Discover Manufacturing

# Design Thinking

## FOR 3D PRINTING

Student Edition

eit Manufacturing

Funded by the European Union

# Discover Manufacturing

I-Form Advanced Manufacturing Research Centre

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# Introduction

Discover Manufacturing

Welcome to this **Design Thinking For 3D Printing** course. This course has been designed specifically to introduce you to using Design Thinking as a process for solving problems.

## What is Design Thinking?

*Design Thinking is an approach used globally by companies, educational institutions, innovators, organisations and communities to discover in-depth insights into the true needs of users for services and products. The world today is much more complex than it ever was and therefore different processes are needed to solve these more intricate problems. Design Thinking is an iterative process combined with a solution-based technique to solving problems. In addition - it can be adopted as a way of thinking and working through difficulties using a hands-on approach.*

Specifically, in this course we will be concentrating on using 3D printing to design and print a device to improve health for you or someone in your community.

Your teachers / facilitators will help you with this course and the **<3D Printing Health Challenge>**. There is a separate document explaining the Challenge in detail.

Also - look for the **<Tips & Tricks for 3D Printing>** document to help you with the technical aspects of 3D Printing.

## Notes

- Many of the Design Thinking steps may be revisited or even skipped depending on your project. It is a good idea to both revisit and reuse some of the tools for the different Design Thinking steps during the project.
- Many of the tools are interchangeable - it is advisable to read through all steps and familiarise yourself with the tools before beginning.
- Design Thinking is **always** user-centred, iterative and adaptive.

## Design Thinking Steps

STEP 1 **Empathise**

STEP 2 **Define**

STEP 3 **Ideate**

STEP 4 **Prototype**

STEP 5 **Test**

STEP 6 **Implement**

# Empathise STEP 1



**THE VERY FIRST THING** you will need to do even before beginning to learn about Design Thinking is to create a "Problem Statement" for the **<3D Printing Health Challenge>**. This will be the basis for the project and give your team goal to work towards. The user(s) should always be at the heart of your Problem Statement and any solution devised. You should steer away from solutions to problems that may not exist or a problem with a working solution already implemented. It's perfectly normal to want to jump straight to the building and prototyping stage as that can be the most interesting and fun. However - the process is more important than any final working product.

You should read through the questions in the box below. Try to answer them individually or with your team. Other types of questions and strategies to employ are **<5W+H>** - **<5x Why>** and the **<AEIOU>** tools.

After creating your Problem Statement, the next thing to do will be to "Define Success". The goal of this is to work together to achieve a consensus of what success actually is - taking your Problem Statement into account. Note that success is not just winning the competition!

## 3 types of Empathy

**COGNITIVE | EMOTIONAL | COMPASSIONATE**

- Cognitive empathy is also known as "perspective-taking" and is "empathy by thought", rather than by feeling. It is about seeing another person's perspective.
- Emotional empathy is when you quite literally feel the other person's emotions as if they were your own. Emotional empathy can be both good and bad as it can easily overwhelm your emotions.
- Compassionate empathy is what we usually understand by empathy: feeling someone's pain, and taking action to help. This type of empathy is usually the most appropriate for Design Thinking.

## Define the Problem Statement

**QUESTIONS TO ASK AND DISCUSS:**

- What is the problem?
- Why is it a problem?
- Who has the problem?
- Who has a need?
- When and where does the problem occur?
- Is it already being solved?
- Do you identify with any problems or needs?

After you have created the Problem Statement and achieved consensus of defining success - now you can move towards the first step in the Design Thinking process. As mentioned previously - the user(s) should always be at the heart of the Design Thinking process - so we begin with **Empathise**. You should empathise with the user(s) of your Problem Statement before looking directly at a solution. To do this, you will need to employ a number of strategies. You can develop empathy by observing, interviewing and immersing yourself in the Problem Statement and with your user(s). The first thing to do is measure your own empathy by taking this quiz - **<Empathy Quiz>**.

You can use tools such as the **<Empathy Interview>**, and the **<Empathy Map>** to do research, acquire data and gain insights into your user(s). It's important to conduct some research to develop an understanding of the end-users, their needs and what might best help them.

The aim of this step is to learn as much as possible about the needs of the potential user(s). These findings in turn will help you to sharpen the Problem Statement iteratively and come to a common understanding of the problem for your team.

# Define STEP 2



**THE SECOND STEP** in the Design Thinking process is to **Define**. In the first step, **Empathise**, you began to discover your user(s) needs after creating your Problem Statement and Defining Success.

Here - you need to specifically define the problem before moving to the next step of brainstorming ideas to solve it. Once you complete the **Define** step, you should be completely ready to tackle the next stage of the Design Thinking process - **Ideation.** This is where you will formulate ideas to solve the [now] well-defined problem. The **Define** step in the Design Thinking process is about sharpening and focusing the details of your teams' existing Problem Statement and Empathy research.

The first way to consider this step is to use the **"How might we..."** question. (see across) This will allow the user(s) identified needs to be simplified and defined even further. This step is generally very easy to navigate and quick to complete.

The second way for you to narrow choices is to tell a story of the user(s). Use the **<Storytelling>** tool to accomplish this. This is to further understand possible ways the user(s) interacts with the problem. After this stage, you'll be ready to move on the to the **Ideate** step. This is where you will brainstorm lots of ideas to solve your problem. Note that this is just the beginning of the define and design process and will almost certainly change before your final iteration - and certainly before any 3D printing begins!

## How might we...?

**THIS QUESTION IS SPECIFICALLY DESIGNED TO HELP YOU BEGIN TO THINK DIFFERENTLY.**

- **"How"** implies there may be more possible ways to solve your question.
- **"Might"** allows you a safe space to know that a potential idea may work and can be attempted.
- **"We"** reminds us you are working as a team, not individuals.
- The question should be followed up with a verb (see suggested list below)
  - **a verb** - eg: design
  - **a noun** - eg: a gripping mechanism
    and
  - **a user(s)** - eg: for people with rheumatoid arthritis

Question
*"How might we design a gripping mechanism for people with rheumatoid arthritis?"*

## VERBS TO TRY

| KNOW | UNDERSTAND | APPLY | EVALUATE | CREATE |
|---|---|---|---|---|
| Define | Predict | Solve | Frame | Create |
| Identify | Reflect | Apply For | Compare | Develop |
| Describe | Demonstrate | Construct | Experiment | Change |
| Match | Differentiate | Choose | Ask | Paraphrase |
| Recognize | Discover | Prepare | Check | Generate |
| Select | Research | Produce | Correlate | Imagine |
| Investigate | Transform | Show | Separate | Negotiate |
| Tell | Describe | Judge | Analyse | Design |
| Visualise | Compare | Transfer | Compare | Structure |

# Ideate STEP 3



**THE THIRD STEP** of Design Thinking is **Ideate**. The classic way of ideation is brainstorming - and that's what you're going to do almost exclusively in this step. A definition of brainstorming is *"a group discussion to produce ideas and ways of solving problems"*. This is exactly what you will need to do - **produce ideas**. This step is all about generating as many ideas as possible before they are sorted, combined or clustered into a final solution for 3D printing. Look at <Brainstorming Rules> for more information before beginning.

Give yourself plenty of space to make ideas using lots of tools such as paper, markers, cardboard, Post-its - anything! Don't concentrate too long on any one idea - 3 minutes is a good maximum. You're looking for quantity rather than quality!

Once you generate your ideas - begin to select your ideas within a framework of evaluation and voting from the whole team.

For the selection process - you can try the <2x2 Matrix> can be useful tools here again. Generating ideas is usually pretty easy to do - while the selection of ideas can be a little more challenging. For the selection of ideas - look to the <6-3-5 Method> - this will help you cluster and narrow your ideas.

## What to do next...

### How to kick off your Brainstorming Session

- Prepare a clear "How might we..." question.
- Start to Brainstorm! Draw, sketch and write all ideas down!
- Group, cluster and assess ideas at regular intervals to narrow choices - the goal is to finish with a single clear idea.
- When discarding ideas - consider moving them to a "Parking Lot" of unused ideas rather than deleting entirely.


## Brainstorming

### Things to generate...

- Ideas. Lots of ideas. Lots and lots of ideas!
- Enthusiasm and momentum!
- Creativity and originality!
- No criticism! - All ideas are good!
- Energy and passion! *Early morning sessions are best!*
- Drawings, pictures, text and wordclouds! https://www.wordclouds.com

# Prototype STEP 4



**WE'VE PROGRESSED RAPIDLY** into the next phase of Design Thinking - **Prototyping**. Building prototypes makes all the previously selected ideas tangible and perceptible. There can be many different types of prototypes - from vision prototypes up to a final prototype. Building prototypes (especially for 3D Printing) can require a lot of different materials - you don't necessarily want to jump straight into printing the final device. This is especially true when 3D Printing, as it can take a long time for a 3D printer to create a print - even at its lowest setting. The first stage is for you to take your final idea from the **Ideate** step and create a Vision Prototype (See Prototyping Categories below).

After this, concentrate on the next few stages of prototyping. Begin to use a low resolution (Low-Res) to high resolution (Hi-Res) methodology. Use basic physical materials and tools (See below) such as cardboard, paper, glue, wood, straws, elastic bands, wire, string, hot glue, skewers and more in the next two prototyping stages. You should consider making physical prototypes from your previous hand-drawn sketches - then move to a slightly more complicated digital format. See **<Digital Prototyping Tools>** for ways to move your prototypes from hand-written to digital. After this - you can try simple 3D printed pieces or even the whole solution - but always be aware this can take a lot of time!

Your ideas will shortly begin to become reality! A few things to note however - patience is required as prototyping and 3D printing takes time. It is also very important to go slowly through these stages to save time later in the project. (Try to manage your expectations - you may want to just create the design and print it... without iteration, testing or even prototyping - and if your project is very simple, that can be OK - but often there can be hidden complications.)

There are many types of prototyping but as this is a **<3D Printing Health Challenge>** - 2 things are fundamentally important: the user experience and the functionality of the device. These can be broken into: Critical Experience Prototype (CEP) and Critical Funtion Prototype (CFP). (See Prototyping Categories below)

## Prototyping Categories

*It would be expected to build a minimum of 2 functional prototypes before 3D printing your final project. It's best to go through many small iterations rather than a single large one.*

### Vision Prototype

» Take your Problem Statement, definition of success and combine it with your How Might We... question then mix in your brainstorming ideas... to create your Vision Prototype! It's better to sketch or draw this prototype.

### Critical Experience Prototype

» Now take your Vision Prototype and add in the Critical User Experience. The goal here is to again empathise with the user so their needs are met in conjunction with your Problem Statement being solved.

### Critical Function Prototype

» Once you have built the first two prototypes - you now must ensure the functions all work as expected before progressing.

### Final Prototype

» Now that you have done your prototyping - begin to move towards the Hi-Res version. You can either build this - perhaps using some 3D printed individual parts or move towards 3D printing the whole solution.

The user is always at the heart of what you are trying to accomplish. To this end, the user(s) experience and how a device will improve life for them is extremely important. You will want to ensure what is designed will ultimately help them. (This ties directly to the first step of Design Thinking - **Empathise**). Also critical is to ensure the device won't malfunction in some way leaving the user at an immediate disadvantage. Not only is the experience important, but the function is equally as important.

## Physical Materials

1. **PHYSICAL TOOLS** : Pliers, scalpels, scissors, drills, rulers, markers, pens, pencils, hot glue guns, staplers, etc.
2. **MATERIALS** : Cardboard; Lego; tape (plain, duct, painter, electrical); paper (heavy, light, tracing); glue (hot glue, Superglue, glue stick); skewers; wire (multiple weights); bottle caps; cable ties; straws; elastic bands; brass fasteners; scraps (wood, fabric and plastic); almost anything!

**Don't forget that it's best to from work Low-Res to Hi-Res.**

# Test STEP 5



**WE'VE ARRIVED** at the second to last step in Design Thinking. We're not done yet, but nearly there! To better inform this step, let's revisit what you have completed so far. (See text on right)

If you have access to your user(s) - getting direct feedback from them would be the ideal way to progress. However, this is not always possible. There are still plenty of ways to test your solution. The goal here is to get feedback on your project. If the user(s) aren't available - you could ask other teachers, friends or parents to play the role of the user(s).

The two most important things for you to do here are:

- Set up as close to a real-life scenario as possible to mimic a user(s) experience.
- Ask open-ended and detailed questions - but not leading questions.

In this step of Design Thinking you will need to test your finished (or nearly finished!) prototype thoroughly. You can use the **<Testing Sheet>** to give you a good guide to know where and how to setup a good testing scenario. You can also use the **<Feedback Capture Grid>** to test with your team before going out to your end-user(s) or other potential testers.

## Emapathise • Define • Ideate • Prototype

**WHERE HAVE YOU BEEN AND WHAT HAVE YOU COMPLETED?**

- Created a Problem Statement
- Defined Success
- **Empathise**
  Researched your user(s) to better understand how to solve their Problem Statement.
- **Define**
  Further clarified the critical elements of what will make the project successful for your user(s). Sharpened and focused their empathy research while ensuring to always keep the user(s) at the heart of both your Problem Statement and solution.
- **Ideate**
  Brainstormed to find ideas, concepts, plans and solutions for your Problem Statement. You came up with lots and lots of ideas - some of which may formulate their ultimate solution for this project - other ideas may be possible solutions to different projects!
- **Prototype**
  You began building what your solution would look like. You started with Lo-Res drawings and sketches - moved to slightly more complicated digital prototypes, then on to Hi-Res versions. Finally you designed and 3D printed your workable solution.

# Implement STEP 6



**THIS IS THE LAST** step in our Design Thinking process! Now comes implementation. This step is all about taking the device, service or product and putting it out into the world for sale and use. In the case of the **<3D Printing Health Challenge>**, you should begin to look at next steps for the project. The prototyped 3D printed device has been created and now you should begin to query the final manufacturing process. The project [probably] won't go to that step - but you should understand the requirements to make it happen. Most devices and products go to large companies to manufacture in bulk - and use a variety of different materials. Steel, aluminium, rubber, plastic, textiles and more can be used in a final product. What would your device require?

Query the larger questions such as funding, manufacturing plants, development costs, ownership, intellectual property rights, business setup, legal challenges and more. You don't necessarily needs answers to these questions - but should be aware of the questions and give them consideration.

## Example questions to ask

*You should explore one final step in the Design Thinking process - bringing your prototyped device to the manufacturing stage. Below are some example questions to consider.*

**WHO**
- ...will purchase the device? ...needs the device?

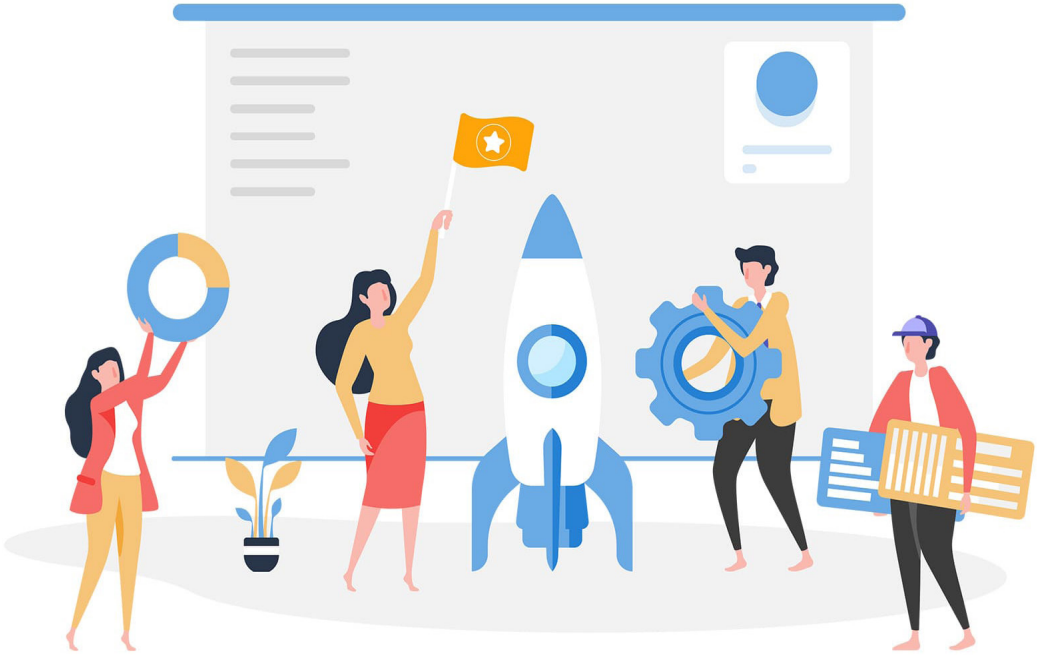
**WHAT**
- ...will it cost? ...colour will it be?

**WHEN**
- ...will it be available publically? ...can it be ready to sell internationally?

**WHERE**
- ...will the funding come from? ...can we get it manufactured?

**WHY**
- ...was it worthwhile to solve the problem?

**HOW**
- ...would it be marketed?



## Expert Tips

- This Step is about thinking further than the boundaries of this project.
- Use the **<5W+H>** method as a reflection tool.
- Many times adults have short-sightedness when considering problems and solutions. You still have a very fresh perspective on the world and how things work - use that to your advantage.
- Use the **<6x3x5 Method>** to explore infinite possibilities. "What if..." you had unlimited budget, time, resources and materials?

# Questions:

» Who?
» What?
» When?
» Where?
» Why?
» How?

| Who | What | When | Where | Why | How |
|---|---|---|---|---|---|
| Who is involved? | What do we know about the problem? | When did the problem start? | Where does the problem occur? | Why is the problem important? | How could this problem be an opportunity? |
| Who is affected by the situation? | What would we like to know? | When do people want to see results? | Where was this resolved before? | Why does it occur? | How could it be solved? |
| Who makes decisions? | What should we look at? | When does it happen? | Where did similar situations exist? | Why was it not yet solved? | How often does it happen? |

***How to use this tool:***

1. **ASK** : Use this tool to gain deeper insight into a project, research, interview or observation.
2. **ASK AGAIN** : It can be valuable to ask the same questions repeatedly to gain further insight. Much as a child will continually ask "Why"? - it provides further information gathering when we continue to ask the same question.
3. **CHART QUESTIONS** : Use the chart on the left to record answers.
   - ◊ **NOTE** : Chart on the left is an example only. Define your own questions that are relevant to your project.

## Expert Tips:

» If a question does not fit the particular context of what you are looking to learn more about - just skip it.

» Change the question around by using negative perspectives. eg: "When does the problem NOT occur?" or "Who is NOT affected?".

» Facts only. While it is possible to have silly and untrue answers, this won't help the project. Stick to the facts.

» This is a favourite tool of researchers, writers and authors. When these questions are asked, they generally require in-depth answers rather than simple one word responses.

» This tool can also be used to augment a brainstorming session.

# 5x Why



| 1. Why is it a problem (problem statement)? | Consequence |
|---|---|
| **Answer** | What is the problem?<br>What are its symptoms? |
| **2. Why?** | **Direct Impact** |
| **Answer** | Why does the problem occur?<br>What technology is used? |
| **3. Why?** | **Cause – Effect** |
| **Answer** | What could be another cause of the problem? |
| **4. Why?** | **Organisational hurdles** |
| **Answer** | How could the problem be avoided? |
| **5. Why?** | **Systematic hurdles** |
| **Answer** | What systematic approach might prevent the occurrence? |

## *How to use this tool:*

1. **DESCRIBE THE PROBLEM** : Using as much detail as possible, describe the problem. You could also use photos or sketches to illustrate it.
2. **ROOT CAUSE ANALYSIS** : Ask "Why" as often as possible. Try to counter each answer with another "Why" question.
3. **STOP** : There will come a time when it is no longer relevant or makes sense to ask "Why". Stop here and look to a different problem or explore in a detailed discussion with the interviewee their answers.

   ◊ **NOTE** : Matrix on the left is an example only. You can define your own questions!

## Expert Tips:

» Try not to make assumptions of the root cause of a problem.

» There is no guarantee that five why questions are enough to get to the bottom of things. Keep asking until it is uncomfortable or you feel you have discovered the root cause.

» Let your interviewee tell their story - listen attentively - then ask further questions should something still be unclear.

» Check results with reverse questions. In order to verify the problem, reverse questions in the form of an "if-then" sentence are great.

Example: **Q:** *Why did you get sick?* **A:** *Because I spent time outside in the fresh air.*

Reverse Example: **Q:** *If you hadn't spent time outside in the fresh air, would you be sick now?* **A:** *The lack of a jacket was probably more of a cause than being in the fresh air.*

**Therefore the fresh air is only PART of the cause - with more "Why" questions the root of the problem can be further broken down.**

# AEIOU



| | |
|---|---|
| ACTIVITIES | What happens?<br>What are the user(s) doing?<br>What is their task?<br>What activities do they carry out?<br>What happens before and after? |
| ENVIRONMENT | What does the environment look like?<br>What is the nature and function of the space? |
| INTERACTION | How do the individual systems interact with one another?<br>Are there any physical interfaces?<br>How do the user(s) interact among one another?<br>How does the operation work? |
| OBJECTS | What objects and devices are used?<br>Who uses the objects and in which environment? |
| USER(S) | Who are the user(s)?<br>What role do the users play?<br>Who influences them? |

## *How to use this tool:*

1. **RESEARCH** : Do some research first before using this tool.
2. **OBSERVE** : (If possible) observe the user(s) in their own environment. If not possible - try to extrapolate the user(s) in context of the problem statement.
3. **TEMPLATE** : Use the AEIOU template to gain insight and answer specific questions.
4. **GROUP & CLUSTER** : Group and cluster like answers together. Begin to narrow your choices.

   ◊ **NOTE** : Table on the left is an example only. Create your own questions!

### Expert Tips:

» This tool is about observation in order to better understand your user(s).

» The questions in AEIOU can (and should) be adapted to suit your own project.

» AEIOU is not a rigid framework - it only provides categories that have proved useful. Be flexible!

» Sometimes drawing and sketches tell a greater story and help focus ideas better than text. Don't be afraid to draw!

# Empathy Interview



| Existing assumptions about the user(s) and the problem. |
| --- |
| |

| How might we empathise with the interviewee so they share more details of their story? | Key questions for the story… | Keywords and topics for the user(s) emotions. |
| --- | --- | --- |
| | | |

| Outline of the user(s) story… |
| --- |
| |

### *How to use this tool:*

1. **PUT DOWN YOUR EXISTING ASSUMPTIONS** : Discuss with your team what you think is happening for the user(s) already.
2. **PREPARE** : Write out your questions beforehand and discuss with the team what they think.
3. **CONSIDER EMOTIONS** : This may be difficult for the interviewee - consider how they may feel.
4. **OUTLINE** : After the interview - write the outline of their story.

### Expert Tips:

- Each team member should have a role. One to document (audio and video if possible), one or two asking questions and one to record answers.
- Build trust with the interviewee. Help and assure them that their information is not being made public. Explain the parameters of your project to them.
- Build a personal relationship. Try to see things from the interviewee's point of view. Avoid saying things like "I understand you - my cousin has the same problem." This inhibits the interviewee telling their story and giving their own insights.
- Try to get the interviewee to tell you different stories about their problem. This will provide better information and emotional experiences of the user(s).
- Avoid closed questions that cannot be answered by "yes" or "no". Use open-ended questions instead. {See **<5W+H>** for ideas.}
- Observe non-verbal information such as body language and eye-contact for more clues.

# Empathy Quiz



## University of California - Berkeley

This quiz was developed by the University of California, Berkeley's "Greater Good Magazine". It draws from 3 scientifically validated scales researchers have created to measure empathy: the *Toronto Empathy Questionnaire*; the *Interpersonal Reactivity Index* and the *Emotion Specific Empathy Questionnaire*.

***Go to this URL and take the quiz:***

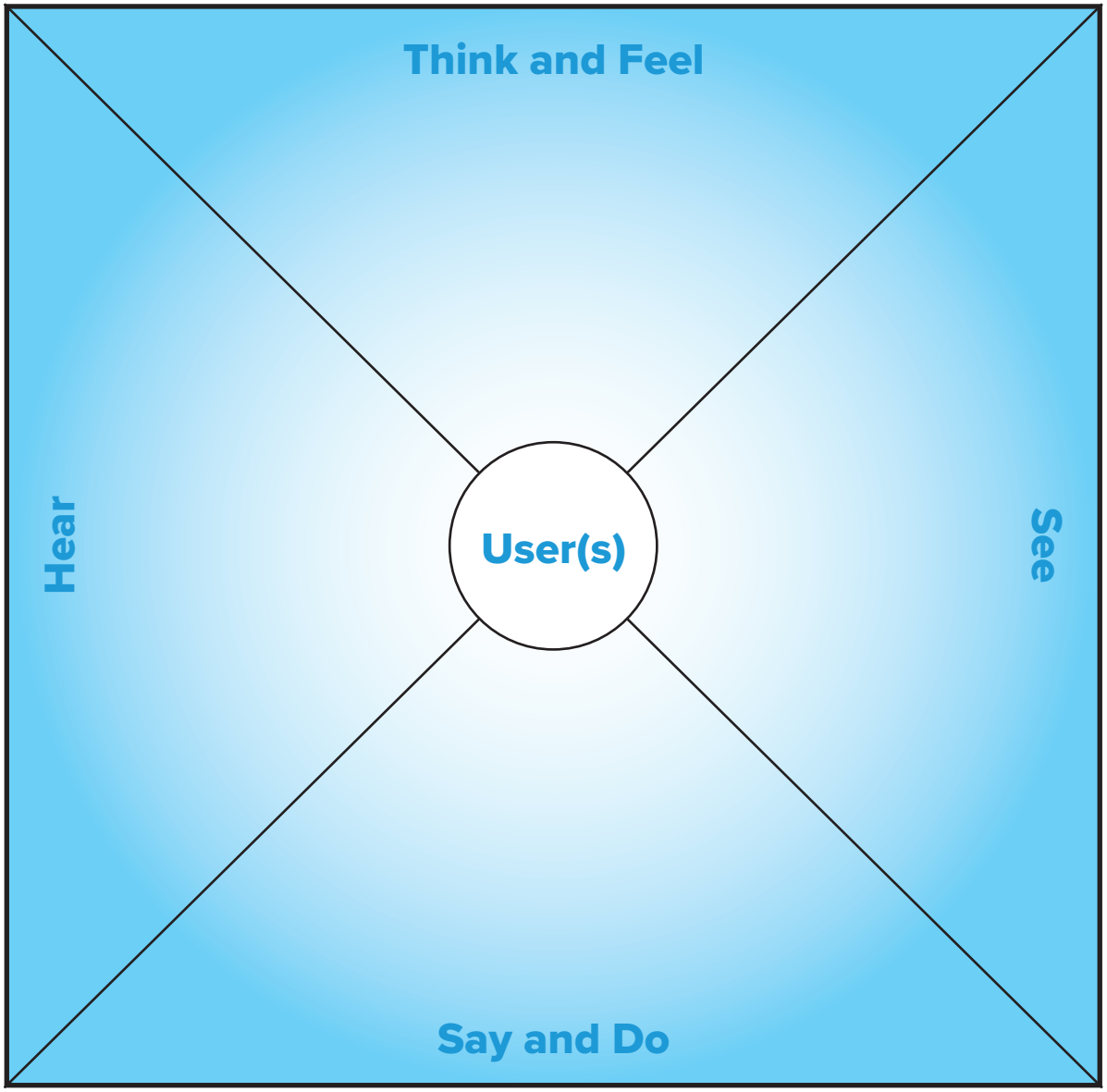
**https://greatergood.berkeley.edu/quizzes/take_quiz/empathy**

***How to use this tool:***

1. **GO TO THE URL** : Take the Empathy Quiz.
2. **ANSWER** : There are 28 questions - answer the questions as honestly as you can - there are no right or wrong answers.
3. **SEE SCORE** : When complete - submit. You will get your score immediately. It will tell you how empathetic you are and suggestions on how to improve your empathy.
4. **DON'T SHARE** : This quiz is purely for you to measure your empathy. It is only a rough guide, so don't take any definitive results from it. Lastly - there is no need to discuss your answers or suggestions with others - this is just for you.

# Empathy Map






### *How to use this tool:*

1. **THINK OF QUESTIONS FOR THE USER(S)** : Come up with questions to ask your user(s).
2. **FILL IN THE CHART** : Ask questions about the user(s) needs. This tool is used to identify feelings, thoughts and emotions.
3. **THINK AND FEEL** : What emotions does the user(s) have? What do the user(s) think?
4. **SAY AND DO** : What do the user(s) say? What must the user(s) do?
5. **HEAR** : What things do the user(s) hear? Who speaks with the user(s)?
6. **SEE** : What does the user(s) environment look like? What does the user(s) see?

### Expert Tips:

- Try to frame your questions in terms of verbs (activities) instead of nouns (solutions).
- For even more insights - after asking questions - consider using the “Pains” and “Gains” idea. This is simply asking yourself 2 questions after interviewing the user(s).
  - What are the user(s) biggest challenges?
  - What are the opportunities the user(s) may have?
- Pay attention to body language, tone and word selection - these can give more information than spoken words.
- Look for contradictions. Sometimes what user(s) say and what they do can be different - try to understand why this could be the case.

# Storytelling



| Team Member | User(s) | Characteristics | Interpretations | Conclusion | Insights |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

### *How to use this tool:*

1. **CHART** : Reproduce the chart on the left. Use a large whiteboard, flip chart along with pens, markers and Post-its.
2. **USER(S)** : List your user(s) - even make up similar user(s) but with similar problems.
3. **CHARACTERISTICS** : Each of your team members should list a characteristic, quote or special feature of your user(s).
4. **INTERPRET** : From all answers, progress the story by adding emotions, setting, direction, highs/lows, actions, plot and conflict all the way through to resolution.
5. **CONCLUSION** : Conclude your story and hand it over to your team members. Now your team members should draw 3-5 insights from it as they understood it - these should be noted on the whiteboard, etc. After everyone has told their story and drawn conclusions - begin to cluster thoughts and ideas to summarise your findings. Now you have an idea of your user(s) journey that they may take.

### Expert Tips:

- Don't just write words on your chart or template - use drawings and sketches as well.
- Experiment with different types of stories - introduce cliff-hangers; love; action/adventure; comedy; rags to riches and more!
- You aren't limited to your own story - use other team members (ask first!) stories and add to them, change or adapt them (in a meaningful way!) Even use existing stories from literature, film or songs!

# Brainstorming Rules

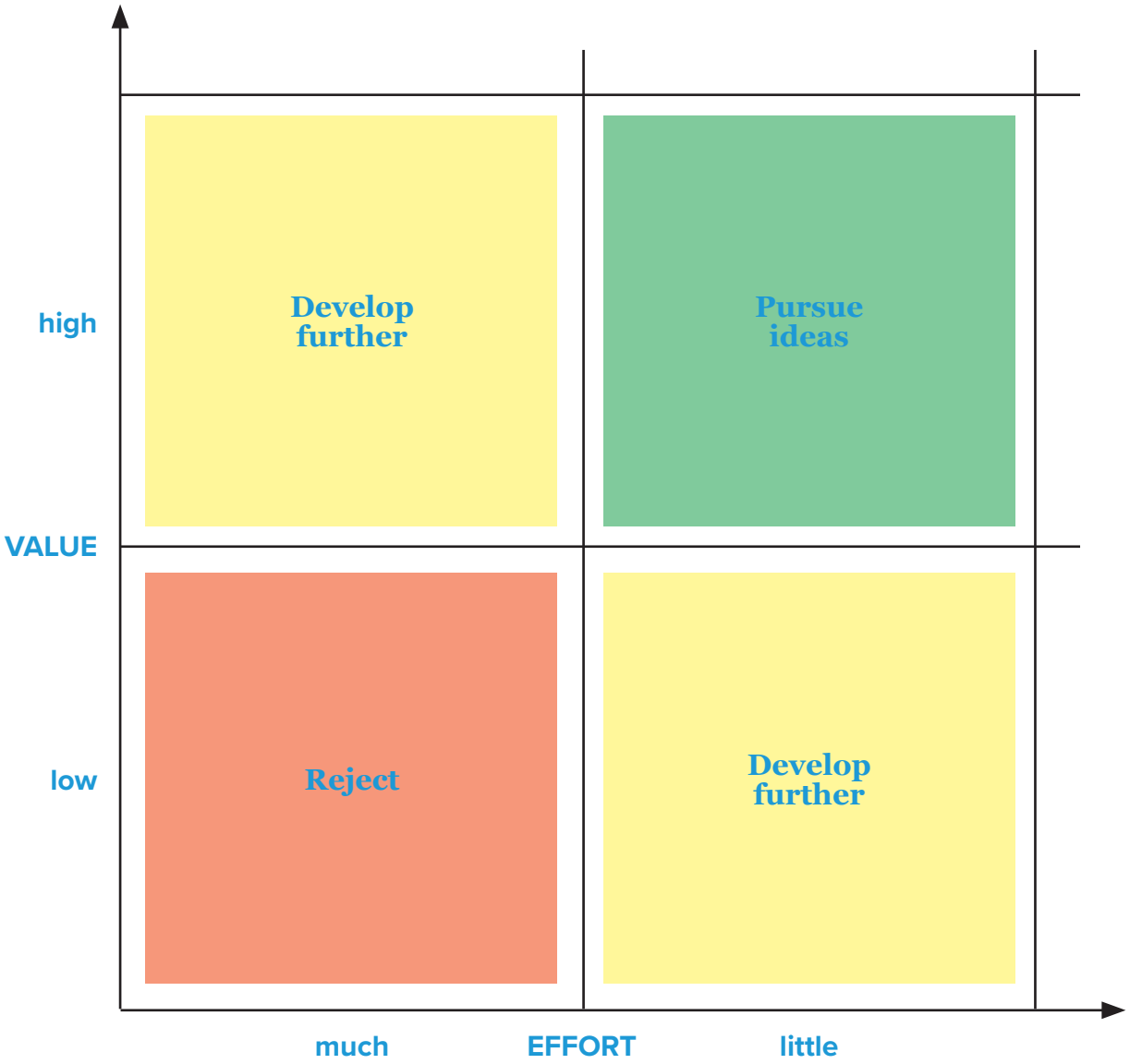



***Brainstorming Rules:***

1. **CREATIVE CONFIDENCE** : Encourage students to be as creative in as many ways as possible using as many tools as possible. There is no wrong way to be creative when brainstorming.
2. **QUANTITY BEFORE QUALITY** : The goal of brainstorming is the generation of ideas... we don't care how pretty they are, if they'll actually work or even if they are absurd - get them out there!
3. **VISUAL IDEAS** : Most people learn easiest visually - encourage students to draw or sketch their ideas. Use stick figures, perspective (such as out a window), give it a face or personality, use rough sketches and quick notation. What's it like under water or on a muddy country lane?
4. **USE GESTURES** : When people begin to explain their idea - encourage the use of gestures to get their point across. This can lead to freeing up the brain to think of more ideas.
5. **BUILD ON THE IDEAS OF OTHERS** : Let students take other people's ideas and run with them. In this case, it's not "stealing" - it's adapting and building. Remember, it's your team and you already have a goal to work towards!
6. **ONLY 1 PERSON SPEAKS** : Each team gets a chance to explain their idea - if this sparks an idea in a team member - ask them to write, draw or sketch it out while someone else is speaking.
7. **NO PREJUDICES** : No idea is bad. Save crazy ideas for later - you never know when you might need them.
8. **CONTINUE TO BRAINSTORM** : Let others spark your imagination and when the session ends, don't stop considering your ideas.
9. **FAIL EARLY AND FAIL OFTEN** : Be unrealistic and impractical early in the discussion. Accept some things aren't workable right now and move on. Create a "Parking Lot" of ideas that are exciting but don't contribute to the solving the problem.

# 2x2 Matrix






### *How to use this tool:*

1. **DEFINE THE AXES** : Think about and sketch different possibilities how the axes can be labeled. Put this on a whiteboard / large sheet of paper before completing.
2. **POSITION THE IDEAS** : Fill the matrix with your ideas.
3. **FINDINGS** : Record their findings and get them to work towards a single, simple idea.

   ◊ **NOTE** : Matrix on the left is an example only. Define your own options depending on your project, ideas or problem.

### Expert Tips:

» The 2x2 Matrix is a visual way of categorising ideas.

» Use this tool to quickly determine which ideas should be used and which should be discarded.

» This tool reduces the complexity of ideas generated.

» Use opposite attributes such as “benefits” and “feasibility” or a “cool” and “doable” axis.

» A “SMART” approach can be a valuable way to use this tool. (Using the guidelines of: **S**pecific; **M**easurable; **A**chievable; **R**ealistic and **T**imely to focus your thoughts.)

» The 2x2 Matrix is highly modifiable as any type of meaningful axis attribute can be used. The versatility of this tool makes it ideal to quickly narrow down possibilities.

# 6-3-5 Method



| Problem Statement |
| --- |
| |

| | | |
| --- | --- | --- |
| 1.1 | 1.2 | 1.3 |
| 2.1 | 2.2 | 2.3 |
| 3.1 | 3.2 | 3.3 |
| 4.1 | 4.2 | 4.3 |
| 5.1 | 5.2 | 5.3 |
| 6.1 | 6.2 | 6.3 |

| Clustered and narrowed ideas: |
| --- |
| |

### *How to use this tool:*

1. **GRID** : Create a grid similar to the one on the left. There should be as many rows as team members. (The columns remain at 3)
2. **IDEATE!** : Each team member gets an individual sheet. (as example shown). The Problem Statement is written at the top by all team members. Each team member writes 3 ideas on their sheet within a defined period of time. (2-5 minutes is good). No discussion of ideas - the exercise is done in silence until the end.
3. **ROTATE** : The sheets are passed clockwise to the next team member. Repeat the Ideate process. Team members may build on previous ideas or create new ones.
4. **CLUSTER AND NARROW** : After each team member has filled in all the sheets - have a quick discussion, then cluster and narrow ideas in the final box. Then further narrow and cluster your ideas by combining sheets.

### Expert Tips:

- Start off your process with a “How Might We...” question - making sure it is narrowed down to a unique perspective.
- Focus. The question should be very specific so that participants all understand what is trying to be achieved.
- Show - Don’t Tell! It can be very useful to sketch or draw ideas instead of describing them with words. It can speed up the process as well.
- Don’t always come up with new ideas - build on others ideas. Iterate, change and narrow them down.
- At some point - you need to begin to narrow your ideas down... begin to cluster similar ideas together and either move unused ones to a “Parking Lot” of ideas or discard.

# Digital Prototyping Tools



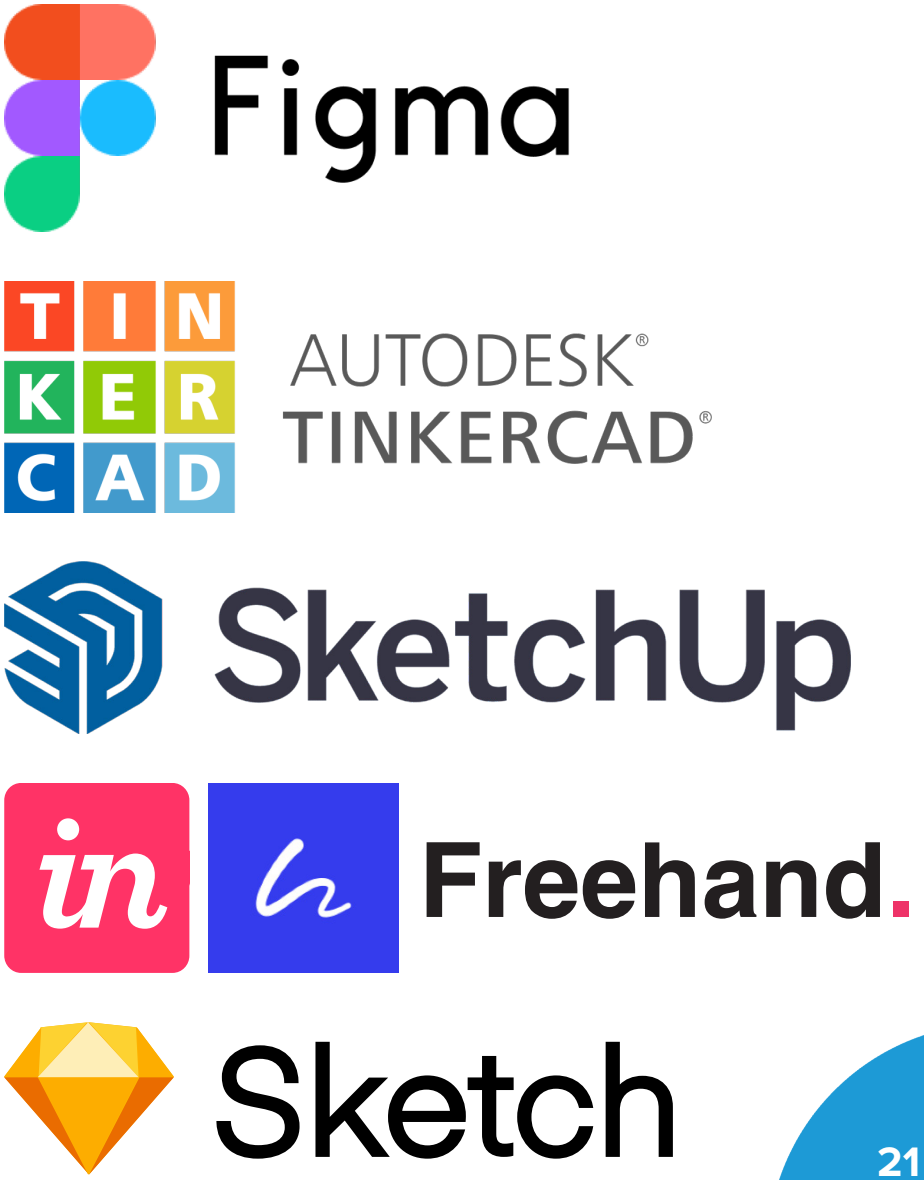
***How to use these tools:***

1. **ACCOUNTS** : Most of these tools are free to use, but will require you to sign up for an account. You should use their own email address to sign up and sign in. Some of these tools are collaborative (such as InVision) - whereby you can share data and work together on the same project.
2. **USAGE** : Almost all of these tools are easy to pick up and use with little training required. However, some require guidance (such as the drawing/3D modeling tools Tinkercad, Sketch and SketchUp). The “free-flow” style of Figma and Freehand may at first be confusing - just remember that it does not have a linear method of working. This is the nature of prototyping. Ideas are generated and tested, then refined. Remember to begin Low-Res and move to Hi-Res.
3. **INTUITIVENESS** : Many software tools are simple and intuitive. This is true for most Apps and many pieces of software. However - in this case, you are moving to using professional tools with many options and variables. This can sometimes be frustrating when things don’t work as expected. Ask your teachers for help and look up the help built in to all the Apps. Also - YouTube videos are great resources when you need to know how to do a single task. You can always prototype by doing more physical making or 3D printing individual pieces and putting them together.

## Digital Prototyping Tools

**DIGITAL TOOLS TO HELP YOUR PROTOTYPE DEVELOP...**

| | |
|---|---|
| **Figma** | https://www.figma.com |
| **Tinkercad** | https://www.tinkercad.com |
| **SketchUp** | https://www.sketchup.com/products/sketchup-for-web |
| **InVision Freehand** | https://www.invisionapp.com/freehand |
| **Sketch** | https://www.sketch.com |



# Testing Sheet



## Test Scenario

| Brief description of test scenario | Test criteria |
|---|---|
| | |

| Procedure | Roles | Questions |
|---|---|---|
| | | |

## Test Results

| Documentation | Summary |
|---|---|
| | |

### *How to use this tool:*

1. **TEST PLANNING** : Consider where the test should take place. Ideally at the user(s) location in their own environment - but if not possible, try to recreate as much of the scenario as possible. (Refer back to **Empathise** and Define stages)

   Assign roles to testers and plan the sequence of how it will work. Different people asking different questions can be better than one single person.

2. **TEST PROCEDURE** : Run the test and observe the user(s) keenly. Ask for honest feedback. Beware user(s) who will want to please the testers with just positive feedback. Write down any and all important quotes from user(s).

3. **TEST DOCUMENTATION** : Document the test with photos or better yet, short videos of the most important findings. Summarise the findings.

### Expert Tips:

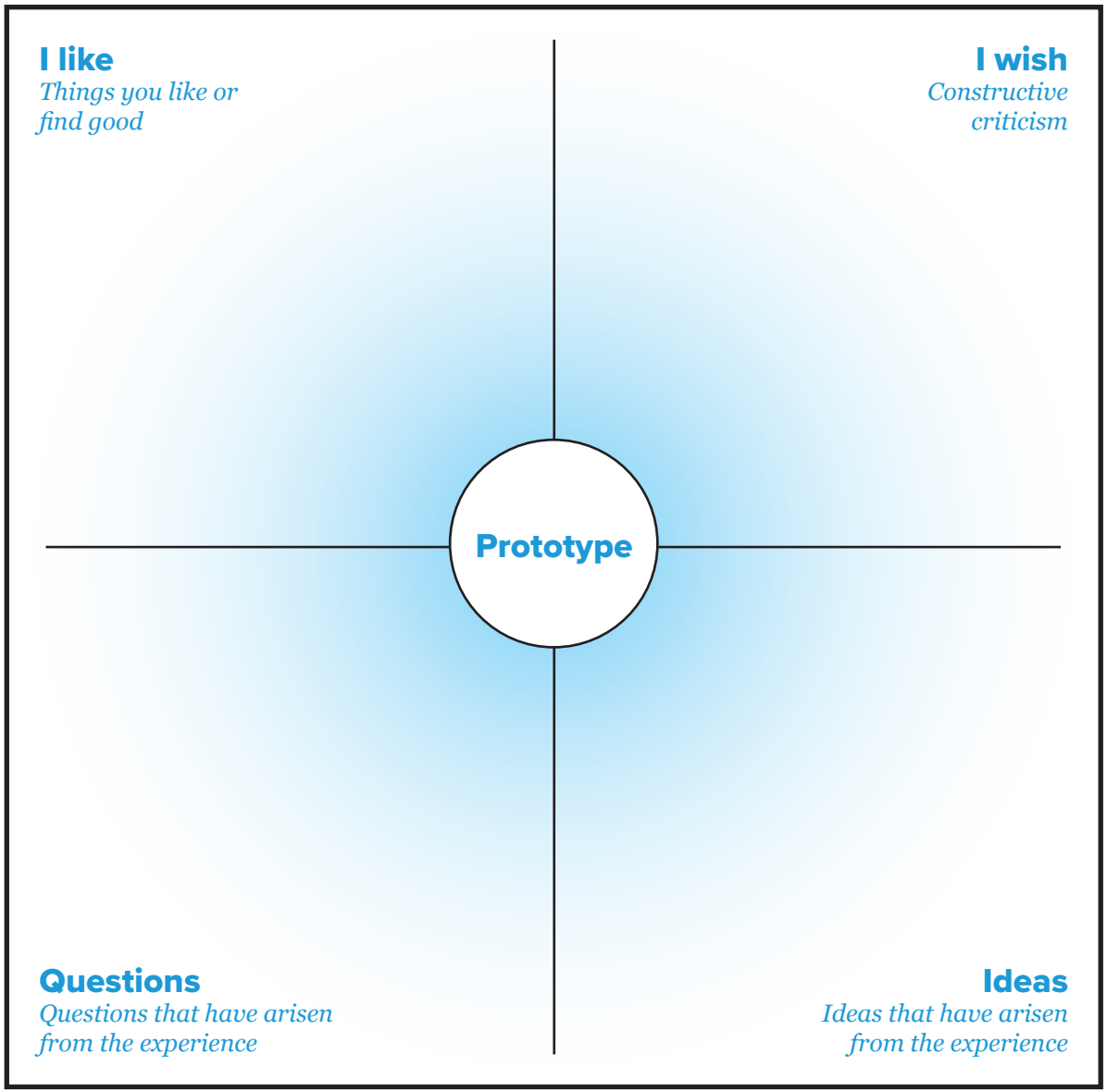
» It is vital to ensure you ask relevant questions keeping the Problem Statement and solution in mind. Questions similar to “Is it OK?” are poor questions.

» Questions should be not be leading. Instead, they should be detailed and open-ended. “Could the button be moved to a better place?” is a leading question.

» Sometimes (but not often) user(s) may completely reject the device. Don’t be disheartened - this is excellent feedback! Try and understand why this is the case. Ask very detailed questions and consider revisiting the **Empathise** and Define steps.

# Feedback Capture Grid






***How to use this tool:***

1. **CREATE GRID** : Create Feedback Capture Grid on a whiteboard or flip chart.
2. **TEST** : Always start a Feedback Capture Grid by actually seeing and experiencing the prototype.
3. **FILL IN THE FIELDS** : Document the test by filling in each quadrant of the grid. Use Post-its or markers and pens.
4. **ASK "WHY?"** : When answers are submitted - ask yourself (or user(s) "Why?". You may get better information by querying why the answers were given.

**Expert Tips:**

» Don't just use this tool with yourself or your user(s). Ask people who don't know anything about the project and no idea why it exists. The answers you get may be surprising.

» Listen, watch and try not to ask questions or explain the prototype at first. Let the device explain itself.

» Don't explain the idea to the user(s). If too much explanation (other than how it works and what it is for) is required... it may be too complicated.

» Write down exact quotes or comments from the user(s). These will be valuable to making any last minute changes or adaptations

# Post-it Notes




Download on the App Store | GET IT ON Google Play | Download on the Mac App Store

**Apple / iOS:** https://itunes.apple.com/us/app/post-it-plus/id920127738?mt=8

**Apple / Mac:** https://apps.apple.com/us/app/post-it/id1475777828?mt=12

**Google / Android:** https://play.google.com/store/apps/details?id=com.mmm.postit&hl=en_US

**The Post-it app will also interact directly with both Miro and Trello.**

(Free online collaboration and whiteboard software)

**Miro:** https://www.miro.com

**Trello:** https://www.trello.com

miro Trello

### *How to use this tool:*

1. **ASSIGN COLOURS** : Give teams or individuals their own colours.
2. **ANSWERS** : Individuals or teams write your answers either with text or visually. (Shorter, neater words are better)
3. **COLLECT** : Collect and collate data from answers. Begin to form clusters to narrow choices and decisions.

### Expert Tips:

» **COLOURS** : A variety of colours is very useful. Use different colours for thoughts, ideas, groups, individuals, clusters and more!

» **BRAND** : You don't need the official Post-it brand - there are plenty that are as good and available from many other sources.

» **USAGE** : Writing text or sketching visual ideas - as individuals or groups. It will help your focus both by limiting space and allowing for quick iterations. Use to brainstorm, iterate, discuss, vote and more!

» **DIGITAL** : Become a Post-it Master by using both the paper and digital versions. There is a free app available for both Apple (iOS) and Google Play (Android) stores. The App allows you to take a photo of wall full of Post-its and it automagically reads the text, colour and position of the note. You can then re-organise, add, delete, edit and change how you like. An excellent tool for documentation!

# Definitions / Terminology

Discover Manufacturing

| | |
|---|---|
| Team | The group of students who will submit an entry to the competition. Minimum of 3 per team. Each team can submit only 1 entry. |
| School | Name of the school submitting an entry. Schools can have more than one Team. |
| Class | Class year within the school. Classes may have more than one team. |
| Design Thinking | A methodology used to solve problems. |
| .stl file | A 3D printing file. {Stereolithography}; {Standard Triangle Language}; {Standard Tessellation Language}. Files can be created from various pieces of software. Used to describe surface geometry only, rather than colour, texture or other attributes. |
| User(s) | The actual person(s) who will use the product the teams develop. {The end user} |
| Iterate | To develop (a product, process or idea) by building upon previous versions or “iterations”, using each version as the point of departure for refinements, tweaks and changes. |
| Problem Statement | A simple statement of a difficulty describing a complication or impediment. Usually arrived at through a process of understanding the user(s) and empathy. |
| Innovator | A person who designs, develops and introduces new methods, ideas or products. You! |
| 21st Century Skills | 21st century skills refers to a broad set of knowledge, skills, work habits, and character traits that are believed - by educators, employers and others to be critically important to success in today’s world. Broadly these are: critical thinking, creativity, collaboration, communication, information literacy, media literacy, technology literacy, flexibility, leadership, initiative, productivity and social skills. |