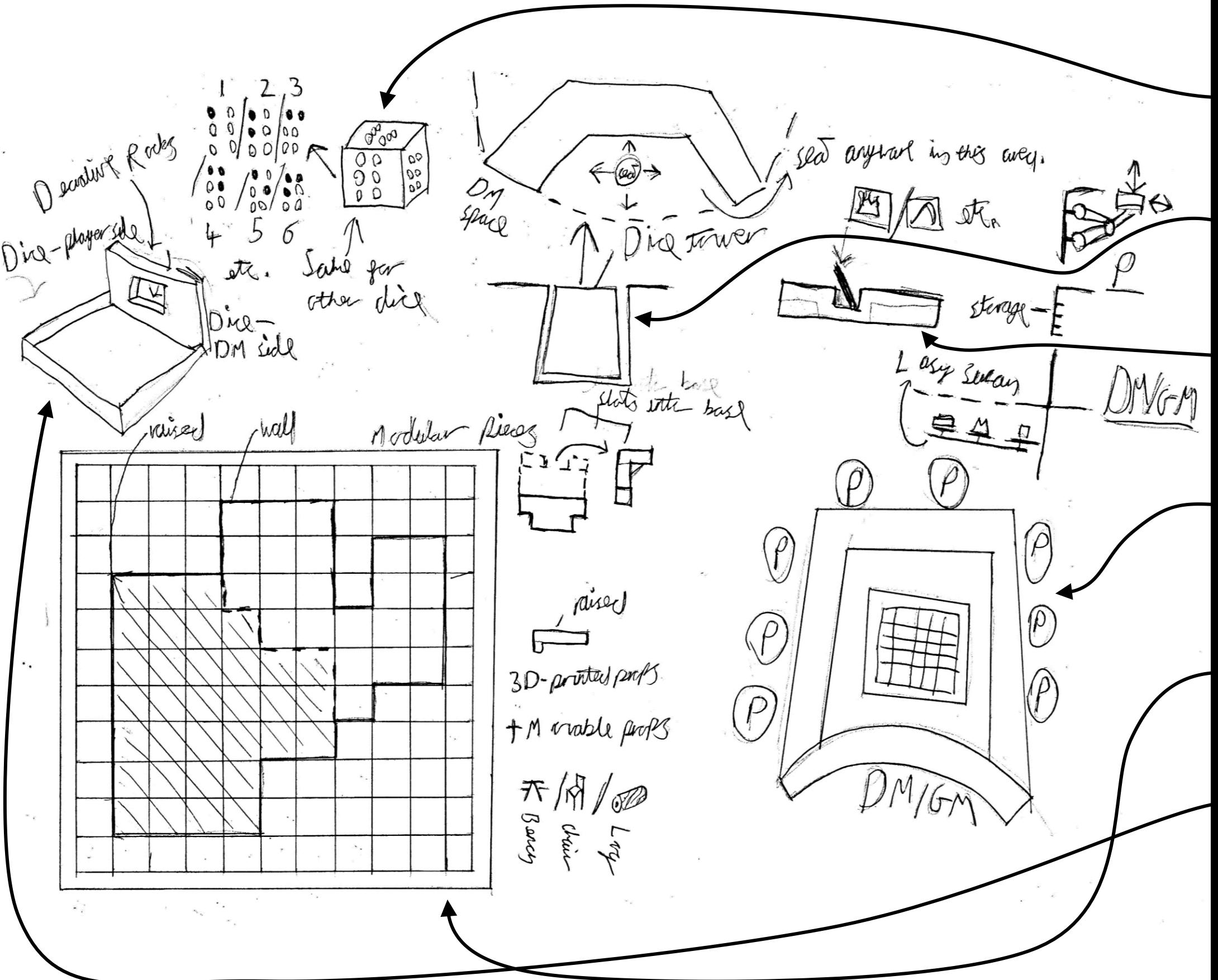
Portable DM Screen

This would be a Portable DM Screen with built in storage for dice and a customisable screen using cork and pins to allow notes of your choice. This would allow for a DM to do less setup and to use a personalised screen if they are DMing somewhere unusual.

DM table

(Convenience) This would be a small table to go on the end of a normal one, to provide a separate surface for DMs to place stuff and a build in DM screen with options to pin anything you want to it. The surface would be lower down to hide it more.





Tactile Dice

(Accessibility) The Dice would have brail numbers on. They would have to be made in such a way that they would still roll fairly and be easily readable.

Collapsible Dice Tower

(Convenience) This Could be a smaller part of another project (Such as a full table, or DM Screen). It would collapse down to be flush with the surface and would then unfold to create a dice tower. It could also provide storage for a small number of dice.

Rules Memory Aid

(Rules) This would be something to show various rules such as conditions, resistances, abilities and other similar things. They could be a set of tokens or hinging slots to hold these and show when they have been used or when they are relevant.

Full Table

(Convenience, Rules) This would be a full table designed exclusively for TTRPG's (and 5E DND) it would provide many quality-of-life features and allow space for several players and a DM. It could have the ability to collapse or compress when not being used. The DM screen would be customisable but also be collapsible so it can be lowered.

Modular Topview Grid:

(Cost, Convenience) This would be a grid (and set of props) to allow you to quickly create simple topview maps with different elevations, walls and other features. The walls and floors would slot into the base, as would some immovable features. Whereas tables, chairs and other similar props would be free to move so people can interact with them.

Dice Tray

(Convenience) This would be one or multiple dice trays or objects to emphasise dramatic rolls or just to have a place to roll dice. This could also provide storage. Designs could include:

- A skull with a snake.
- A Dragon skull with a sword in its mouth.
- A Castle with a dragon towering over it.
- (Pictured) A tray with a rocky backdrop and a hole for DM to roll through.
- Etc.

Shifting Grid

Aesthetics: A generally Rustic style. Hiding mechanical elements would be ideal

User: The only thing that would need to change for larger groups is the number of miniatures or accessories. Therefor if storage is suitable, there is nothing that needs scaling.

Cost: The primary cost would come from any mechanical components allowing the pieces to move/stay in position.

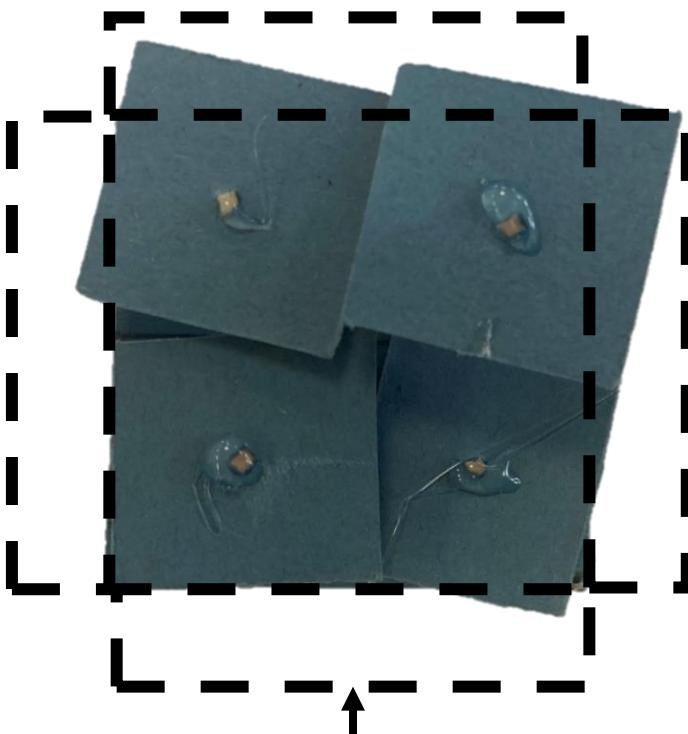
Function: The movement could be done with either some kind of smart material, friction and motors and/or bolts. There could also be storage around the outside of the grid for miniatures/tokens.

Ergonomics: Avoid having it too tall or heavy so it is convenient. Make the whole board itself small enough to reach over. Make the mechanism easy to use.

Size: varies based on how many squares you want. 25.4mm per square on each axis and a bit for storage. (e.g. a 10x13sq grid would be about 280x355mm)

Materials/Components: The mechanical components would be durable and ideally replaceable. To allow it to be repaired if it was broken. The rest of the product would be made of materials that satisfy the Aesthetics specification.

Safety: All mechanical components would be hidden within the product so there is no chance of things getting stuck in them. Light enough to lift comfortably so it wouldn't get dropped.



This is where the storage would go



The different tiles will move to different heights to allow 3D terrain to be made without manually crafting it out of foam or other materials.

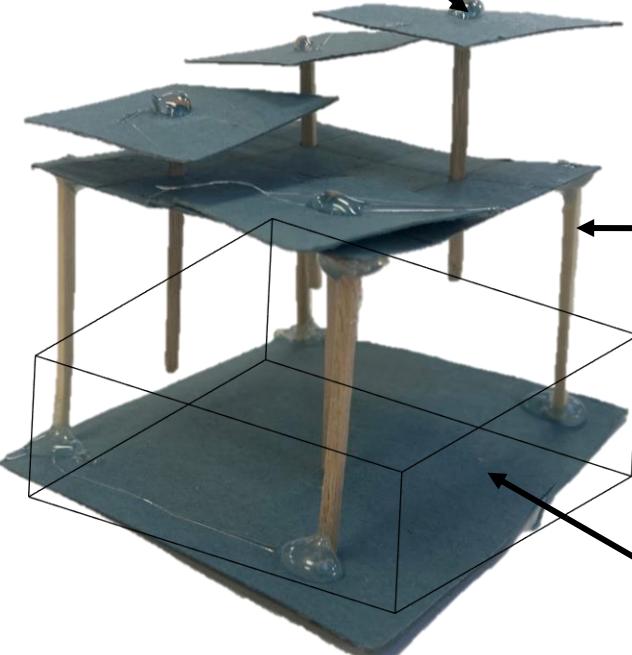


This kind of telescopic pole could also work, but I think it would be too small and fiddly to work.

One possibility for the mechanism, is a form of smart material called "two-way shape memory" material. This means it can be deformed when heated, hardens when cooled, and re-sets to flat when heated again.



There could be springs that expand when heated and contract when cooled, this would allow a current to flow through them to expand by a certain amount allowing computer control of the structure.



The frame would be stronger and thicker on the final one everything about this model is less than the product would be.

This is where the mechanism would go

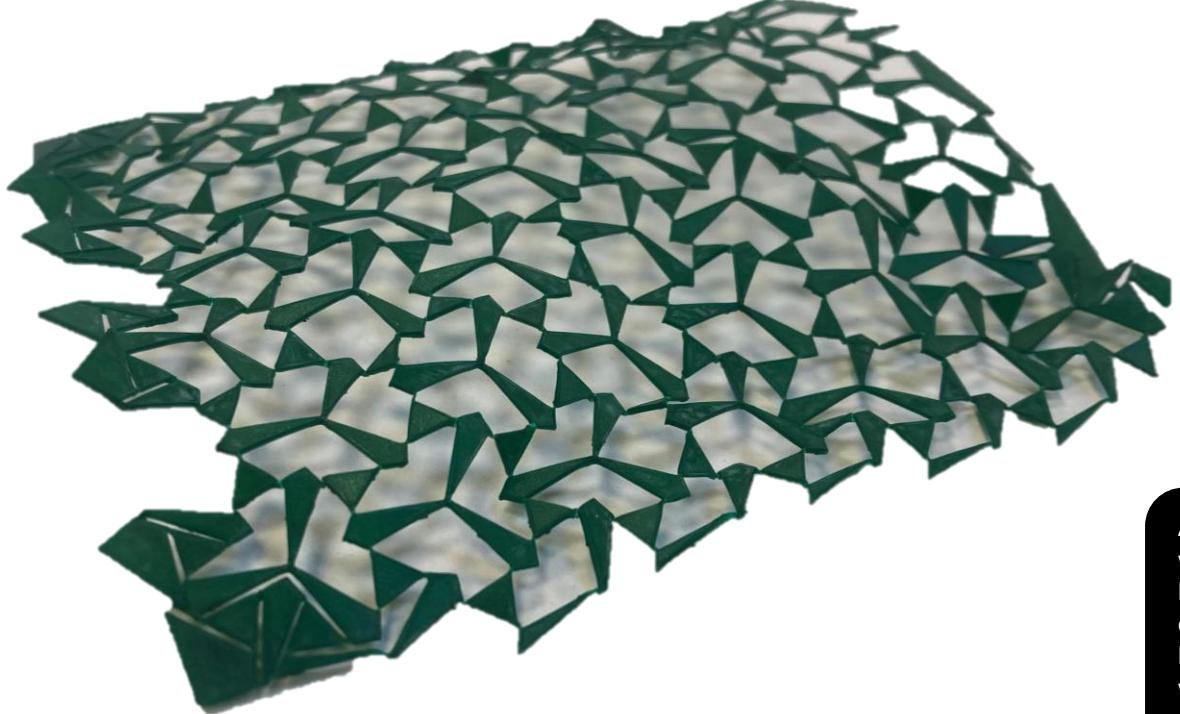


Telescopic poles could also be used as they are very intuitive to use and simple. But could be a very slow and manual process to set up.

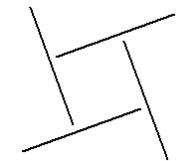
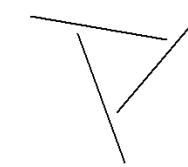
This idea would be to make a 3D combat grid where each tile can move to different heights so you can make 3D terrain on the fly. This could include lights (or different colours) to show different types of terrain, and there could be different versions to allow for a square combat grid or a hexagon world-scale grid. The mechanism could be several different things (smart material, bolts etc.) but it would need to be stable enough for miniatures and other props and could include storage.

Auxetic Material Terrain

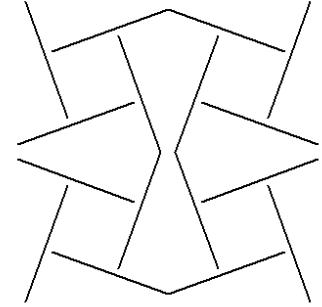
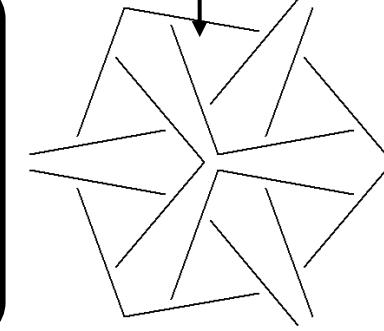
This was an idea for a combat grid that can be stored flat but (using a bistable auxetic structure) when expanded, creates larger 3D terrain. This would allow for storage and quick and easy setup. I first came across the bistable auxetic structure from this video, and it is also where I got the pattern from:
<https://www.youtube.com/watch?v=vrOjy-v5JgQ>



The auxetic structures start as a single building block that is mirrored and copied.



This creates a single cell, this cell is then copied many times into a grid to form a full piece of auxetic material



All this means when the small living hinges in each building block move, the whole material expands or contracts.



Aesthetics: (Limited by the material)

Cost: The cost would be quite low, as the material is cheap and can be Lazer cut quickly.

Function: An auxetic material is a material where if stretched one way, also stretches the other. For example, a non-auxetic material (like blue-tac) gets thinner in the centre when you stretch it. Whereas an auxetic material (see Right) gets wider.

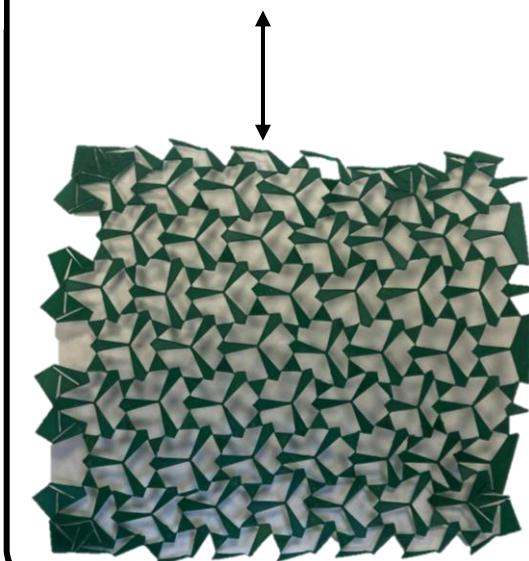
(For more detail: <https://en.wikipedia.org/wiki/Auxetics>)

Ergonomics: Avoid having it too big so it is convenient. Make the whole board itself small enough to reach over. It's a very easy mechanism to use.

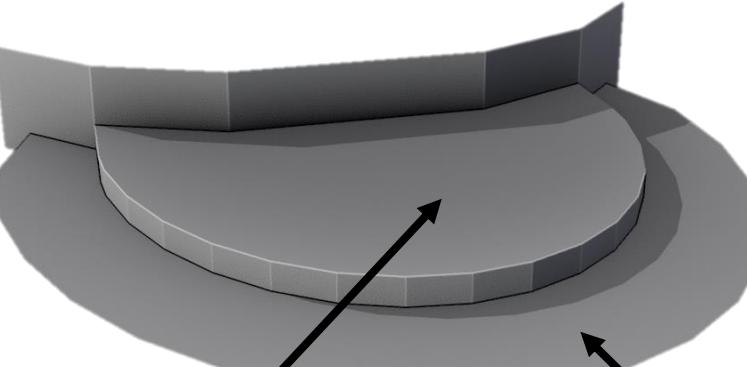
Size: Varies

Materials/Components: The boards would be made of laser cut rubber sheets. The flexible properties of rubber allows the auxetics to work and remain bistable, while providing suitable durability.

Safety: There are no safety issues.

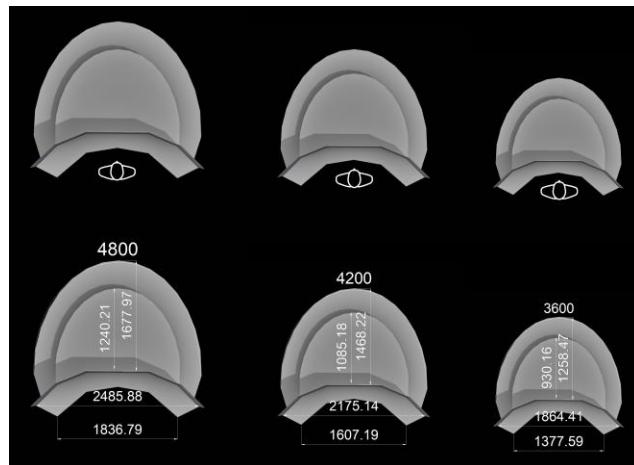


Full Size Table

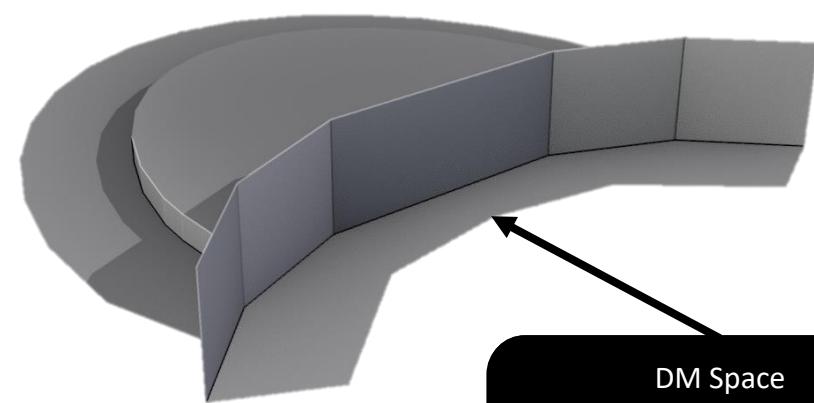
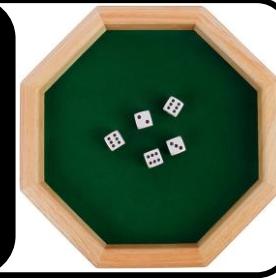


Space for Combat Grid

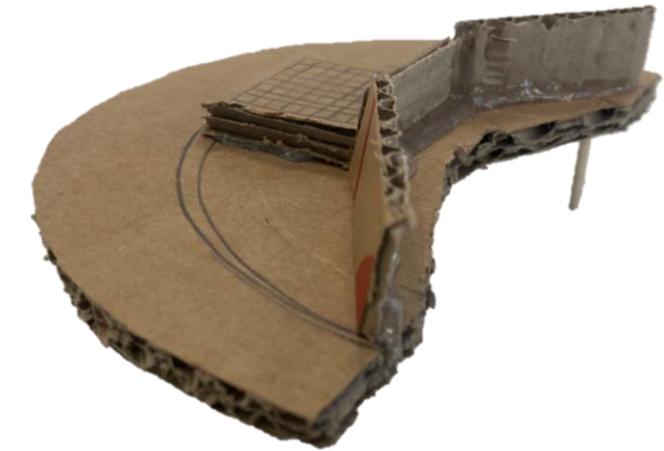
Player Space



The player Space could have a wide groove running through it for dice rolling.



DM Space
Could contain digital screens to connect to a laptop. Or cord boarding to allow stuff to be pinned there. Or magnetic sheets.



The player Space could have dice towers embedded into the table, but this would mean it was less of a smooth curve.



Aesthetics: Varnished wood. Hiding mechanical/electrical elements would be ideal.

User: The only thing that would need to change for larger groups is the number of seats and certain game elements like dice trays etc.

Cost: The Cost would be quite high, for several reasons: Sheer Amount of material; many mechanical components to augment the product; many electrical components and (because of size) manufacturing costs.

Function: The DM screen and table-space would provide enough room for notes, tools, dice and any other resources required. The players would need enough space for dice, character sheets and any other accessories. Ideally this would also accommodate the use of digital character sheets on tablets/phones.

Ergonomics: The height, (built in, adjustable?) seating, and general size/shape should accommodate a range of people (and a range of numbers of people) comfortably.

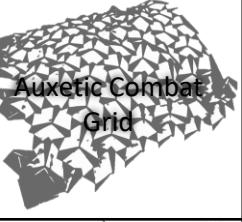
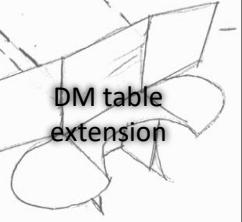
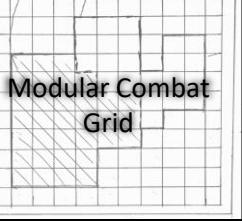
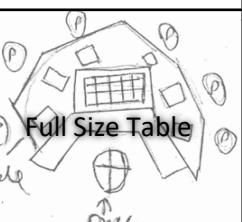
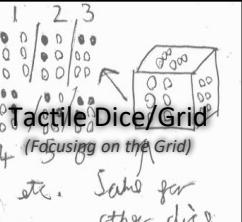
Size: (See Diagram) All dimensions are approximate.

Materials/Components: The mechanical/electrical components would be durable and ideally replaceable. The rest of the product would be made of materials that satisfy the Aesthetics specification. Ideally Wipe clean.

Safety: All mechanical components would be hidden within the product so there is no chance of things getting stuck in them.

Source: <https://www.youtube.com/watch?v=YGFx15JaCdE>

Design Evaluation

Design Idea	Aesthetics	User	Cost	Function	Ergonomics	Size	Materials/Components	Safety	Sustainability
 Shifting Combat Grid	This fully fulfils the specs because it would be made of suitable materials and allows for suitable variety. It could be better by ensuring all mechanical elements are hidden but it may be infeasible. This may be able to be done with some precise manufacturing methods or could be ineffective.	This fully fulfils the specs as the grid itself doesn't need to scale for more players, only more miniatures/props to go on it. (And therefore, possibly storage) The main improvement could be to provide it in multiple sizes so that if you don't need the larger grid, you can just get a smaller one. This could be provided as modular pieces to allow groups to expand over time or change it depending on the encounter size.	This mostly fulfils the specs as the shifting grid could replace multiple, more expensive, pieces of 3D terrain or maps. The only issue is the components required to make the mechanism work could be too expensive to allow a low price.	This fully fulfils the specs as would visualise 3D-terrain at the standard 25.4mm:5ft scale. Use of condition tokens can also aid with rules. The only improvement would be to allow multiple levels, but this would likely be impossible.	This fully fulfils the specs as no adjustable elements are required. Ideally the board should be kept small enough (thin enough) that you don't have to lean over it or crane your neck in any way. And storage should be accessible. Also there should be a focus on making the mechanical elements easy to use ideally even for those with motor impairments.	This mostly fulfils the specs as to allow the mechanism of raising/lowering platforms it would have to be quite thick. This means the whole thing would be large. A possible solution to this would be to split it into multiple smaller pieces that then slot together. These may still be impractical to store though.	This mostly fulfils the specs as suitable material can be sourced and finished appropriately. The only issue is that components within the board may be inaccessible.	This somewhat fulfils the specs as the internal mechanical components may be too open at the top. (where the grid is.) And due to the number of components, it may be too heavy to carry comfortably. A possible solution to the weight, would be to split it into multiple smaller pieces that then slot together.	
 Auxetic Combat Grid	This fails to fulfil the specs as, to allow its auxetic properties, the material would need to be some form of rubber/flexible sheet. The impracticality of painting it also adds to this problem. This is a fundamental flaw with the idea and can't be resolved.	This mostly fulfils the specs as the grid itself doesn't need to scale for more players, only more miniatures/props to go on it. The only issue is with storage, since this is not a multipurpose grid, you would need one for each terrain. This could be combatated using modular pieces to allow groups to change the terrain, but this may not be possible with the Auxetics.	This mostly fulfils the specs as it would be a cheap way to buy 3D terrain, due to the quite cheap materials and inexpensive manufacturing methods (ie. Laser cutting)	This mostly fulfils the specs as it would visualise 3D-terrain at the standard 25.4in:5ft scale. The main problem is that you can't have any steep curves due to its auxetic properties.	This fully fulfils the specs as no adjustable elements are required. Ideally the board should be kept small enough that you don't have to lean over it. Thickness is not important as the thickness to allow its auxetic properties is thin enough.	This fails to fulfil the specs as when flat these would be only a few millimetres thick. So, several of these could be stored vertically; conserving space efficiently. The only possible problem is that the grid itself would still be quite wide and long. This wouldn't be an issue.		This fully fulfils the specs as rubber is light and flexible; this means it can be carried with ease and will bend before damaging anything else.	
 DM table extension	This fully fulfils the specs because it would be made of suitable materials and allows for suitable variety. This could be improved with decoration on the player side, For this I would look at laser engraving.	This fully fulfils the specs, since the DM is the only person to use it, the size of the group shouldn't affect any part of it.	This somewhat fulfils the brief as, on the one hand, this is a more expensive option compared to a normal DM screen. But is a less expensive option compared buying a full table. This is a problem as most people wouldn't buy a table, but most people would buy a DM screen.	This fully fulfils the specs as it would give GM's space for the tools and quick-references that they want. Additionally, the player-side could have its own space for some cheat sheets.	This mostly fulfils the specs as (due to its possible folding elements) the height can't be changed; this should not be an issue as seat height can be changed and most DMs switch between sitting and standing. Though this could merit a redesign.	This mostly fulfils the specs as the screen, drop-leaves and legs would have ways to fold, collapse or detach. Problem is even with all that, it would still have a large bounding box. But that space could still be used for other things like dice trays and books.	This fully fulfils the specs as suitable material can be sourced and finished appropriately. Any & all mechanical components are easily accessible and replaceable.	This fully fulfils the specs as all the mechanical components (ie. hinges) would be placed to avoid danger. The only issue could be with the moving parts that things could get trapped in.	
 Modular Combat Grid	This mainly fulfils the specs as, due to the nature of the grid/props, it would be in the style or theme of whatever campaign you are playing. But the limited resolution of the modular pieces may be problematic. This could be improved by researching 3D-resin-printing to make more complex and detailed models/props.	This fully fulfils the specs as the grid itself doesn't need to scale for more players, only more miniatures/props to go on it. The main improvement could be to provide it in multiple sizes so that if you don't need the larger grid, you can just get a smaller one. This could be provided as modular pieces to allow groups to expand over time or change it depending on the encounter size.	This fully fulfils the specs as this would allow for simplified 3D terrain/locations to be built, without high cost, specifically made terrain. This could be improved even more by allowing the modular pieces to be bought in packs based on the type of terrain they represent (ie. Lava/water/earth/stone/grass etc.) so if a group never used a certain type (or is going to use one type a lot) they don't need to buy them.	This fully fulfils the specs as it would visualise 3D-terrain at the standard 25.4mm:5ft scale. Use of condition tokens can also aid with rules. The use of modular pieces also allow there to be multiple levels/floors. The only difficulty would be ensuring there were enough pieces of each type to allow terrain to be constructed freely. This could be solved by making every piece the same shape, but this may be impractical.	This fully fulfils the specs as no adjustable elements are required. Ideally the board should be kept small enough (thin enough) that you don't have to lean over it or crane your neck in any way. And storage should be accessible.	This fully fulfils the specs as when not used the modular pieces could be removed from the grid (stored in the base?) so the grid can stay flat. The only possible problem is that the grid itself would still be quite big. To solve this, it could fold. But I don't think it is much of a problem as it is still flat.	This fully fulfils the specs as suitable material can be sourced and finished appropriately. There are no mechanical components that would need replacing.	This fully fulfils the specs as there are no mechanical components for things to get trapped in. There are no electrical components. Also, Because of how thin it would be, the weight shouldn't be a problem. The only issue could be if there was storage to make sure it was accessible.	
 Rules Memory Aid (+ Dice Tray)	This mostly fulfils the specs because the base would be made of suitable materials. But the acrylic pieces or possible components to make it fold would be highly visible and could ruin the effect. This is not necessarily a problem, but alternate details could be looked into.	This fully fulfils the specs as each player would have one. That said, there should still be scalable elements to allow different numbers of tokens to be used.	This mostly fulfils the specs as it would allow players to avoid the need to print out a new character sheet every time something changes: they can just change the tokens, and because it is multifunctional (+dice tray) a slightly higher cost can be justified. The only issue is the multitude of tokens you would need for the different abilities, this could be fixed by splitting it into sets for different classes/sourcebooks.	This fully fulfils the specs as the use of engraved tokens and hinged holders would allow abilities and other rules to be always visualised and shown in front of the player, so they don't need to go searching in their character sheet to find it.	This fully fulfils the specs as adjustable elements are required and the tokens/hinged parts should be easy enough for people with motor impairments.	This fully fulfils the specs as it would be small enough to fit into a bag and be stored easily. The hinged tokens can fold flat, so they don't stick out.	This fully fulfils the specs as suitable material can be sourced and finished appropriately. Any & all mechanical components are easily accessible and replaceable. The only problem is that if it was a combination dice tray, the felt at the bottom could absorb spill drinks.	This fully fulfils the specs as the mechanical components would likely be made of PLA plastic, that would bend/break before harming/damaging anything else. The small size of the product also means lifting & carrying would be no problem.	
 Full Size Table	This can fully fulfil the specs as, due to its sheer size, it would have plenty of room to hide mechanisms and electronics. The only problem, is that the DM side could end up covered in electronics (that are un-hideable) as there are so many. Also, any use of digital screens could affect the look of it. This is not a problem however as tools for the DM take priority and screens can display something to blend in when not displaying something specific.	This mostly fulfils the specs as the scalable seating would allow different numbers of people, and since there are no "player stations", just a smooth curve: the shape doesn't limit the places a player can sit. The only problem would be fine tuning the size/shape of the curve to allow enough size for large groups while also being larger-than-practical for small groups. It could be sold in multiple sizes to facilitate this.	This fully fulfils the specs as it would be a high-end, high-cost product.	This fully fulfils the specs as many of the core parts of the table would be there to aid with rules and to visualise the world. For example, the memory aid above could be included and/or one of the combat grid ideas could be implemented. As well as elements of the DM table on the DM side.	This fully fulfils the specs as the seating would be fully adjustable (height, distance and position around the table.) The only problem would be to ensure the space at the centre for the grid is close enough to everyone that they don't need to lean too much.	This fully fulfils the specs as (although it is a big thing) the seats would fold away, and the inside would provide storage space. Because this is a high-end idea: the idea of conserving space is less important as the people buying it would likely have a specific space for it.	This mostly fulfils the specs as suitable material can be sourced and finished appropriately. The only issue is that components within the table may be inaccessible.	This fully fulfils the specs as any mechanical components would be contained within the table. And electronics would be accessible through removable panels. The only problem may be the built-in seats as the mechanics would be exposed. But these could be padded to avoid danger.	
 Tactile Dice/Grid (Focusing on the Grid)	This could fulfil the specs. Depending on how it's made. (Materials/Processes etc.) But as this would take a form-from-function approach I don't think it's a problem. (This is kind of a wildcard because it is targeted at the visually impaired segment of the market, it could be argued that aesthetics is a less necessary part, but they could still be used with other non-blind players so I will keep it in. It could be better to consider the feel of the objects, but I would argue that fits better in the ergonomic category)	This fully fulfils the specs as the grid itself doesn't need to scale for more players, only more miniatures/props to go on it. The main improvement could be to provide it in multiple sizes so that if you don't need the larger grid, you can just get a smaller one. This could be provided as modular pieces to allow groups to expand over time or change it depending on the encounter size.	This fully fulfils the specs as (both) can use cheaper manufacturing methods like 3D printing to reduce the cost. The only problem with this: is that it may be to the detriment of aesthetics as 3D-printing is not always the best looking.	This fully fulfils the specs as they can allow those with a visual impairment to still play the game independently by feeling the dice/grid.	This mostly fulfils the specs as it would have to be made quite specifically as things like dice are harder to roll with motor impairments.	This fully fulfils the specs as both the dice and grid would be small enough to fit into a bag and be stored easily. The only improvement would be to make the grid smaller/easier to store the likely pieces.	This fully fulfils the specs as the right 3D-printer filament (Likely PETG or ABS) would satisfy this criteria.	This fully fulfils the specs as there are no mechanical components for things to get trapped in. There are no electrical components. Also, Because of how small they would be, the weight shouldn't be a problem. The only issue could be if there was storage to make sure it was accessible.	

Suitable recycled/sustainable/fair-trade material can be sourced. For some this may increase the cost. But this is an acceptable trade off.

Evaluation Takeaways

As the decision matrix below shows, the best idea to follow up is the *Modular Combat Grid*. With the *Full table* & *Rules memory aid* at a close second. And the worst (confirming my suspicions) is the *Auxetic grid*.

Soon after the evaluation I performed a focus group with 3 teachers who all play DND 5e. Talking about the 3 ideas that came out on top. They were all very enthusiastic about the *Modular Combat Grid* and had ideas and other things to say about it. They suggested that alternate pieces could be used for features like doors or magical effects. Or a surface that could be drawn on could be used. (E.g. whiteboard) The more multipurpose the better. The idea of wider/taller pieces (e.g. 2x3 or 5x1) pieces was posed. One also said that it could be used for other TTRPGs as well.

The table was the least favourite of the ideas as they wouldn't have space for it, and it would be too high cost to feasibly buy. But given the right circumstance: the more storage the better. And the more DM tools the better. One of them suggested that it could be marketed to Gaming Cafes as they are businesses so could have enough income to invest in such a purchase.

The Rules memory aid was popular: bringing in ideas about maximum customisability and modularity. And the idea that if you had multiple characters: it could be changed out without lots of work. There could also be a distinction between few-use and many-use abilities.

Modular Combat Grid [8.5/9]

This was overall a resounding success and in the focus group, this came out on significantly on top. The points brought up were to have different pieces for doors and other features like stairs. And to have pieces that are larger than a 1x1 tile. Additionally: the more multipurpose the better. The pieces could also be made of white/black-board material (or similar) so pieces can be drawn on to represent ground features.

- Modular Pieces:** These both allow for different elevations and features to be made. The base could also be in separate pieces to allow it to be stored and carried easily. There could also be pieces that are larger (e.g. 3x1 walls or 4x4 floors) These would be useful as you often need large areas.
- Always Fit Tightly:** To allow ease of use, all the pieces that slot together, should fit with an interference fit. Ideally, all the pieces would have the same shape so they can be used at any position (i.e. Wall or floor) With the exception of door/stairs (etc.) pieces. Although this may not be possible.
- Research Whiteboard material:** The pieces could be made of white/blackboard material (painted/veneered/solid) to allow them to be drawn on. This would allow things like water or other similar features to be drawn in, instead of buying a separate set of "water" tiles.
- Sell in batches:** Modular pieces of different types could be sold in groups, so if someone doesn't need a certain type, they don't need to buy them. For example, if you wanted to build up a dungeon: you could buy the stairs and door pieces; but if you just wanted terrain, you wouldn't need to buy this.

Full Table [7.5/9]

This also scored very high. But with that, there are still many points to work on. These are the focuses:

- Built user focused:** Above all else, the function of this product is important. As, to justify the price, it must provide ample functions for players and DMs. This includes quick reference information, visualisation aids, and other indirect things like allowing devices to be charged.
- All modern elements hidden:** There should be no exposed cables and any lights should be "disguised" as lanterns or should be hidden (e.g. in a groove.) The exception to all of this is the DM side, as they will likely have separate equipment (although I wish to minimise this) and the function of that side takes even more priority as the DM has so much to keep track of.
- Removable or Foldable:** Any elements that stick out or are intrusive should either come off to be stored somewhere else; or fold down into the table, so they are out of the way.

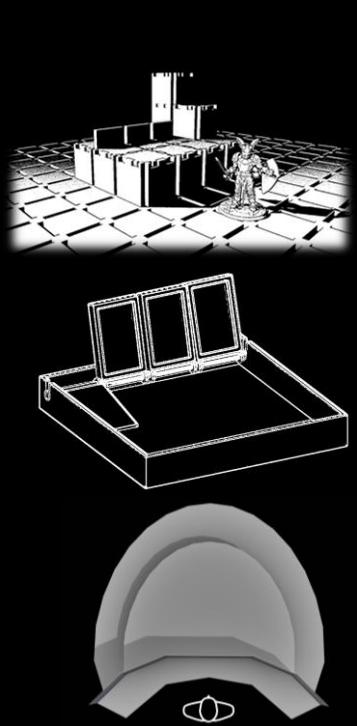
This idea was the least favourite in the focus group, the problem being it would be too high cost, and they wouldn't have enough space for it. And for this reason, I am choosing to rule it out for this project: but it could still be viable, given the right market.

Rules Memory Aid [8/9]

This is my personal favourite of the top 3. As it is the one I would get the most use out of. But despite this, it was not as popular as the grid in the focus group. I think partly because most of them were more experienced players. Never-the-less; these are the focus points:

- Customisation is essential:** The main thing reinforced in the focus group, and something that I had realised through research: is that the ability to customise and rearrange is essential as people like being able to personalise their things. And it should also have the capability to support homebrew mechanics.
- Tactile feel:** The switches and dials and any other mechanism should click into place and when they slot together/next-to each other, no force should be required, but they should not move too much. Tight tolerances should be used.
- Easy Replacement:** If a player has multiple characters, it would be good to allow them to be switched without too much work. This could be done with a replaceable tray, or by having all the pieces click together, so they come out together

This idea was ruled out, since (although it was still positive) the focus group were less enthusiastic. I believe this is because they are more experienced. And because this has already been solved by websites such as D&D Beyond and Roll20: With their digital character sheets. And even when using physical character sheets, there are many variants with different options and layouts.



Aesthetics	User	Cost	Function	Ergonomics	Size	Materials/Components	Safety
This mainly fulfils the specs as, due to the nature of the grid/props, it would be in the style or theme of whatever campaign you are playing. But the limited resolution of the modular pieces may be problematic. This could be improved by researching 3D-resin-printing to make more complex and detailed models/props.	This fully fulfils the specs as the grid itself doesn't need to scale for more players, only more miniatures/props go on it. The main improvement could be to provide it in multiple sizes so that if you don't need the larger grid, you can just get a smaller one. This could be provided as modular pieces to allow groups to expand over time or change it depending on the encounter size.	This fully fulfils the specs as this would allow for simplified 3D terrain/locations to be built, without high cost, specifically made terrain. This could be improved even more by allowing the modular pieces to be bought in packs based on the type of terrain they represent (i.e. Lava/water/earth/stone/grass etc.) so if a group never used a certain type (or is going to use one type a lot) they don't need to buy them.	This fully fulfils the specs as it would visualise 3D-terrain at the standard 25.4mm:5ft scale. Use of condition tokens can also aid with rules. The use of modular pieces also allows there to be multiple levels/floors. The only difficulty would be ensuring there were enough pieces of each type to allow terrain to be constructed freely. This could be solved by making every piece the same shape, but this may be impractical.	This fully fulfils the specs as no adjustable elements are required. Ideally the board should be kept small enough (thin enough) that you don't have to lean over it or crane your neck in any way. And storage should be accessible.	This fully fulfils the specs as when not used the modular pieces could be removed from the grid (stored in the base?) so the grid can stay flat. The only possible problem is that the grid itself would still be quite big. To solve this, it could fold. But I don't think it is much of a problem as it is still flat.	This fully fulfils the specs as suitable material can be sourced and finished appropriately. There are no mechanical components that would need replacing.	This fully fulfils the specs as there are no mechanical components for things to get trapped in. There are no electrical components. Also, because of how thin it would be, the weight shouldn't be a problem. The only issue could be if there was storage to make sure it was accessible.
This mostly fulfils the specs because the base would be made of suitable materials. But the acrylic pieces or possible components to make it fold would be highly visible and could ruin the effect. This is not necessarily a problem, but alternate details could be looked into.	This fully fulfils the specs as each player would have one. That said, there should still be scalable elements to allow different numbers of tokens to be used.	This mostly fulfils the specs as it would allow players to avoid the need to print out a new character sheet every time something changes: they can just change the tokens, and because it is multifunctional (+dice tray) a slightly higher cost can be justified. The only issue is the multitude of tokens you would need for the different abilities, this could be fixed by splitting it into sets for different classes/sourcebooks.	This fully fulfils the specs as the use of engraved tokens and hinged holders would allow abilities and other rules to be always visualised and shown in front of the player, so they don't need to go searching in their character sheet to find it.	This fully fulfils the specs as no adjustable elements are required and the tokens/hinged parts should be easy enough for people with motor impairments.	This fully fulfils the specs as it would be small enough to fit into a bag and be stored easily. The hinged tokens can fold flat, so they don't stick out.	This fully fulfils the specs as suitable material can be sourced and finished appropriately. Any & all mechanical components are easily accessible and replaceable. The only problem is that if it was a combination dice tray, the felt at the bottom could absorb spilt drinks.	This fully fulfils the specs as the mechanical components would likely be made of PLA plastic, that would bend/break before harming/damaging anything else. The small size of the product also means lifting & carrying would be no problem.
This can fully fulfil the specs as, due to its sheer size, it would have plenty of room to hide mechanisms and electronics. The only problem is that the DM side could end up covered in electronics (that are un-hidable) as there are so many. Also, any use of digital screens could affect the look of it. This is not a problem however as tools for the DM take priority and screens can display something to blend in when not displaying something specific.	This mostly fulfils the specs as the scalable seating would allow different numbers of people, and since there are no "player stations", just a smooth curve: the shape doesn't limit the places a player can sit. The only problem would be fine tuning the size/shape of the curve to allow enough size for large groups while also being larger-than-practical for small groups. It could be sold in multiple sizes to facilitate this.	This fully fulfils the specs as it would be a high-end, high-cost product.	This fully fulfils the specs as many of the core parts of the table would be there to aid with rules and to visualise the world. For example, the memory aid above could be included and/or one of the combat grid ideas could be implemented. As well as elements of the DM table on the DM side.	This fully fulfils the specs as the seating would be fully adjustable (height, distance and position around the table.) The only problem would be to ensure the space at the centre for the grid is close enough to everyone that they don't need to lean too much.	This fully fulfils the specs as (although it is a big thing) the seats would fold away, and the inside would provide storage space. Because this is a high-end idea: the idea of conserving space is less important as the people buying it would likely have a specific space for it.	This mostly fulfils the specs as suitable material can be sourced and finished appropriately. The only issue is that components within the table may be inaccessible.	This fully fulfils the specs as any mechanical components would be contained within the table. And electronics would be accessible through removable panels. The only problem may be the built-in seats as the mechanics would be exposed. But these could be padded to avoid danger.

Design Idea

Design Idea	Aesthetics	User	Cost	Function	Ergonomics	Size	Materials/Components	Safety	Sustainability	Total
	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼
Modular Combat Grid	0.5	1	1	1	1	1	1	1	1	8.5 /9
Rules Memory Aid	0.5	1	0.5	1	1	1	1	1	1	8 /9
Full Size Table	1	0.5	1	1	1	1	0.5	0.5	1	7.5 /9
Tactile Dice/Grid	0	1	1	1	0.5	1	1	1	1	7.5 /9
DM table extension	1	1	0	1	0.5	0.5	1	1	1	7 /9
Shifting Combat Grid	1	1	0.5	1	1	0.5	0.5	0	1	6.5 /9
Auxetic Combat Grid	-1	0.5	0.5	0.5	1	1	-1	1	1	3.5 /9

Decision matrix rules:

- Fully Succeeded: +1
- Mostly Succeeded: +0.5
- Somewhat Succeeded: +0
- Failed: -1

This allows me to see clearly when something has succeeded. "Mostly" gets 0.5 as it is not as good, but still positive. "Somewhat" is not good enough to add but it doesn't make the product worse. A Failure means it brings the overall quality of the product down so takes away from the overall score.

Design Variations

(the names are arbitrary)

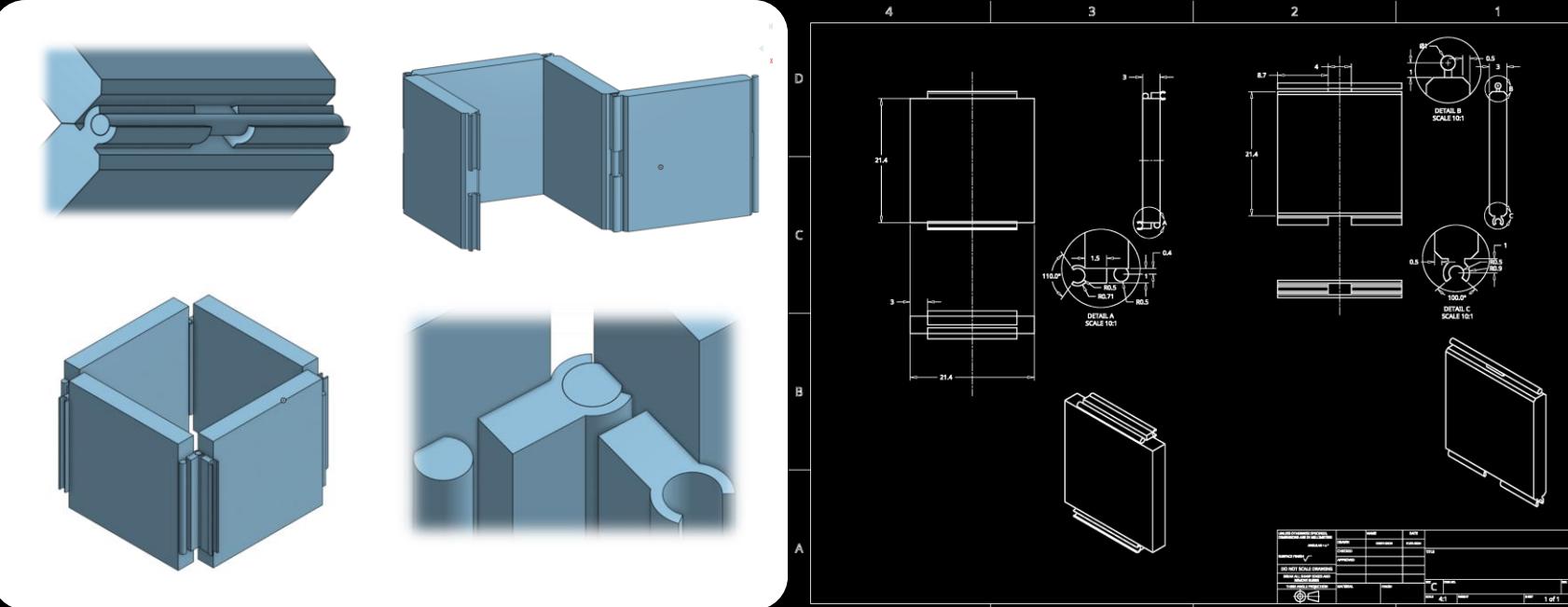
Variation 1 (Top-Right): Click-lock

This idea is a set of 3D-printed pieces. They would need very tight tolerances to ensure a balance between being a secure structure and being able to click together.

Sub-variation 1 (Lower of the two): is a set of walls that can click together in any combination, Once clicked into place, the parts won't move. I didn't manage to get the top/bottom pieces working and they may not be possible with this exact design. But there is potential.

Sub-variation 2 (Upper of the two): is a long line of walls joined together; hinged so they can be placed at any angle. (in 90 or possibly 45-degree increments)

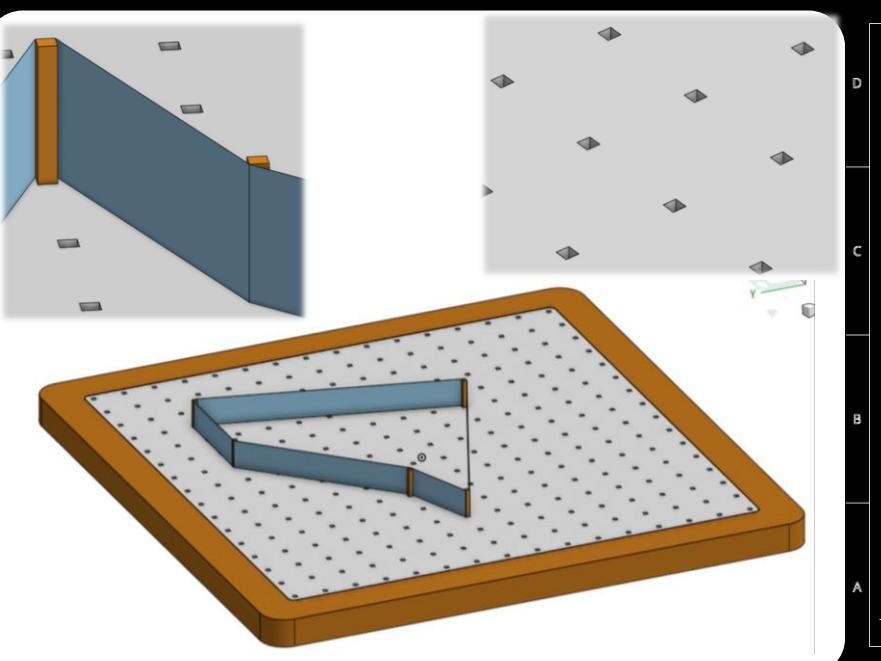
Both would attach to a base using a similar mechanism that they join together with.



Variation 2 (Middle-Right): Fabric walls

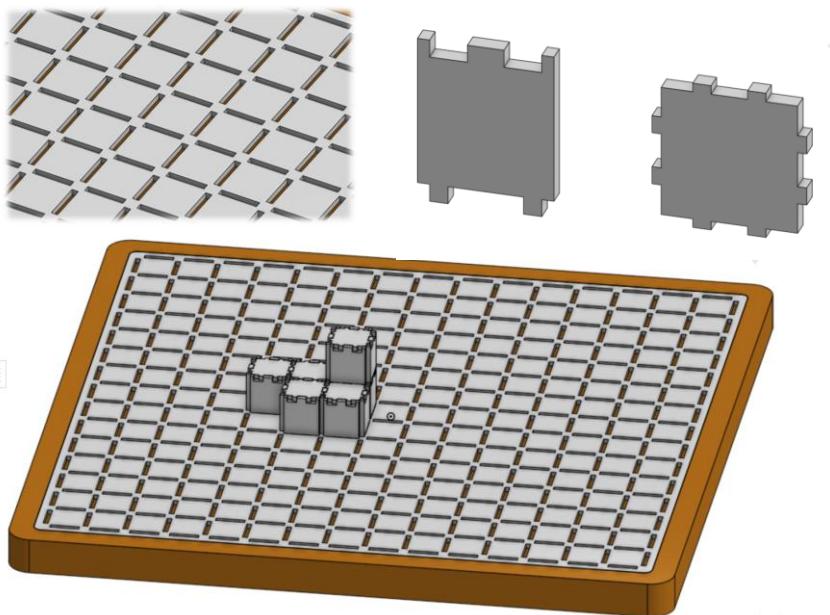
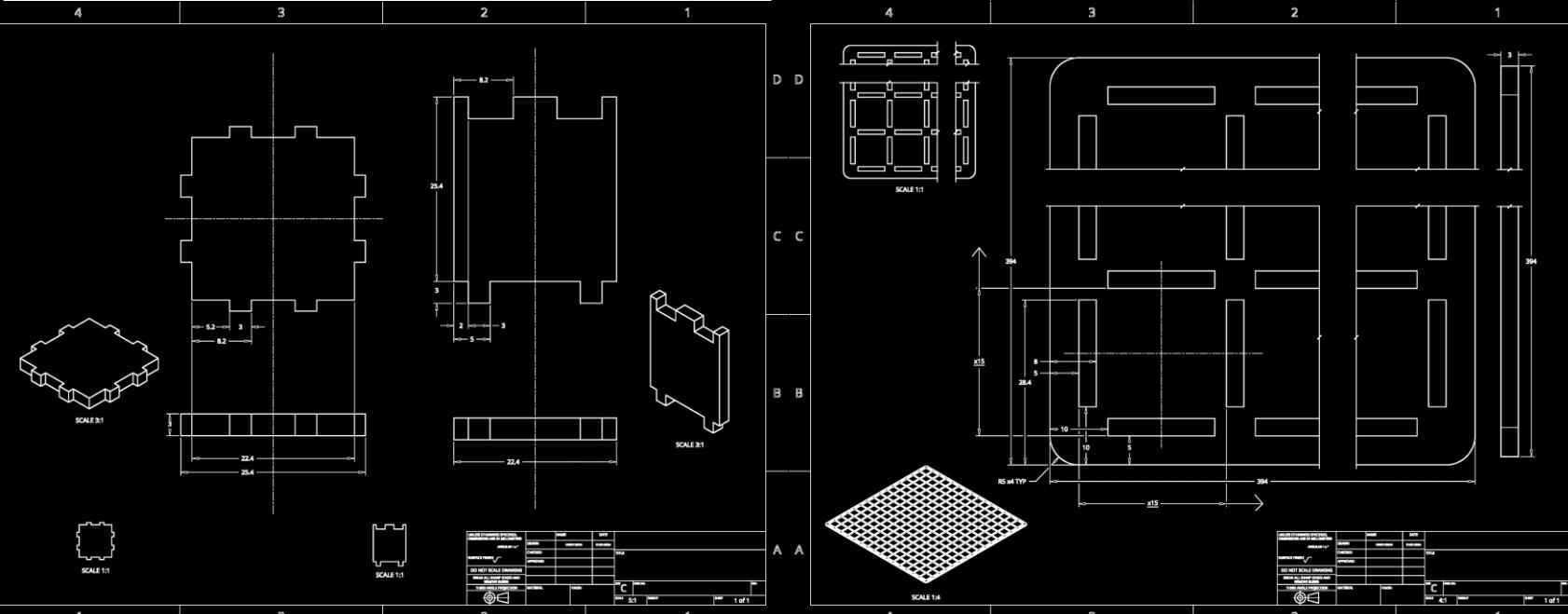
This is the simplest of the ideas, using only dowls (square or round) and fabric, the exact details of how they join and are secured is not certain*: but the principle is there. The base idea is that fabric wraps around the dowl. The base could be drilled if they are round, or laser cut if square. The dowls could be bought and cut to length using jigs. Tolerances could be relatively loose.

*(they could be joined to a pole at each end (or both ends to one) and stretch around the others. Or it could stick to poles)

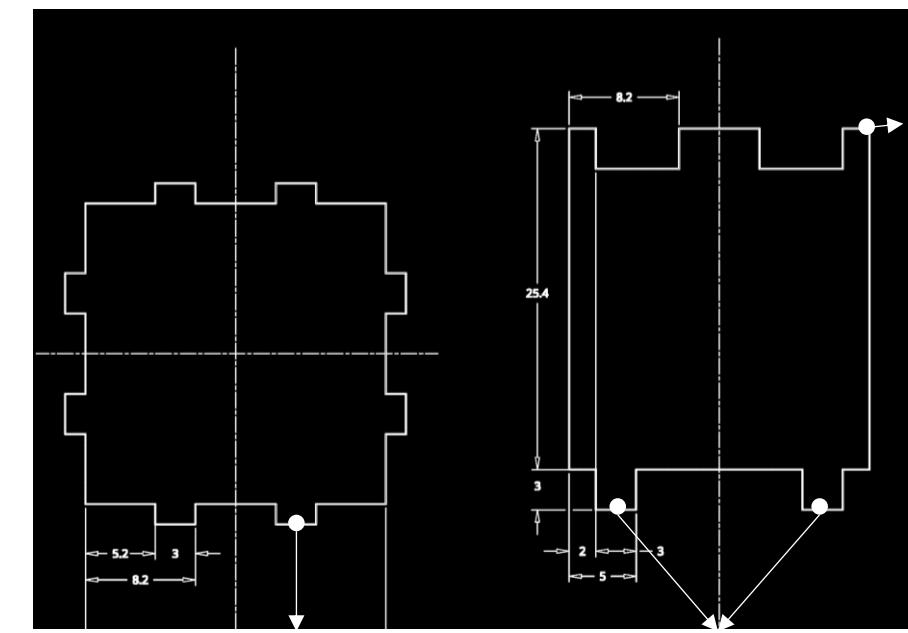


Final Decision:

I have decided to follow up on the *Finger Joints* idea, since it is the one that would be cheapest and quickest to manufacture and has full support for many layers. Its current limits are that it is stuck on the axis of a square grid and is made of 2 types of pieces. The grid could be combated by bringing in ideas from the fabric idea and allowing some kind of elastic or fabric to bridge gaps diagonally. Combining the pieces into 1 universal piece is hard, and I believe impossible if one of the aims is to have n sized pieces. I will still experiment and at least see if there is a way to simplify and strengthen the current pieces to work better. Overall, this is the most promising idea.

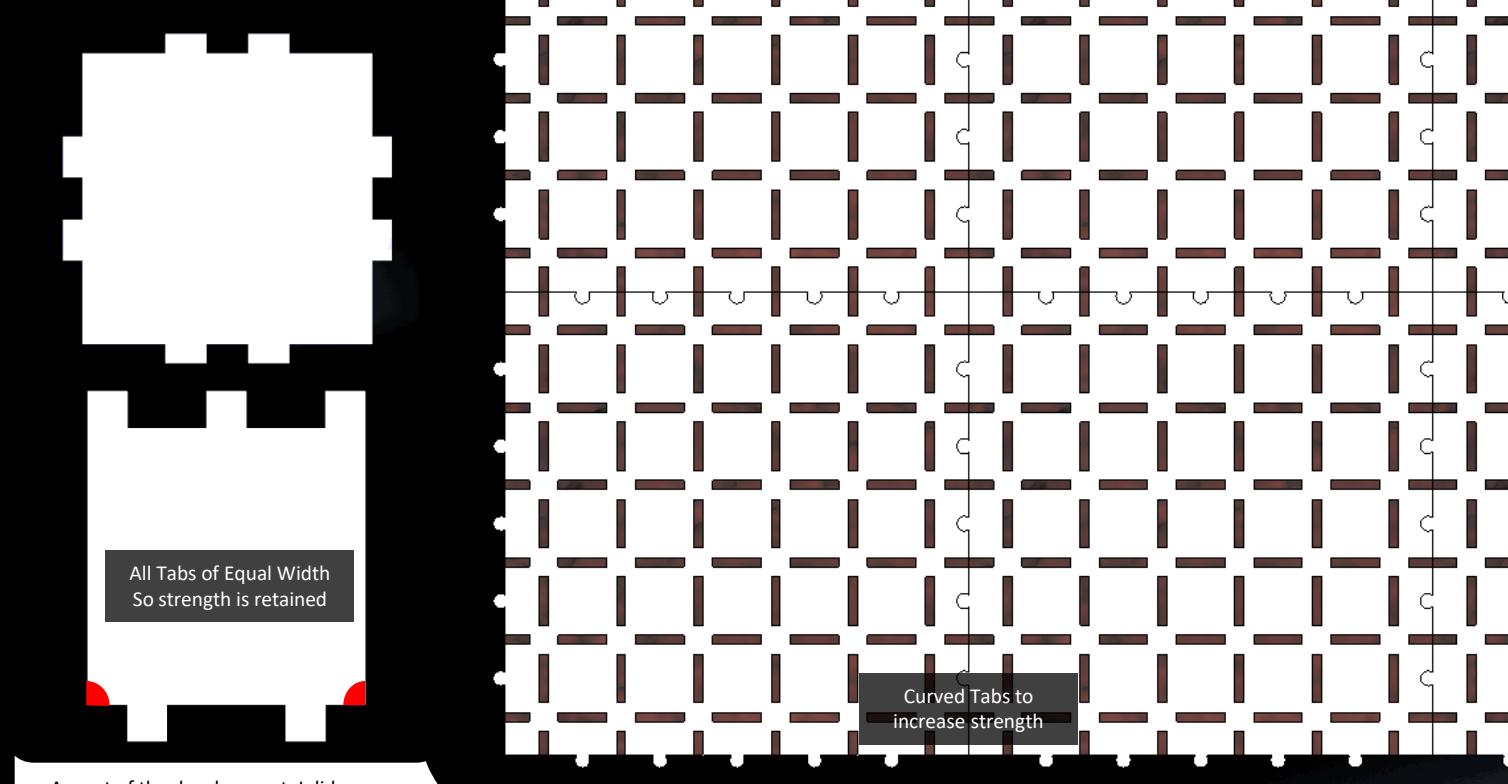


The Chosen Idea:



These pieces need to exist so the side piece will be held in place if there is no top.

All the tabs need to be changed so they are all the same width (or appropriate widths) to allow good strength for all of them



As part of the development, I did some stress testing in Autodesk's Inventor, this led to the insight that the lower corners were under more pressure. To combat this, I could round them off slightly. But overall, the stress is still minimal so I will prioritise aesthetics and keep them sharp. All the tabs seemed to have about the same amount of stress on as each other. So, I will keep those all at equal width.



I believe Acrylic is the best material for this because it is readily available, comparatively cheap and (although not sustainable) is long-lasting so that negligible.

Base

One idea that has been in the back of my mind throughout this whole project is the idea of other props/tools for making the playing experience better. The ideas I could look at are: an affordable way to make miniatures and props; risers to allow miniatures to float, fly or fall and/or cheaper distance/area of effect references. These is something that will take secondary priority to the main grid, but if I have time: I'll look at.

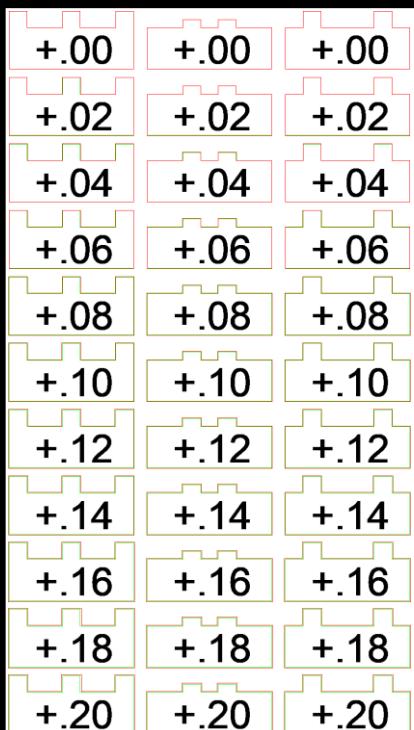
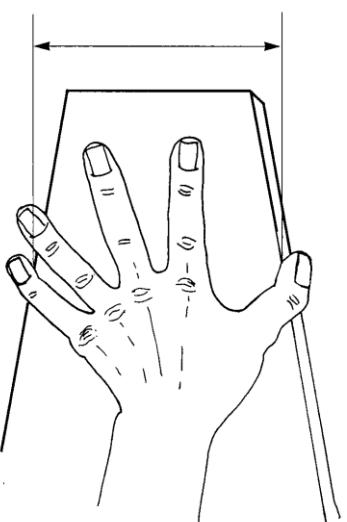


Base

The initial idea had a box containing the base, but this went against the "maximum modularity" design requirement. So, I decided to find a way to replace large base, with a set of smaller ones that can slot together. (Above) I used round tabs since they would be stronger than square edged ones. And instead of one large box containing the whole base, each piece would have a wooden layer below it to provide structure. This would mean you could make grids of any size so if you wanted a long thin room, you would not need to get a very large grid, just rearrange the pieces you already have. Each piece could have a half squares on the edge, so it joins with the one next to it. I need to do physical testing on it to make sure the tabs are strong enough, and that the wooden layers doesn't affect the way they join. (I could just end the wooden layers on a straight edge instead?) And I should check that the slots around the joins still allow the walls to fit on-top. I should do the same testing on the wall/top pieces.

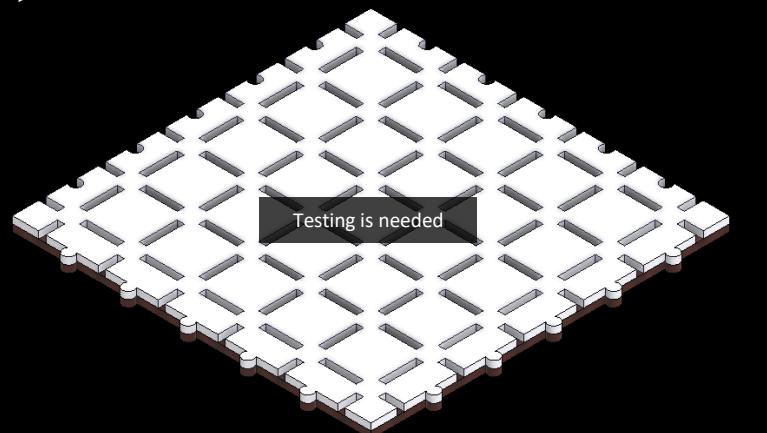
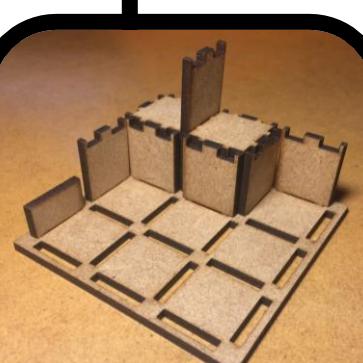
The Dimensions of the individual base parts should be able to be picked up from the side (So if there is a structure is built on them, they can still be moved with ease) The best size for this is a 4+2/2 square grid (4 full squares and the 2 half squares at the edge edge) at 127x127mm. This is only just above the 5th percentile for both men and women, meaning slightly less than 95% of people can pick it up. This still allows for a good size base piece. (This doesn't match the images on this slide because I did this maths afterwards)

Country	Sex	Mean	5th%ile	95th%ile
UK	m	152.4	124.9	180.0
	f	139.9	118.2	161.6



I also did some tolerance testing (Left) on the acrylic I planned to use. I found that I needed an offset of +0.1 on each side (see above) to achieve the best balance between fitting tightly and being easy to use. Unfortunately, the fit was unreliable since there was an angle to the kerf, this can't be fixed with the equipment at school (without sanding each piece individually: an impractical idea) so I will have to just make do with what I've got.

Below are 2 prototypes testing the shape of the pieces to make sure they fit together. The left one is the one I showed to the focus group. The right one testing the new shape



Definition

The maximum distance between the square edges of a wedge, which the thumb and little finger can grip.

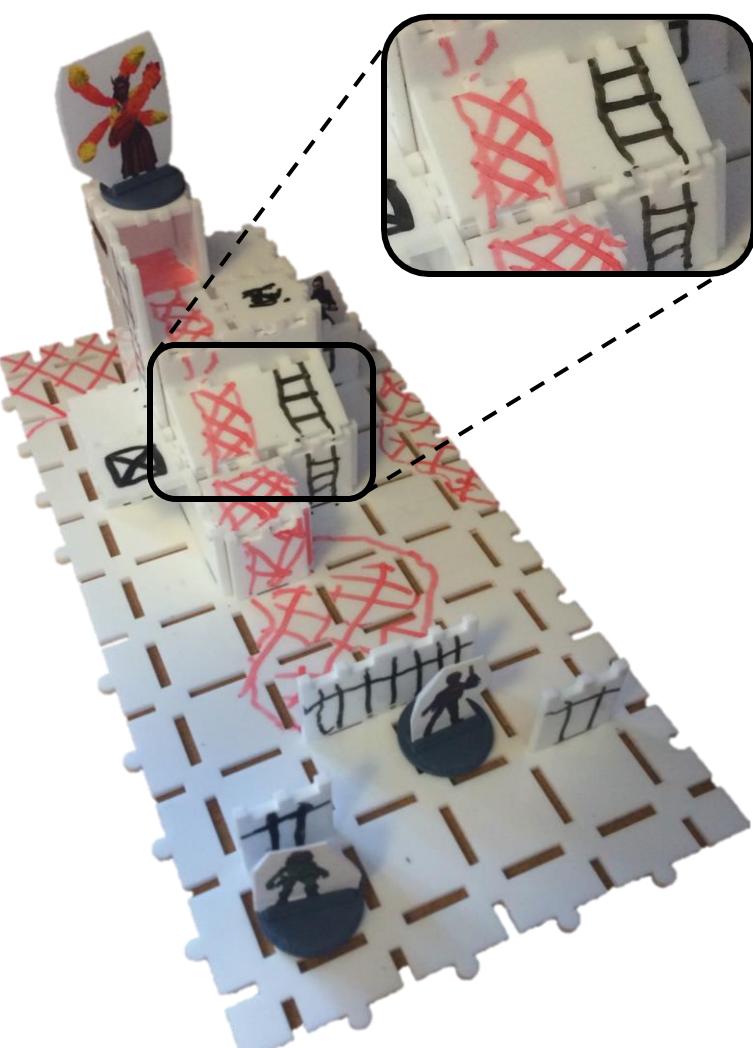


Unfortunately, many of the dimensions must be based around inches since D&D is an American game, so the standard grid (that must be kept to so normal scale miniatures can be used) is based around 1-inch squares. This is to a scale of 1in:5ft

Final Prototype

This final prototype (Below) proves the idea perfectly! It has put to rest most of the worries that I've previously had. I have found it's often possible to use pieces in unintended ways to create more complex structures (Focus Below) For example, having wall pieces angled by resting them on others. I also showed the focus group the latest version, and the response was overwhelmingly positive. Despite all these successes, there are still several important takeaways and ideas to think about:

1. Adjust tolerance: The pieces were slightly too tight so I will reduce the tolerance adjustment to +0.09mm (I'm slightly worried that this won't be enough, but in testing, +0.08mm was too loose, I may need to do more detailed testing than the small pieces I did before)
 2. Base layer: everyone who I asked agreed that the wooden layer beneath the base pieces was unnecessary. So I will remove that and replace it with a layer of fabric or felt (If necessary) so it doesn't scratch tables. If it won't scratch, I may not have the felt because it's really nice to have the simplicity of only the acrylic. (My clients agreed with this.)
 3. Number of pieces: This is going to be mainly determined by the size of the material I'm cutting, but I will need to figure out how big a set should be. Based on my conversation with the focus group: a starter set could be only about as big as the prototype I've already made, but I'm thinking about something slightly bigger: likely whatever fits on a 600x400mm sheet of acrylic. Because that is a stock size that best fits in the laser cutter. (see Bottom Right for detail)

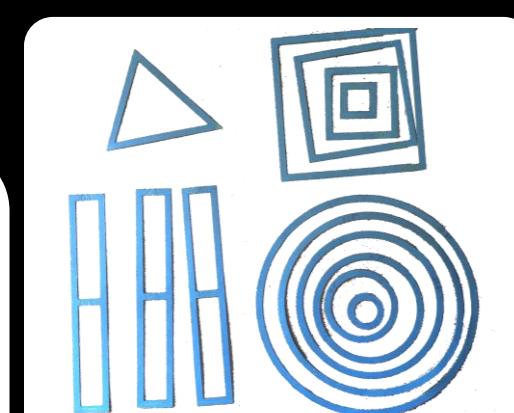


Shareware

The Decals, miniatures and risers could all be used as shareware (on a dedicated website made specifically for these things, or something preexisting like thingiverse) i.e. The 3D-models and images can be shared for anyone to use (under a variety of possible licenses: From *creative commons* to *free for personal use to all rights reserved*)

Making the final cut file

The file (Below & for the prototype) was made in Techsoft's 2D design. The process of converting from the models on the last slide to this was to take measurements and to recreate it (Before creating a graphical contour around it to account for the width of the laser); I couldn't find a way to export from Autodesk Inventor, This is something I could investigate.



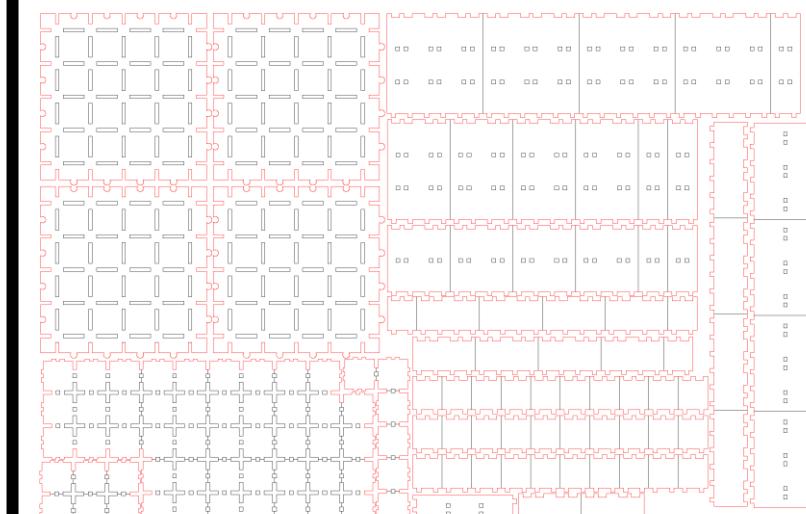
These are made of card and so aren't very durable. This makes them ineffective products. Also, you need to have many different types of them to account for the many different types of measurement you need to make. To fix this I could try to make a single multipurpose one that can be used to measure everything; out of a material that is more durable while still retaining a low cost. (*Also these are effectively 2D replicas of the 3D-printed ones I found during research so it would be good to have it a little.*)

Distance reference

Cheap Miniatures

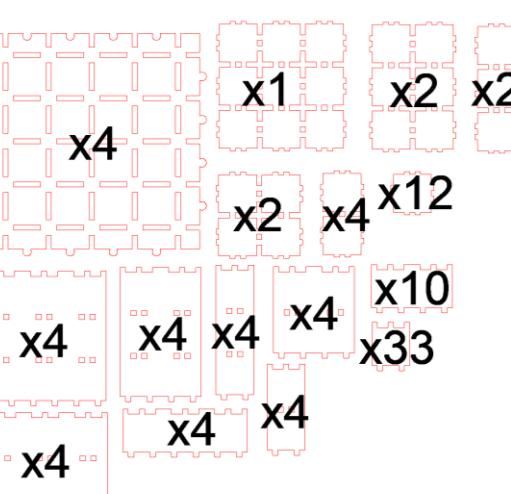


While cutting the prototype, I designed this 3d-printed miniature stand where paper (with an image of the character on it) can be slotted into it, allowing it to be cheap. Currently they are too big to fit on the grid as the base is too wide to fit between walls. This will need to be changed for version two. Additionally: I could make a version for general props instead of just characters (that takes up a smaller space)



The Cut file

The image to the left shows a cut file in two colours, in reality those will be cut as two separate files to make it more efficient and more accurate when cutting. The black (inside) pieces will be cut first, then the red. This means that pieces won't fall out or move before the inside is cut. Both files can then be ordered by the laser cutting software. This won't result in a perfectly efficient order, but it is the best trade-off between effort and time. The file has been nested to minimise waste and double lines between pieces removed because they are unnecessary. In order to ensure a perfectly aligned cut, the material should be taped down, and the cut head should be set to return to start position, so the second job can be placed in *exactly* the same place as the first. In ordering the cuts, it should mean there is less risk of the workpiece shifting, but it is better to be safe than sorry.



Risers

This is the first test version of a riser, and it has basically worked. There are a couple of changes to make though.

Firstly: I need to change the seam position to random, so you get a more uniform finish on the outside of the cylinder. Secondly, I couldn't get all the supports out of the middle segment, so I should raise the roof of the hole a little higher (1-2mm) so it doesn't matter if there is still a layer or two stuck inside. Finally, as it is, this will only hold miniatures currently, but if I was to decree the height of the base piece by 3mm, it could also hold parts of the main grid up as well. While keeping it on the same level as the rest of the grid.



Part List

I think these numbers of each piece provides a good balance between variety in what you can make, and not having too many pieces that you won't use. Having 4 of each larger wall type allows you to make squares out of them, and the smaller the wall the more you should need. The 600x400mm stock form is perfect as it allows for about twice as many base pieces, and a suitable number of pieces to go on them; and also fits in the laser cutter.

04x Wall(3x3)	01x Floor(3x3)
04x Wall(2x3)	02x Floor(2x3)
04x Wall(1x3)	02x Floor(2x2)
04x Wall(3x2)	02x Floor(1x3)
04x Wall(2x2)	04x Floor(1x2)
02x Wall(1x2)	12x Floor(1x1)
04x Wall(3x1)	
10x Wall(2x1)	04x Base
33x Wall(1x1)	

Manufacturing Process

The parts highlighted in red show points of quality control/assurance.
The Green points to the right are health and safety

3D-Printer
Don't touch the nozzle or bed because they are hot.
Make sure nothing gets trapped in the mechanisms.

Laser Cutter
Don't open lid (despite the automatic E-stop)
Don't stare at the laser.

After Laser Cutting
Make sure you wait until all the fumes have been extracted
Watch for sharp edges (there shouldn't be any, but just in case)

The Grid

Pre-Manufacturing

Test Laser-cutter

- Find best cutting speed for acrylic
- (Iterate over different speeds)

Buy acrylic:

- 3mm-White
- 1-sheet (600x400) per set
- Visual check to see if it looks flat

Miniatures & Risers

Pre-Manufacturing

Check thickness of acrylic

- Measure with calliper at several points in the sheet

Manufacturing

Tape onto laser-cutter base

- Ensure edges are square
- Ensure it wont move

Load file into 2D

- Check ordering
- Check Tolerance Adjustment

Manufacturing

Distance reference

Pre-Manufacturing

Test Laser-cutter

- Find best cutting & engraving speed for card

Manufacturing

Export to Trotec

- Check Base Size
- Turn off Quick Print/Auto name
- Set material to 3mm acrylic

Test cutting

- Small triangle in the corner
- Ensure it cuts through

Set laser height

- 30mm (Use Physical measure not rule: reduces chance of random error)
- Average height over sheet

Check Cutter

- Check/Clean lenses
- Make sure bed is level/secure

Set laser height

- 30mm (Use Physical measure not rule: reduces chance of random error)
- Average over whole sheet

Check Cutter

- Check/Clean lenses
- Make sure bed is level/secure
- Tape if needed

Start Cut

- Keep an eye on it in case something goes wrong e.g. the material shifts.

Take out the workpiece

[Peel off protective layer]

- Commercially, this step would be done before cutting because a commercial laser cutter wouldn't have the problems of fumes staining the material.

Test assembly:

- Use test piece
- Shake a bit to make sure it isn't too loose

Box

(I don't have time to design or make this, but this is what I would do)

Pre-Manufacturing

Test Laser-cutter

- Find best cutting & engraving speed for 3-mm MDF

Manufacturing

A justification

Throughout this project, almost all manufacturing (except for early prototype models) has been done using CAD CAM, either 3D-printing or Laser cutting. Although it could be questions as to whether this is necessary, I would say it absolutely is, for a variety of reasons. The main [n] are:

- **Precision:** The use of CAD CAM allows parts to be made to very tight tolerances. This is important for each part of my project because the grid, miniatures and risers must slot together in the best way possible the only way to do this is to use tight tolerances.
- **Complex shapes:** The only way to get the complex shapes required for the grid, miniatures, risers and (to a degree) the distance references is to use CAD CAM because they would not be at all easy to cut using another tool. Though it would be possible, there is no way you would get the required precision required, as said above.
- **Repetition:** By using CAD CAM it ensures every time a part is made, it will be the same as the others, this repeatable accuracy allows it to be done commercially far more easily than if it was done manually.
- **Cost:** this is the primary factor. Because the product needs to be low cost to fit to the specifications CAD CAM is the most effective way to accommodate this. For the distance references it makes the manufacturing time a matter of minutes because the material is card and so engraves and cuts incredibly fast. For the grid and 3D-printed parts, it makes the manufacturing require little manual labour and far quicker, and therefore low cost commercially. On the left you can see my attempt to make a piece by hand using a fret saw. This is clearly far too inaccurate, and it took far too long to make compared to the speed of laser cutting. Additionally, this is one of the simplest pieces, so proves the impracticality of cutting all the pieces manually.

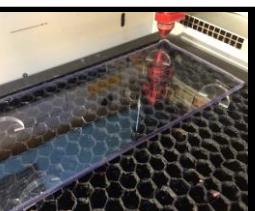
Finish

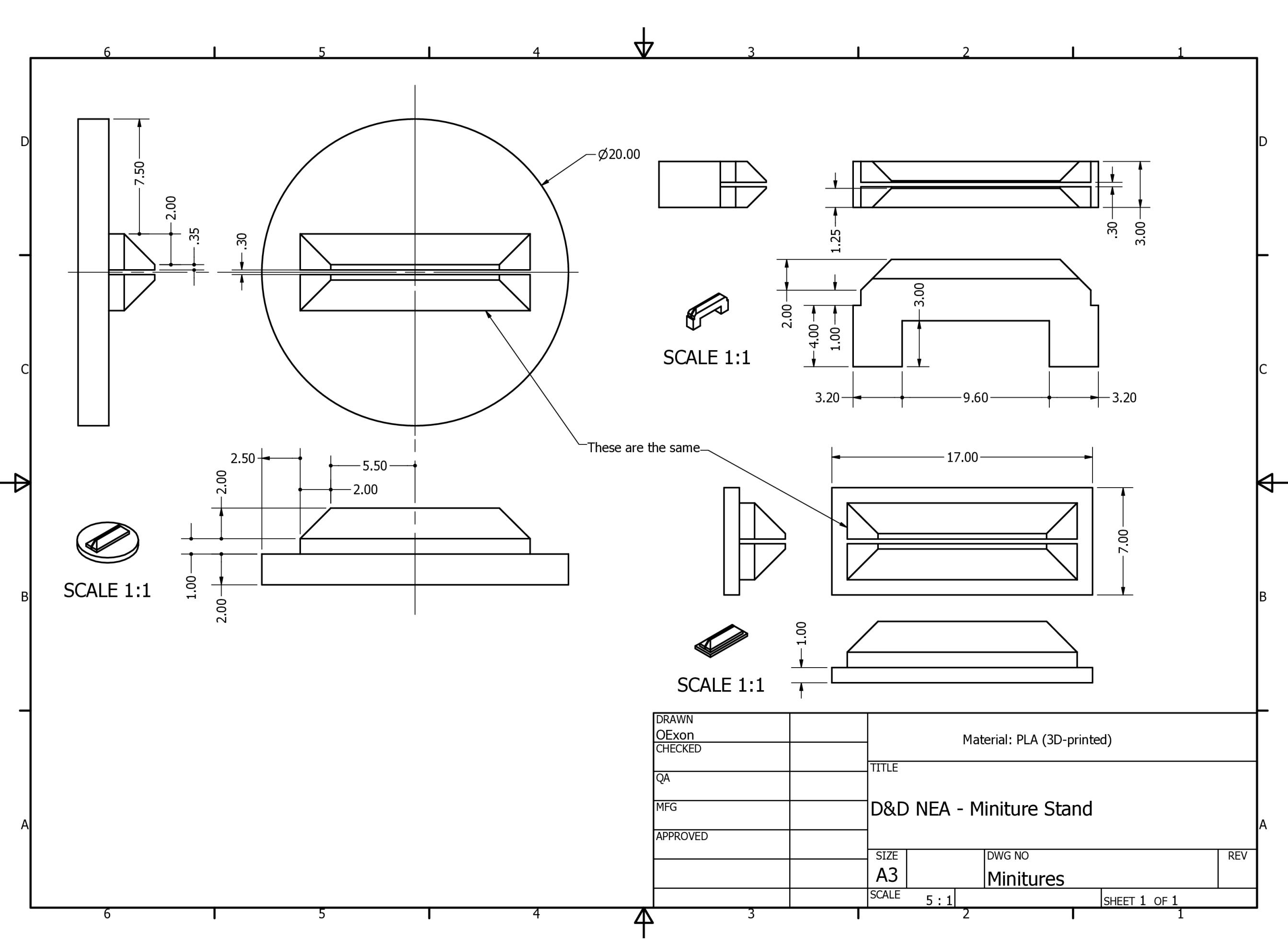
- Stain using a cloth to leave a slightly rustic look to it.

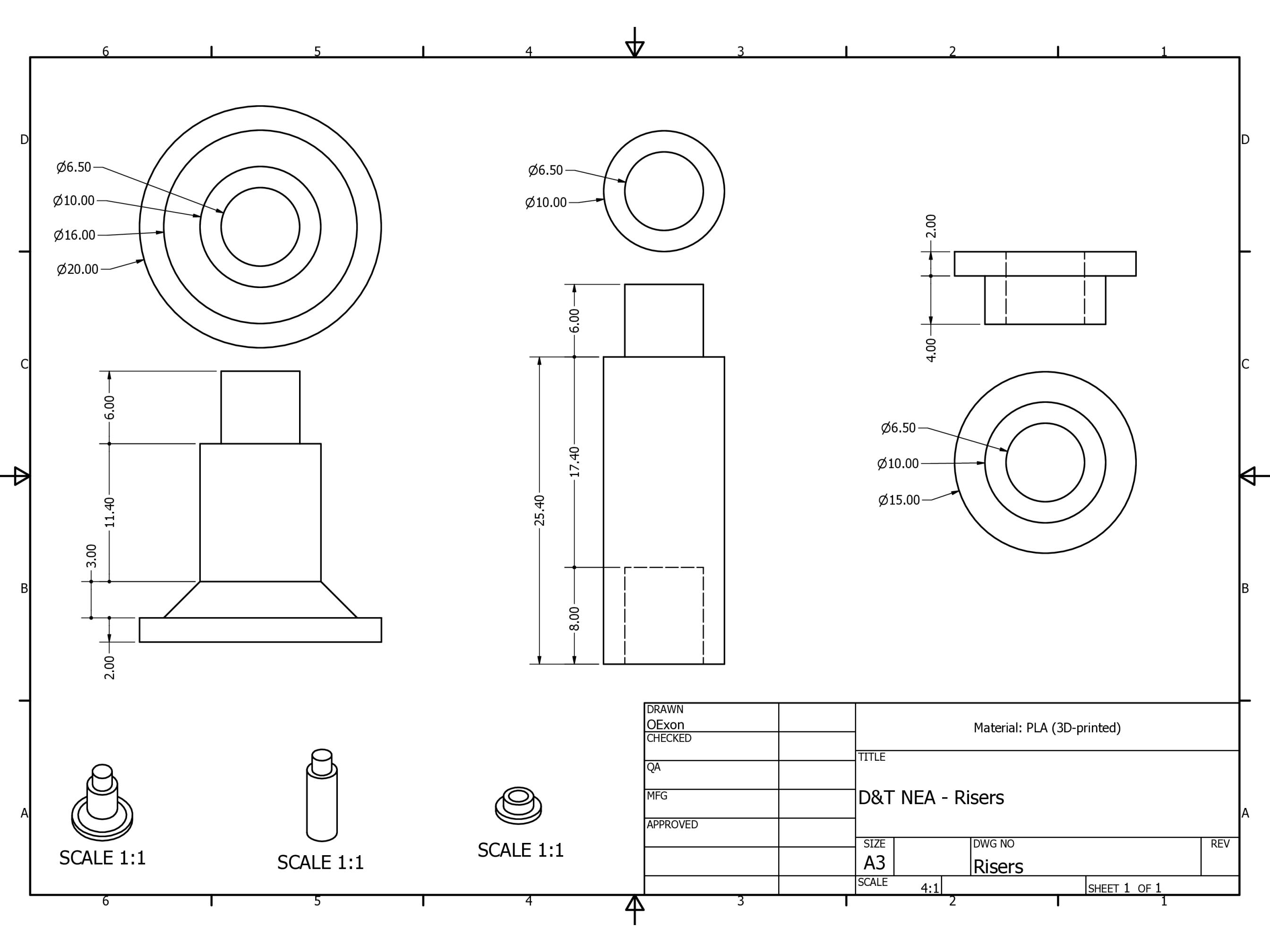
Insert

- Add of foam insert to allow pieces to be placed safely

I was considering using some acrylic shapes to raise up the acrylic to reduce the effect of burn marks on the back of the acrylic. This wouldn't be a problem commercially and is actually impractical for this because there is a chance pieces could flex before being fully cut out, resulting in inaccurate cutting. But it was an interesting idea to consider and test.







Final Evaluation & commercial manufacturing

Overall, I am very pleased with the result. This feels not just like a viable product but one with real promise both for social good and theoretically profitable. There are several problems and talking points as detailed on this slide and the next. These are things I would look at if I were to continue this project, even up to a commercial level.

Distance Reference: After several attempts to cut, this is the newest version of the ruler. At the moment it feels like it could be too long to be practical but at the scale it is, the multiple of 100 means it will fit on most grids, and if you need it to be longer, it makes the adding up very easy. The small tabs at the end, allow you to hold it 60-degrees: the angle required for a cone.



Acrylic or..?: 3mm Cast Acrylic can be a problematic material. This is for a variety of reasons: the main 2 being its brittleness and its variation in thickness. It snaps quite easily causing sharp edges and an unsatisfactory experience. And the precision of the pieces is limited because it can vary in thickness by a good $\pm 0.7\text{mm}$. This not only affects the pieces directly, but also means there is a chance it won't cut well (as was experienced in the cut above) Ideally, an alternative would have some natural elasticity to it will temporarily deform while being used. But the most important thing is it must still work as a whiteboard.

Tolerance Adjustment:

Many of the pieces were too tight, this could be for a variety of reasons, including slightly thicker material or similar. But overall, I think it is better to be looser than tighter as it's easier to put up with something that is slightly precarious than something that breaks when you disassemble it. Causing safety concerns. To aid this I can slow the laser even more and reduce the offset down to $+0.8\text{mm}$ on each side



Laser Cutter:

When cutting, not all pieces were cut through entirely so some had to be broken out (not helping with the tightness or sharpness) So I would slow down the laser cutter. This was likely caused by variation in the thickness of acrylic.



Miniature Riser

I am really pleased with these. I actually had the opportunity to test it in a game myself and it worked perfectly. The DM had some flying monsters that could make use of the risers. The fit is slightly tighter than before (because of the randomised seams) but that is a good thing. It is even quite stable at tall heights I found up to about 10 pieces tall (50 in-game feet) was workable. I could make an alternate version of the base that is wider and heavier to allow for even greater heights. And/or one that joins to the grid directly. Also, currently you need to stick the miniatures on with Blu Tack. I could try adding a version of the top piece with a square on top (this could also be used with larger squares for floating magic platforms and the like.) This would also mean if you want to hold the grid, you can use the top that already exists. But that if you want to use miniatures you can keep them on the 5ft grid by raising them another 3mm

Cheap Miniatures

After changing the base size, the character miniature has turned out well. And you don't need to necessarily print out something but could also use a quick drawing or sketch (As shown by my artistic stick-man) The prop miniature has also worked well. The white filament fits in with the grid better but is notoriously unreliable so I could use a different colour commercially.

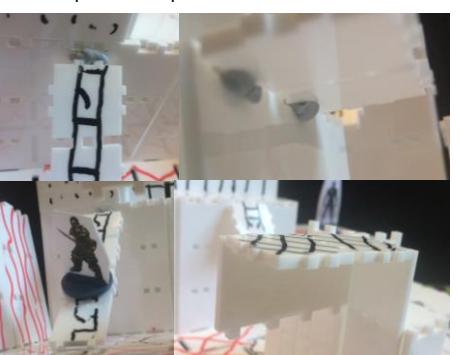


Commercial Adjustment:

If this was being made commercially, I would research other methods of cutting such as water-jet or cutting using a tap/die. This is because they could be better than laser-cutting. In regards to precision other methods can be more precise, and regardless, a better machine than the one at school would be used because it would be much quicker and therefore cheaper. Also working at a commercial scale would mean cutting far more pieces at once, increasing efficiency. Possibly inducing only doing 1 type at a time, and then counting them out into sets.

Blu Tack

As you can see in these images blu tack (or similar) can be used to hold pieces in place if you are making more complex unstable or overhanging structures, this can also be used to hold miniatures in place on tilted surfaces. Although, quite complex overhanging structures can be made even without it. Also, this can be used to create more off-grid elements. This is also aided by the new risers because they can be used to hold up the floor pieces.



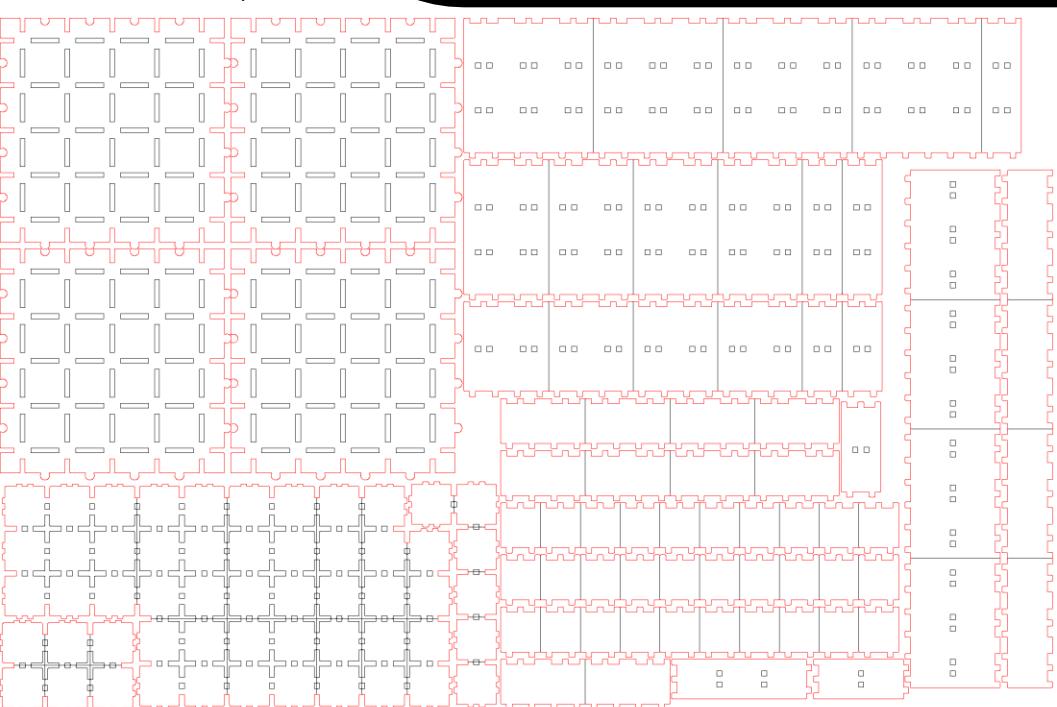
Corners

Currently the corners of the pieces are quite sharp, Causing some minor safety concerns. So I'm going to add a small ($1/2\text{mm}?$) bevel to exterior ones on the outside edge. This will also aid with the tight pieces. And, from the quick test I did, I suspect it could actually make the pieces look a little more professional because it has a look of intention to it. (Despite what I said before about aesthetics; I've changed my mind now I've tried it)



The Cut File

The old order was very inefficient, so I can manually redraw the cut file in the order I want it to be cut so it is more efficient and more accurate. This would replace the 2 separate cut files because I would redraw the inside first meaning it would be in the correct order by default. Additionally, some of the lines that were separate can be combined to avoid unneeded laser movement. Additionally, I have slightly changed the number of pieces to allow a little more freedom and consistency.



04x Base

04x Wall(3x3)

04x Wall(2x3)

04x Wall(1x3)

04x Wall(3x2)

04x Wall(2x2)

04x Wall(1x2)

04x Wall(3x1)

10x Wall(2x1)

30x Wall(1x1)

01x Floor(3x3)

02x Floor(2x3)

02x Floor(2x2)

02x Floor(1x3)

04x Floor(1x2)

12x Floor(1x1)

Compared to the Specs & Drawings (Not to Scale)

Aesthetics:

Because you are creating the environment that the characters are in it fits automatically fit the theme to a degree. This is aided by the whiteboard functionality. Acrylic is not the most attractive material, but the whiteboard-ability outweighs that. Alongside the use of the prop stand and because it is such a blank slate, any kind of theme is possible. Because of this, the Aesthetics specification is *fully* fulfilled.

Cost:

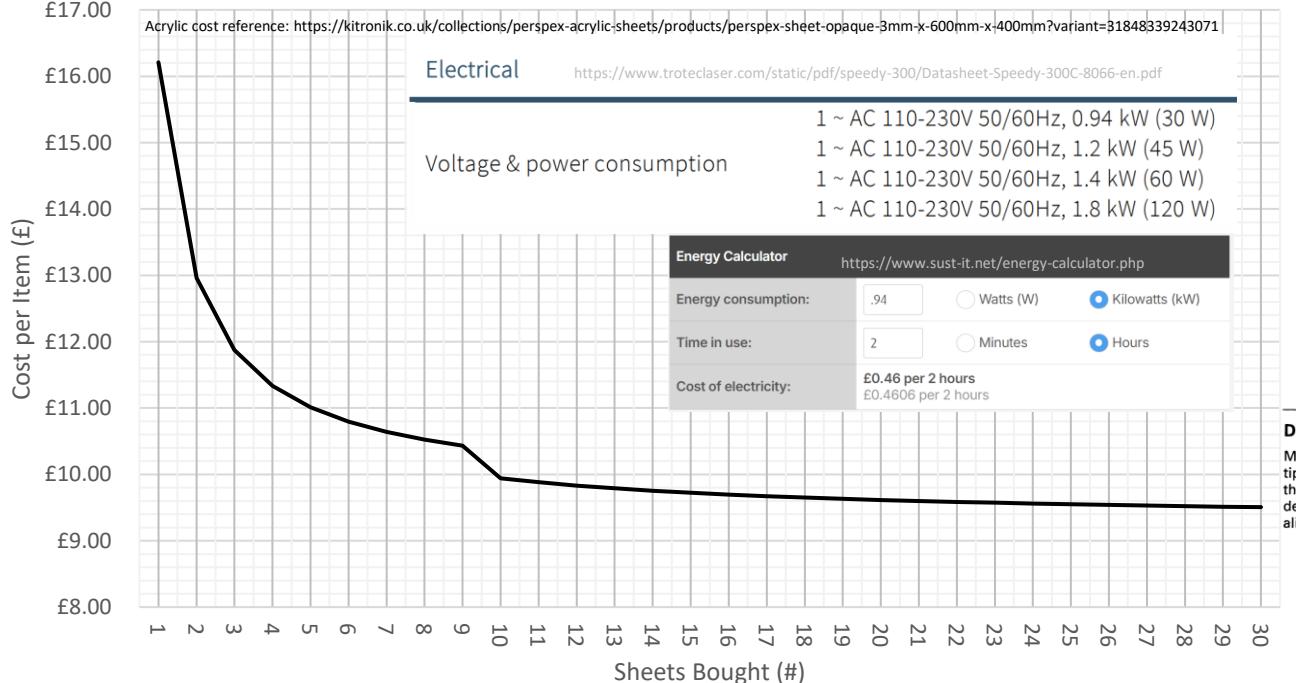
This is a real positive point for this project. In using CAD/CAM manufacturing it reduces the cost significantly because of speed and low labour. A £9.24 (or less) sheet of acrylic is used for the entire file on the right. The machining cost would vary depending on the method of cutting. But it should be low because of speed. (And commercially: because you can benefit from economies of scale) Because of these, the Cost point is *fully* fulfilled beyond my initial expectation.

Function:

The grid miniatures and risers provide a way to visualise the game world. And the distance reference and risers aid in remembering (and following the rules) by making something mathematical become visual. The Distance reference particularly aiding the DM. All of this means the specification point is *fully* fulfilled.

As can be seen with this graph the cost of making decrease as you buy more sheets (Jumping down slightly at 10, because kitronic reduce the cost per sheet after that point.) And the cost is low enough (even at its highest) to be sold for a good price while still generating profit. By manufacturing commercially, the cost per item would decrease even further. Also, the cost of laser cutting (at least on the school's cutter) is shown at the top right of the graph.

Cost per item by sheets bought



Ergonomics:

The size of the base means it can be picked up from the side, allowing it to be moved with relative ease. The rounded corners make everything more comfortable to hold. And all the other pieces are small enough to be easy to hold. All of this means Ergonomics are *fully* fulfilled.

Materials/Components & Sustainability:

With acrylic, it is long lasting and, because of the modular nature of the product, the fact it is non-sustainable is less important. It is also easy to clean, and the white board wipes off even if left for over a week. If I was to look into a different material, ideally it would be sustainable and slightly flexible but other than that have the same properties as acrylic. Overall, I would still say this *fully* fulfils the specification point.

Safety:

This is the only concern with acrylic, if it snaps it leaves sharp edges. This would be a perfect evaluation if not for this. With acrylic: *Mostly* fulfilled (Because of a lack of mechanical components etc.) With the theoretical material mentioned above: Fully fulfilled.

User:

Allowing the base to change in size avoids tying the product to one specific group size. This means it can be used by any size group in any size world. So, it *fully* fulfills the specification.

Working Out the Cost

Doing some ergonomics calculations (based on UK data) it should be easy for anyone (down to the female 5th%ile) to carry up to a 3x3 grid of base pieces. (With only 40mm overhanging) There is a reasonable chance that you could be using a bigger grid (I would guess an average at 4x4) but this means that for less complex encounters they can be carried easily.

When innovation isn't needed:

Throughout this project, there has been a worry that there is too little innovation in the ideas I've had and the things I've done. There have been points where I've thought about the use of smart materials, auxetic materials, complex mechanical mechanisms, microcontrollers and more. But since picking the modular grid as the idea to follow up on, all those things have been not just unnecessary, but from my perspective would actually decrease the quality of the product. Because there is beauty and ease-of-use in its simplicity. It's one of the many reasons the 3D-printed version of the grid wouldn't have worked: it's too complex. Alongside the other variations on a combat grid. And it's also why I didn't continue following up on the fabric walls idea.

Initial Expectations

At the beginning, I was certain the table would come out on top in the evaluation, it was my personal favourite at the point because I believed it had the most flexibility and I could develop to the most depth. Overall, I'm glad they didn't because I've ended up with a product suitable for a much wider market. And one that (in hindsight) is much more fun. The three I made models of at the start where the 3 I considered most promising at the time, and I was quickly proved wrong. The small laser cut test of the modular grid was made only after the evaluation to show to the focus group.

Forearm	mean	sd	5th%ile	95th%ile
m	477	21.3	442	512.1
f	431.1	21.2	396.3	465.9

All Dimensions in mm

Arm Width	mean	sd	5th%ile	95th%ile
m	73.3	3.9	66.9	79.7
f	64.1	3.6	58.2	70.1

Width of Base

127

Difference	mean	sd	5th%ile	95th%ile
m	403.7	25.2	362.3	445.2
f	367	24.8	326.2	407.7

Numer of base pieces that can be carried	5th%ile	Mean	95%ile
m	2.9	3.2	3.5
f	2.6	2.9	3.2

(All round up to 3 or more)

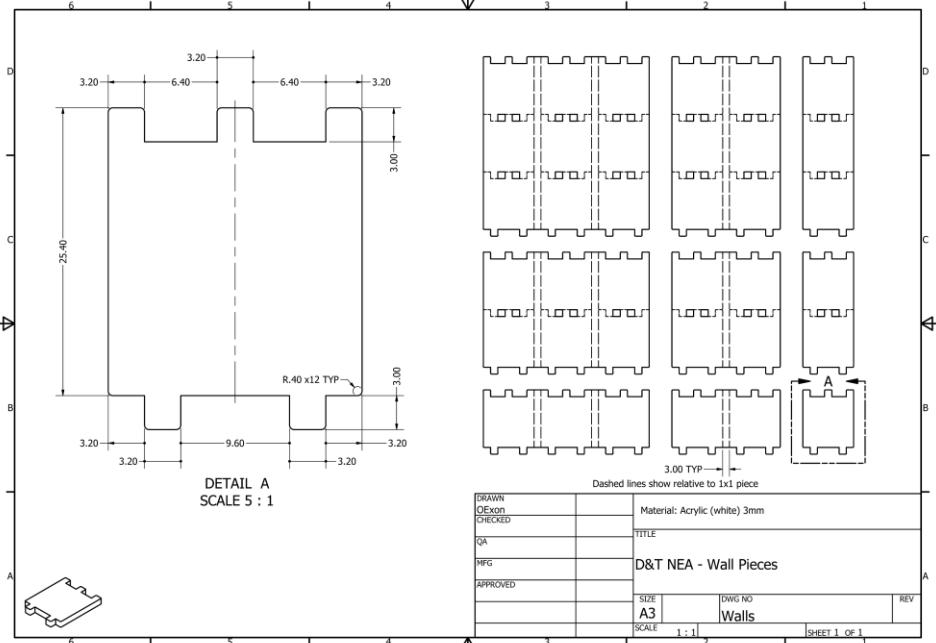
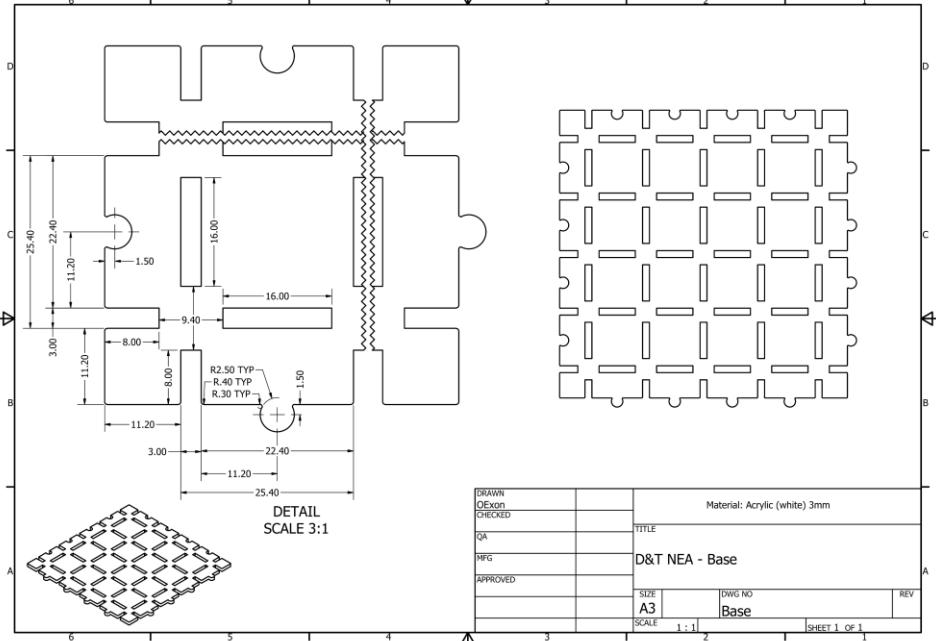
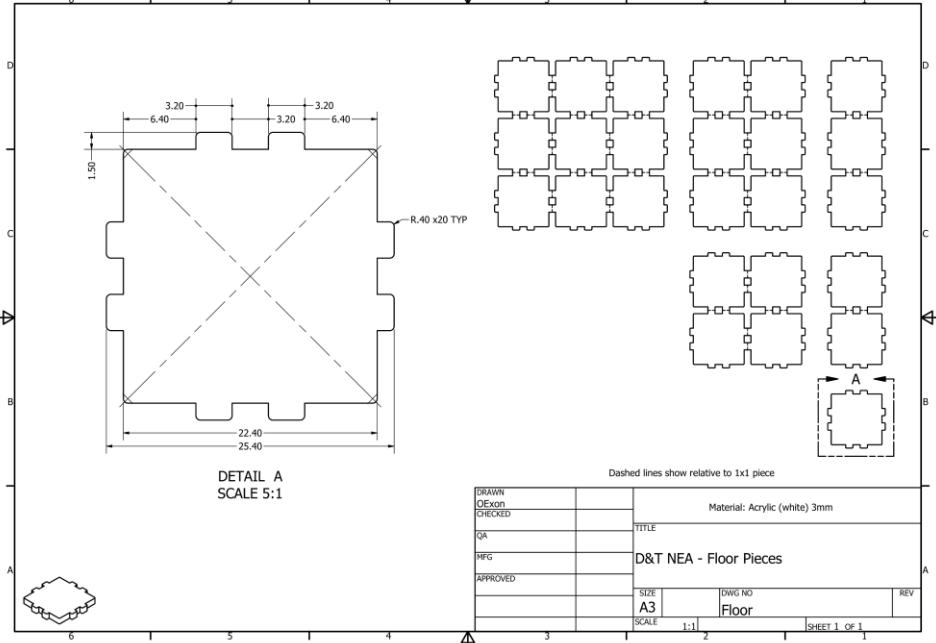
Carrying the grid

Doing some ergonomics calculations (based on UK data) it should be easy for anyone (down to the female 5th%ile) to carry up to a 3x3 grid of base pieces. (With only 40mm overhanging) There is a reasonable chance that you could be using a bigger grid (I would guess an average at 4x4) but this means that for less complex encounters they can be carried easily.

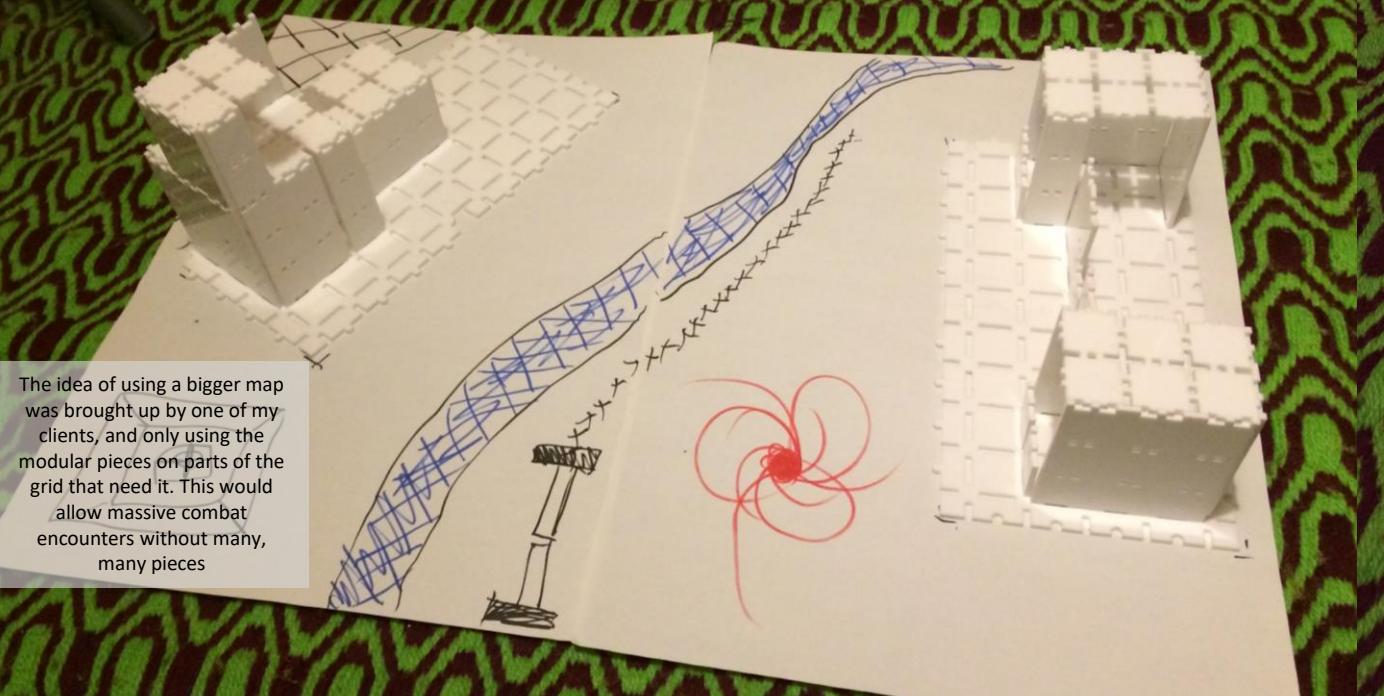
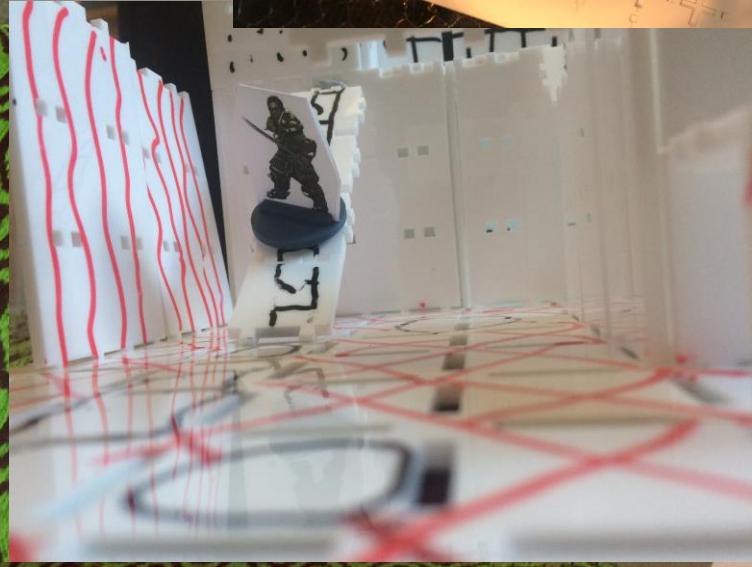
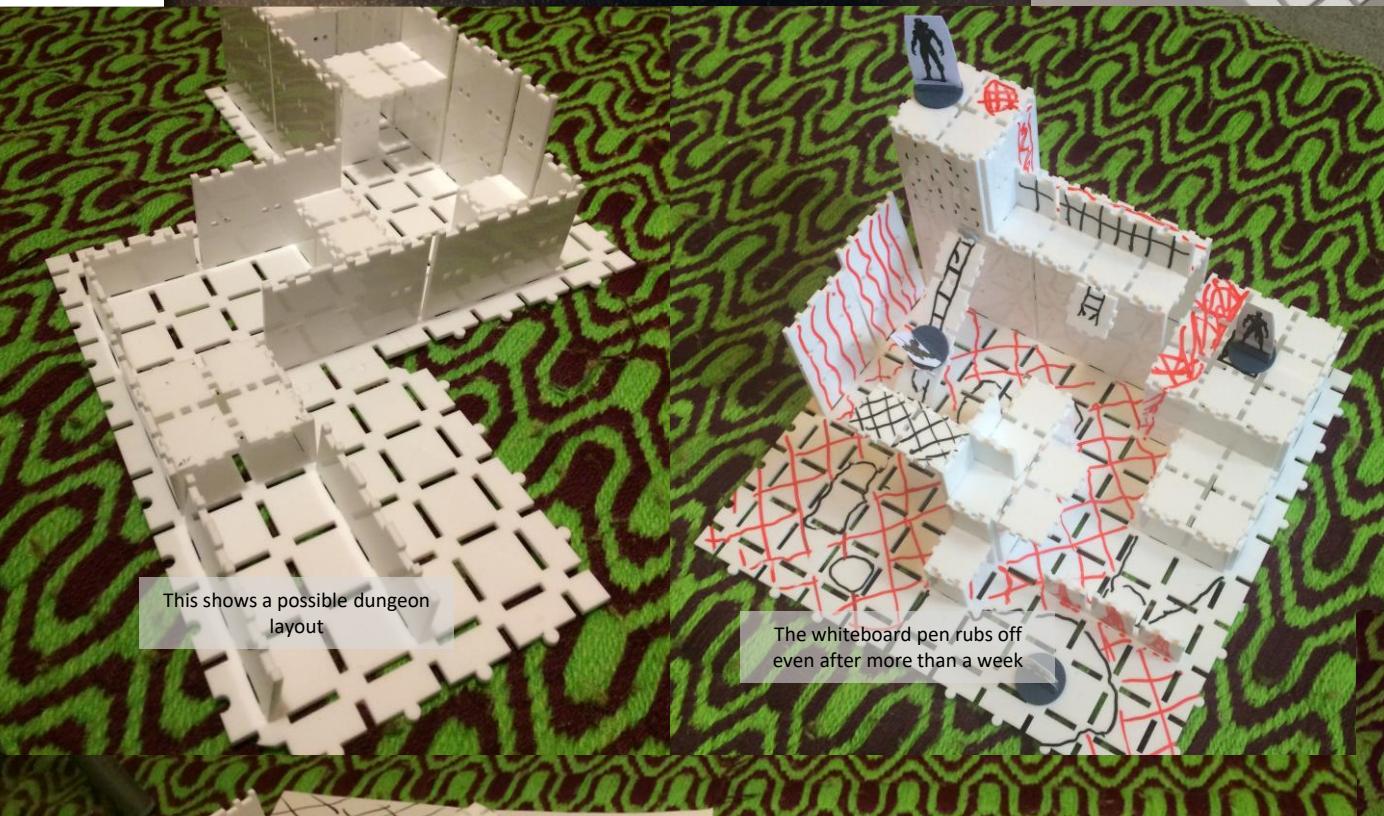
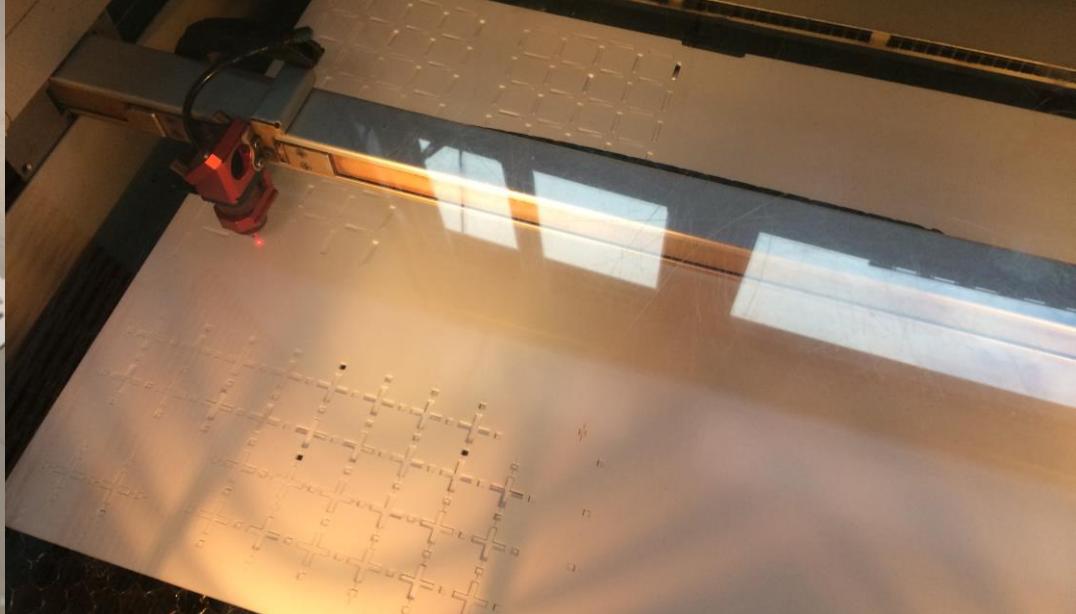
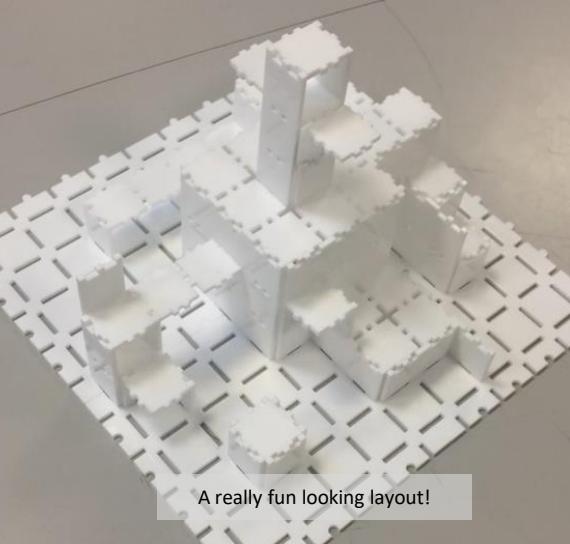
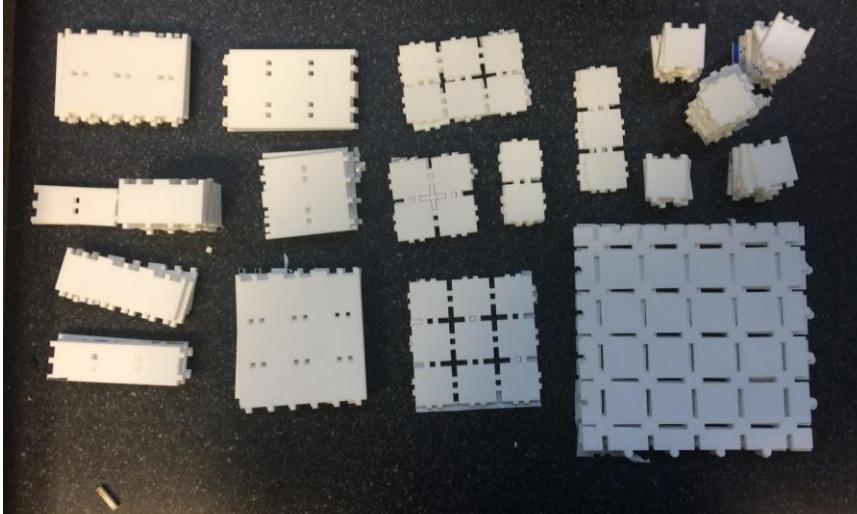


Definition

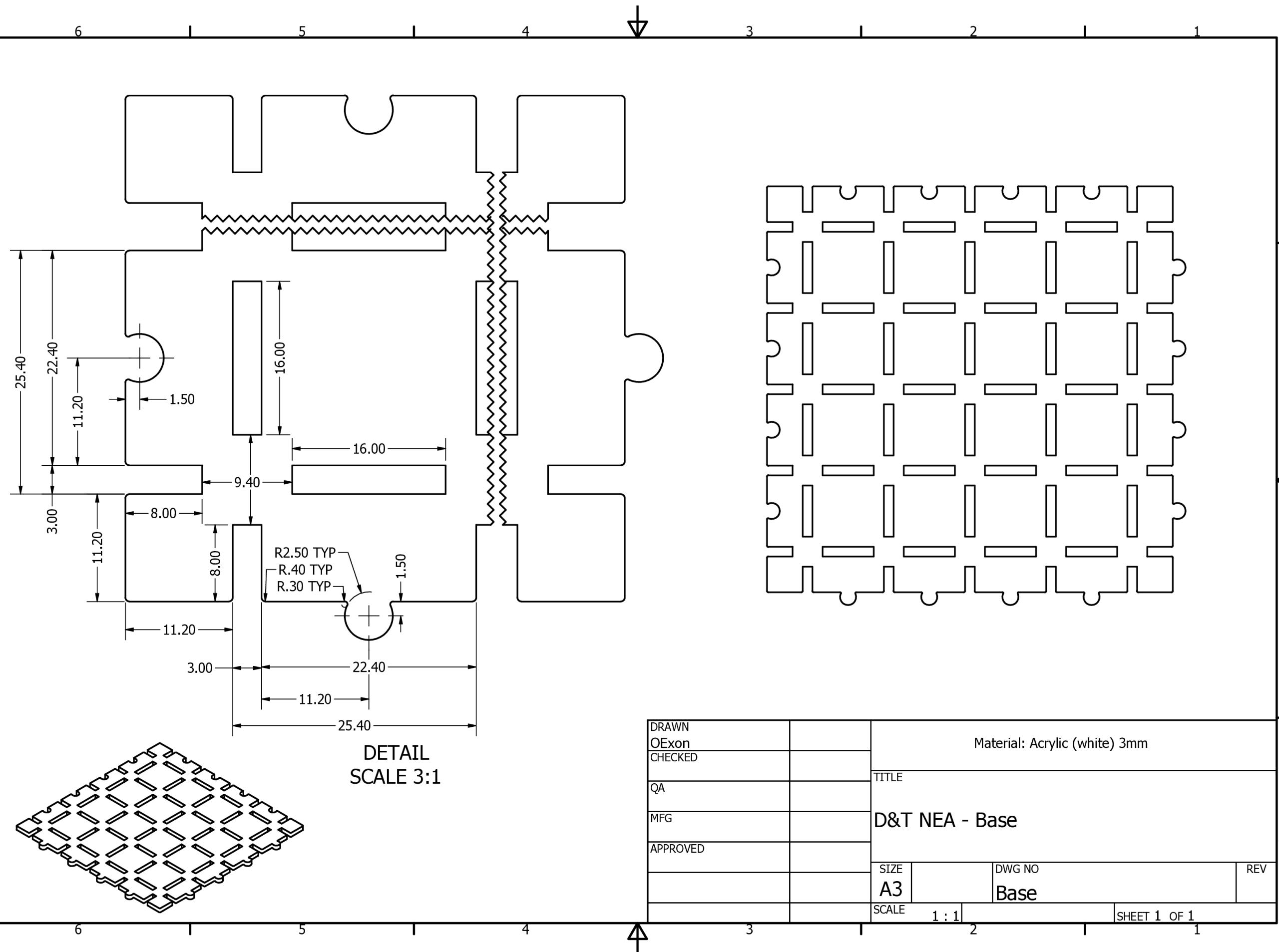
Measured from the back of the elbow (olecranon) to the tip of the middle finger. The person sits or stands, with the upper arm vertical and the elbow flexed to 90 degrees. The hand and fingers are held straight and in alignment with the forearm.



Gallery



This risers can just about stand at this height



6 5 4 3 2 1

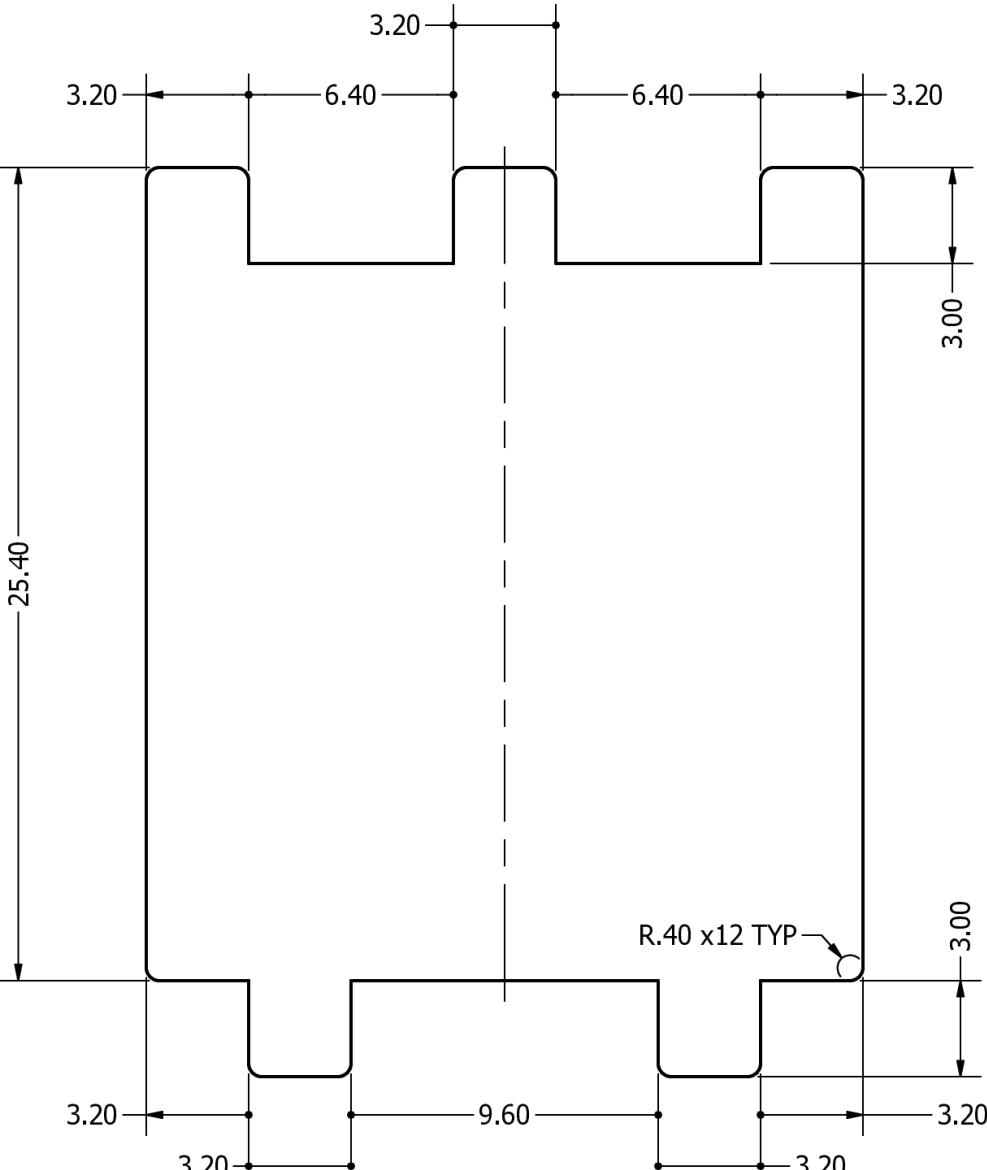
D D

C C

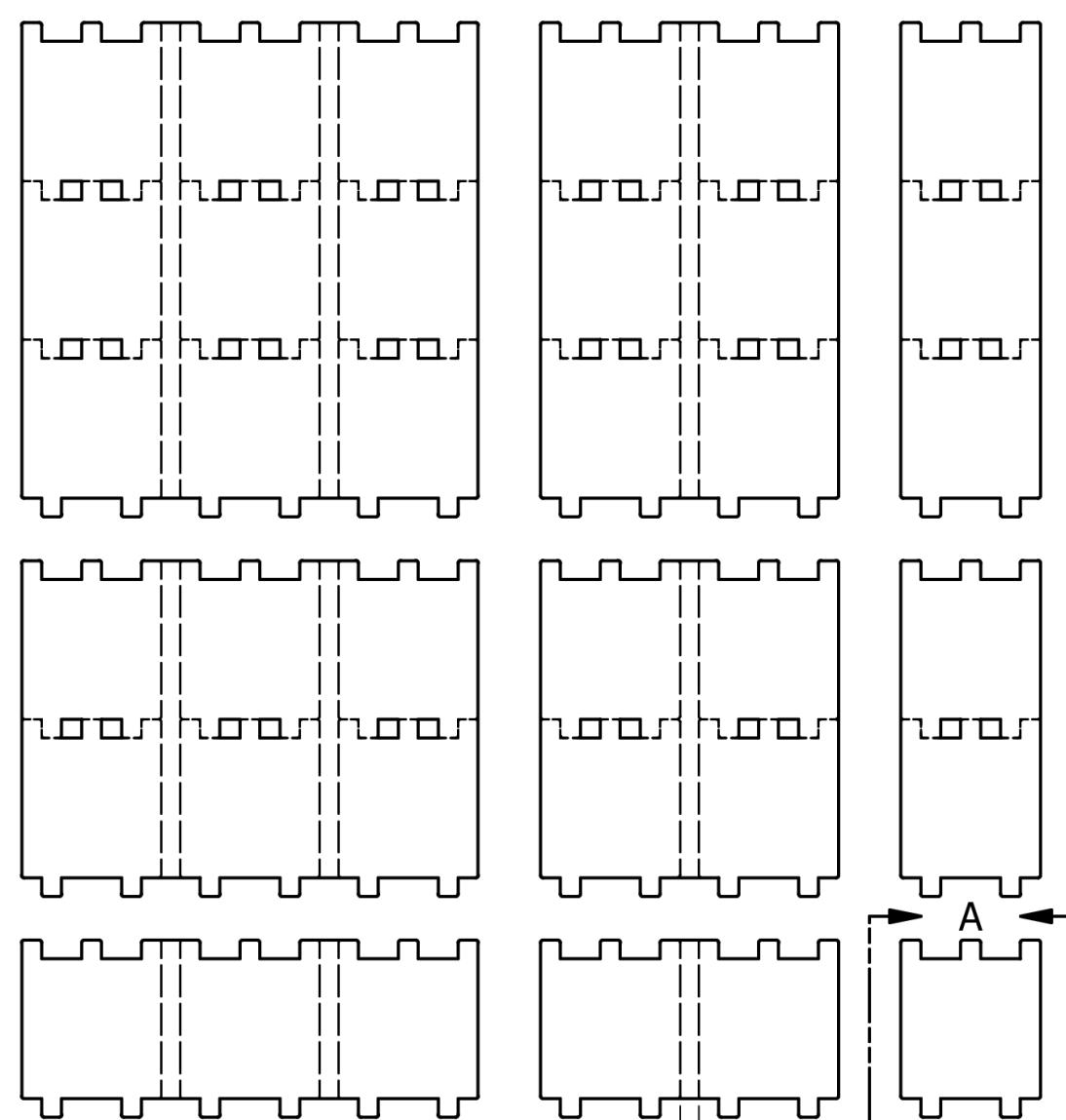
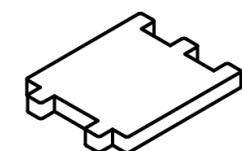
B B

A A

6 5 4 3 2 1

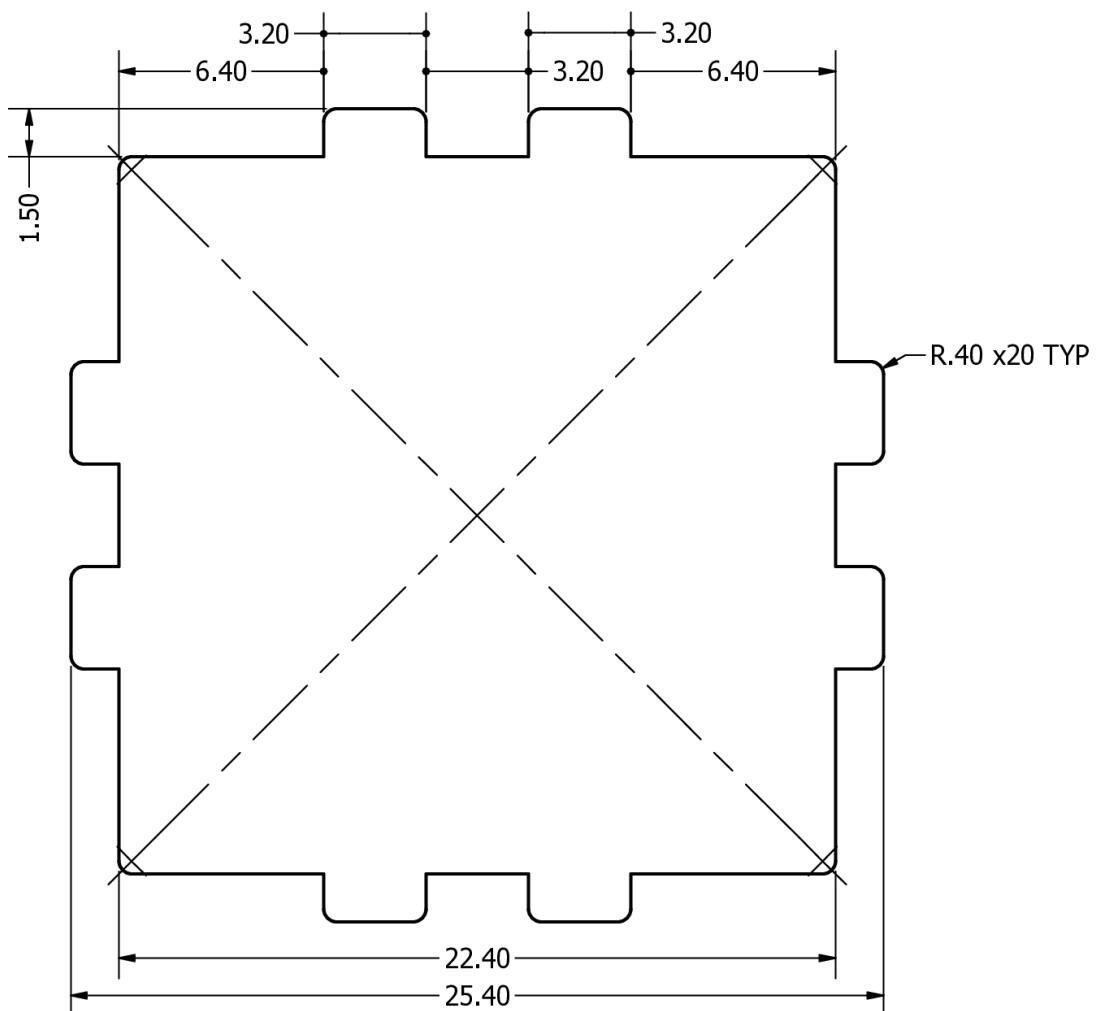


DETAIL A
SCALE 5 : 1

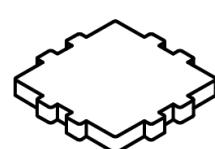


Dashed lines show relative to 1x1 piece

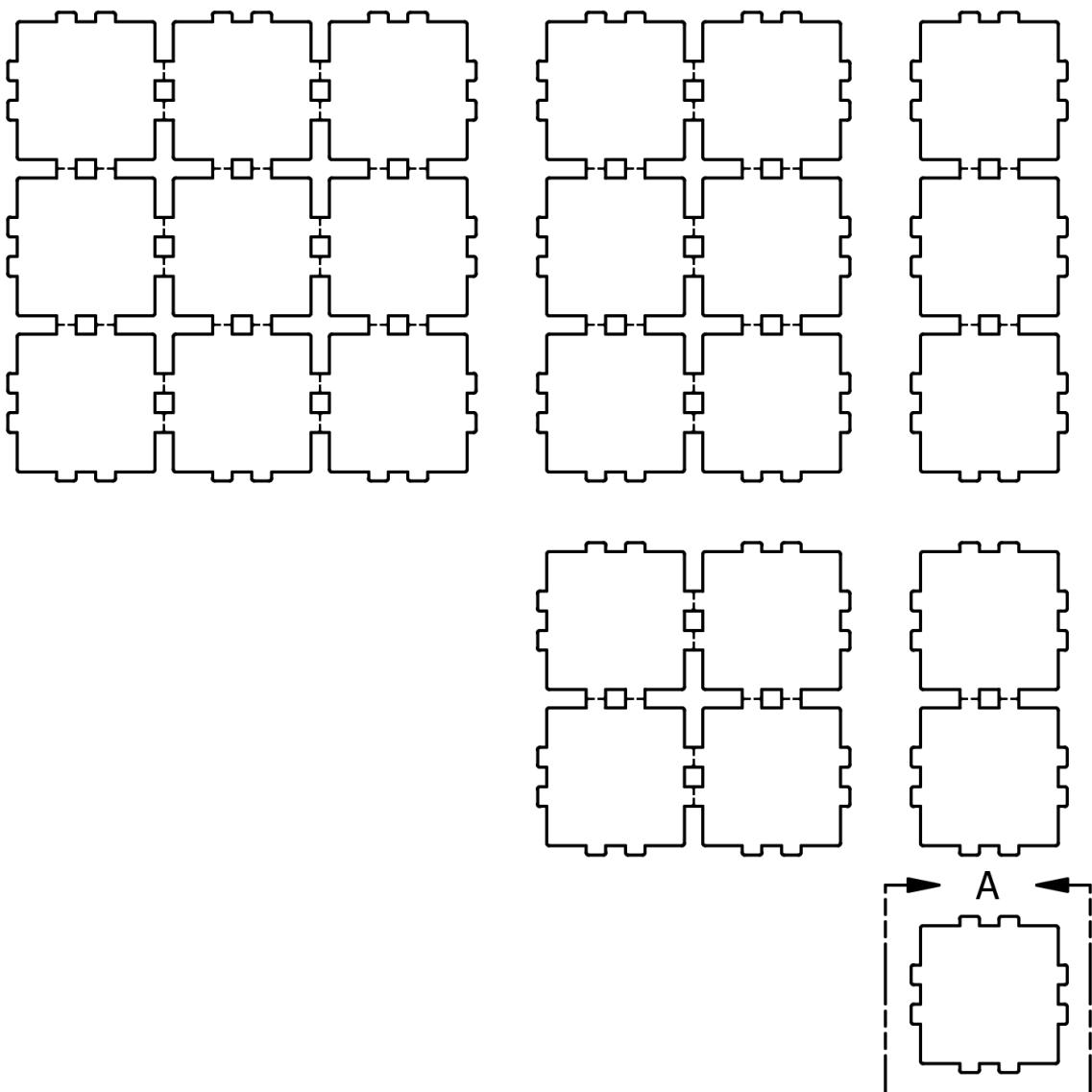
DRAWN	OExon		Material: Acrylic (white) 3mm
CHECKED			
QA			TITLE
MFG			D&T NEA - Wall Pieces
APPROVED			
	SIZE	DWG NO	REV
	A3	Walls	
	SCALE	1 : 1	
			SHEET 1 OF 1



DETAIL A
SCALE 5:1



Dashed lines show relative to 1x1 piece



DRAWN		Material: Acrylic (white) 3mm		
OExon				
CHECKED				
QA		TITLE		
MFG				
APPROVED		D&T NEA - Floor Pieces		
	SIZE A3	DWG NO Floor		REV
	SCALE 1:1			SHEET 1 OF 1