Drought Devastation: Designing to Raise Awareness for Social Sustainability Using Data Visualisation and Visual Storytelling Methods

Thomas Aaron Bancroft

Submitted in [partial] fulfillment of the requirements for the degree of Bachelor of Design (Honours) (Interactive and Visual Design)

Creative Industries Faculty

Queensland University of Technology

Submitted November 2020

Abstract

Since 2017, the current drought which has severely affected Australia has brought the issue of climate change to the forefront of public debate in a way which hasn't been seen before. Furthermore, the confusion around the issue of the Australian drought, as well as climate change, is extremely prevalent in today's modern world. Through data visualisation, socially and environmentally sustainable design, and visual storytelling, 'Drought Devastation' aims to provide an evocative experience, showing how brutal the most recent drought was using data, and showing how it has affected rural communities and people through visual storytelling. This design will explore and use data, as well as real-life imagery, to tell this story, and use visual storytelling to evoke an emotional reaction that sees the users understand the Australian drought, and get a conversation started around supporting these rural outback communities.

Table of Contents

List of Figures

Statement of Original Authorship

The work contained in this project has not been previously submitted to meet requirements for an award at this or any other higher education institution. To the best of my knowledge and belief, the project contains no material previously published or written by another person except where due reference is made.

Signature: 

Date: 1/11/2020

Acknowledgements

In what has been such a strange year, and working under such strange circumstances, it's hard to know where to start in acknowledging so many people who have been pivotal in completing this project. Firstly, I would like to thank my wonderful supervisor, Jane Turner. Your guidance on my physical artefact and exegesis were priceless and were not only helpful throughout this project, but they will also be helpful in my future work, and for the rest of my life. In addition, thank you to my friends in this honours cohort (you know who you are), who have always greeted me with positivity even when the semester has started to get the better of me mentally. Furthermore, a thank to my mates outside of university is required as well. Without their support throughout the countless nights of playing games online, and in-person, this semester would have been so much harder on myself. To add on, another thank you must go out to Pam Crothers, who I met up with in Dirranbandi, and allowed me to visit the engine room in Dirranbandi, which had images and data visualisations of the current drought displayed for myself to see. Furthermore, Pam also got me in contact with Gerry Grant, the president of Dirranbandi Landcare Group, who was extremely helpful in giving me astonishing photos of the drought which she had taken herself, as well as photos from professional photographers such as Sophie Carroll.

Finally, a very special thank you must go out to my partner, Jorja McDonnell, who in the end, was the initial inspiration for this project altogether. Over two years ago, in July of 2018, she packed up her life in Brisbane, and moved out to Roma to start her job as a journalist for the Roma Western Star. Since then, I have constantly been visiting outback Queensland to visit her. In this time, I have visited towns such as Roma, St George, Dalby, Chinchilla, Mitchell, Wallumbilla, and Dirranbandi, and I have experienced the drought and the effect it has had on these outback communities first hand. Jorja, without you, I simply could not have finished this project. Your words of guidance, your support, and your love has been priceless, and I'll never forgot how much of a helping hand you were.

1 Introduction

1.1 Background

1.1.1 Practice Statement and Design Problem/Question

My practice for this project incorporates my interests in data visualisation, tangible interaction, and user experience. In particular, this includes going through data and turning it into a visually pleasing visualisation, and relating it to a visual story which is displayed to the audience on a projector screen. My practice as an interactive and visual designer for this project has been done in relation to the Australian drought, an important sustainability issue that was the initial inspiration of my desire to raise awareness for social sustainability (designing to change people's behaviours in relation to a sustainability issue).

Furthermore, focusing on this particular sustainability issue has highlighted an importance in showing this issue to the general public/audience, raising awareness for the issue, and getting a conversation started around supporting these outback communities struggling through the drought. Therefore, to achieve this, certain design problems must be addressed, and design questions answered. Originally, the question which was being asked for this project was simply how this project could design for social sustainability, in relation to the drought? Since then, the design question has been updated to address how my research and project aims have changed. To raise awareness for social sustainability in relation to the Australian drought, this project asks how a visual story combined with data visualisation can be used to evoke an emotional reaction from an audience, with the aim of raising awareness for the drought?

1.1.2 High Concept Topics

In this document, the high concepts of designing for sustainability, data visualisation, and visual storytelling will be discussed at length in the literature review, however a brief summary of these terms will be explained here. Firstly, sustainability "refers to a state of the world in which one's aspirations are fulfilled over a long period of time" (Walker, 2013, p. 40). In terms of this project, the artefact is being designed with the intention of fulfilling an aspiration to raise awareness for the Australian drought and get a conversation started around supporting outback communities (social sustainability). To raise awareness for social sustainability in this project, data visualisation and visual storytelling will be mainly be used. In recent times, data visualisation has had an integral part in displaying a visual story, and vice versa (Kosara & Mackinlay, 2013). This highlights an importance in using basic data visualisation elements such as graphs, as well as evocative visual storytelling elements to inform the user on the Australian drought and fulfill the necessary aims (which are covered in section 1.2). Finally, a visual story, much like a written or spoken story, has no single agreed-upon definition, however they all more or less use the same elements, including controlled delivery, presentation of information, structures, concepts, people, tools, and channels (Bongshin et al., 2015). While the term 'storytelling' and 'visual storytelling' is hard to universally define, people like Edward Segal and Jeffrey Heer have introduced terms such as 'narrative visualisations', which emphasizes "visual stories that include a narrative, or a series of causally related events" (Bongshin et al., 2015, para. 6). In terms of visualising data using storytelling, a visual data story emerges along with this narrative visualisation (Bongshin et al., 2015). To put it simply, a visual data story "includes a set of story pieces that is, specific facts backed up by data" (Bongshin et al., 2015, para. 7).

1.1.3 The Current Australian Drought

Since 2001, Australia has suffered through extreme weather events, such as the "Millennium Drought" (van Dijk et al., 2013), and La Nina finally breaking the drought with record rainfalls and floods in 2011 (Bureau of Meteorology, 2012). The current Australian drought, which has been

affecting Australia since early 2017, is an important sustainability issue that has forced the Australian public to think about climate change, and the possible effects it is having on the drought, as well as how it affects rural/outback people and communities. The most significant aspects of this drought have been the extremely dry winter months (Hannam, 2019), and the year of 2019, where multiple monthly average rainfall drought records were broken (Bureau of Meteorology, 2020), the best rainfall for the year across Australia was 8% below average (Bureau of Meteorology, 2019), and the devastating bushfires ravaged the eastern Australian states from October 2019 through to January 2020 (BBC News, 2020). Focusing on the dry winter months, the absence of this crucial seasonal rainfall throughout Australia in the last 4 years has been one of the biggest contributors to the severity of this drought (refer to figure 1 below) (Hannam, 2019). While the increased likelihood of a La Nina event (an increased risk of heavy rainfall) occurring (Deacon, 2020) had given farmers and communities in regions like the Maranoa in outback Queensland hope for a winter of above average rainfall (McDonnell, 2020), data shows that rainfall in June 2020 was 54% below average across the country (3rd lowest in recorded history for Australia) (Bureau of Meteorology, 2020), July 2020 rainfall was 43% below average (Bureau of Meteorology, 2020), and August 2020 rainfall was 8% above average (Bureau of Meteorology, 2020).

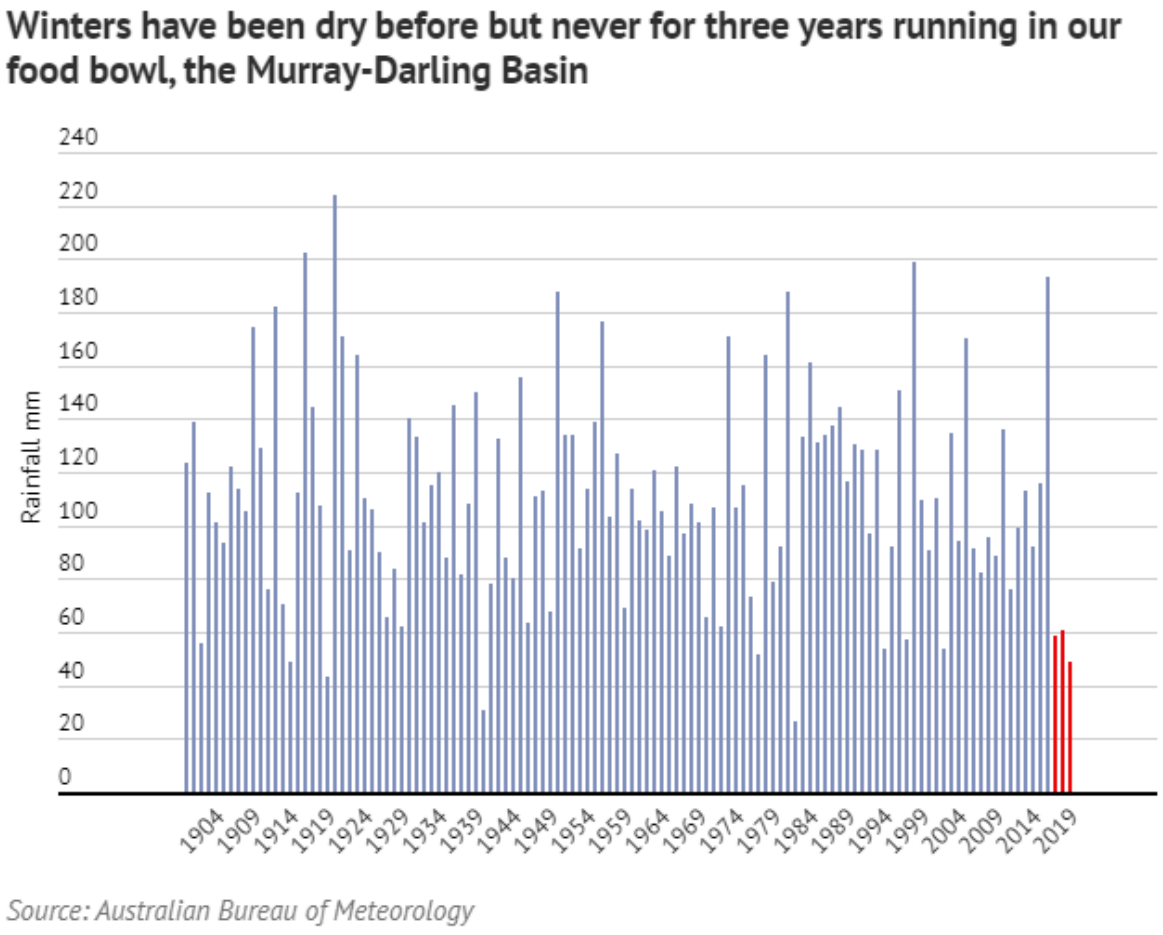


Figure 1: Graph showing 3 straight winters of below-average rainfall. Source: The Sydney Morning Herald (Hannam, 2019)

These significant aspects of the drought mentioned in the paragraph above will be the main focus of the visual data story which will show the audience what the drought has been like using data and evocative imagery. In particular, the drought data which is being used in this project has been taken

from the Bureau of Meteorology Climate Summaries Archive (Bureau of Meteorology, 2020), which is an extensive archive of weather information in Australia dating back to June 2006. Here I was able to find the national monthly rainfall data which informed the data portrayed to the audience on the physical device. To address this data, a focus has been put on finding ways to effectively communicate the facts of this drought to the public and raise awareness on the issue in an evocative and visual manner.

1.2 Aims and Objectives

This design research project will aim to raise awareness about the importance of social sustainability (Walker, 2013), with the ultimate goal of raising awareness on the issue of the current Australian drought, and get Australians to start thinking about the issue and how they can help support rural people and communities. High concept areas (which will be further discussed in the literature review) such as designing for sustainability (Walker, 2013), visual storytelling and data visualisation methods (Bongshin et al., 2015), and tangible interaction will be used to achieve these aims. These methods will be used to create a tangible, graphical device which details the month-by-month rainfall averages from January 2017 to August 2020, showing the effect it has had on the landscape in the form of evocative visual imagery.

1.3 Significance

While I have lived in the Redlands for my whole life, I have visited towns in the Maranoa, Western Downs, and Balonne such as Dalby, Chinchilla, Roma, Mitchell, Dirranbandi, and St George many times in the last two years, and have seen the effects the drought has had on the land and the people living there. Even back in my home town of Alexandra Hills, I particularly remember our local council area being officially declared drought stricken towards the end of 2019. A town only 5 minutes from the ocean being declared drought stricken can only make you imagine how bad the conditions are in outback Australian communities. These experiences, as well as the data shown above, explains why this issue is so significant and important to me, and shows why I want to raise awareness for this issue, and get people talking about it and thinking of ways they can support these communities that have been doing it the toughest for the last 3-4 years.

Secondly, since March 2017, Australia has experienced one of its worst droughts in recorded history, with a number of months throughout the 4-year period experiencing record lows in terms of rainfall averages. The data which has been mentioned in section 1.1.3 provides a brief glimpse into the devastation of the drought and how it effects rural outback communities. This small snippet of data gives off such a worrying feeling, and very much contributes to why this project is so significant for myself.

1.4 Scope and Outcomes

This device will aim to evoke an emotional reaction from the audience using a narrative visualisation and visual data story, which will see the audience think about how they can support these local outback communities. The outcomes for this project will include a physical device which supports the claims of raising awareness for social sustainability through the use of an interactive device, using a combination of data visualisation and visual storytelling. In terms of data visualisation, a 3D, physical graph will display the monthly national rainfall averages from January 2017 to August 2020 using MDF columns. The audience will also be able to compare these monthly rainfall averages to an “average” column which will sit at the end of the device. Some of these 3D columns will also contain blue LEDs inside of them, with the colour blue representing rainfall. These LEDs will light up in sequence, corresponding to the month of the image displayed in the visual story on a screen above. This physical graph/visual story combination will allow the audience to see what the rainfall across

Australia was for that month, and easily compare it to the imagery of that month displayed on the screen. Finally, the user will be able to start this sequence by pressing a button in the middle of the physical device.

The data used for the physical graph device has been taken from the Bureau of Meteorology Climate Summaries Archive, while the visual story will consist of a video made up of images taken by myself, Jorja McDonnell, Gerry Grant, and Sophie Carroll in outback towns such as Roma, Wallumbilla, St George, and Dirranbandi. Furthermore, Arduino technology, wiring, and Arduino and Processing code will be used to have the LEDs sync up with the visual story video.

2 Context Review, Case Studies

2.1 Introduction – The Purpose of this Review

Since early 2017, Australia has experienced one of the worst droughts in recent history, with some of the lowest rainfall averages since 1900 (Bureau of Meteorology, 2020). Furthermore, as of the end of 2019, Australia has had 12 consecutive seasons of below-average rainfall (King et al., 2020). In addition, as of August 2020, Australia has also experienced below-average rainfall in the crucial winter months for 4 straight years now (Hannam, 2019) (Bureau of Meteorology, 2020). As mentioned in the aims and objectives of this project (section 1.2), this issue will be addressed by attempting to raise awareness for social sustainability using data visualisation and visual storytelling. Therefore, this literature review will explore and define the topics of sustainability, data visualisation, and visual storytelling. Furthermore, the methods which are used in data visualisation and visual storytelling will also be explored, with different case studies from these disciplines being looked at as well. Finally, the literature and case studies discussed in this review will be used to inform the benchmarks and insights for the project evaluation framework, which will be used as the benchmark for how I evaluate and reflect upon my designs and iterations in this project. Ultimately, this review will explore the principles of designing for social sustainability, and how physical data visualisation and evocative visual storytelling methods can be used to achieve the aims for this project.

2.2 Sustainability, and how to Design for it

The topic of sustainability is something which is not easily defined, as discovered by experts in the area, such as Leslie Paul Thiele (2013), and Helen Walker (2013). Thiele explains (2013, p. 2) that to define sustainability, it is easier to explain what it isn't. That is, to explain what unsustainability is, and perhaps more importantly, what is considered unsustainable. As she explains it, "a practice, relationship, or institution is not sustainable if it undermines the social, economic, or environmental conditions of its own viability" (Thiele, 2013, p. 2). This contrasting way of defining sustainability was in response to David Owen's quote (Thiele, 2013, p. 2), which was that sustainability is "one of the least meaningful and most overused words in the English language" (Owen, 2011, p. 246). With all of this considered, Helen Walker describes sustainability best (2013, p. 49); "Sustainability, used without further qualification, has become a container for our highest aspirations, but, until we name those aspirations, has no practical meaning other than a very general sense of possibility and continuity." This suggests that, in fact, both Owen and Thiele are correct. Sustainability can be considered quite a meaningless word until we associate the socially, environmentally, and economically unsustainable problems and issues with it. Once we discover these sustainability issues which undermine the conditions which our society is built upon (Thiele, 2013), only then do we discover what our sustainable aspirations are, and the word sustainability then "refers to a state of the world in which one's aspirations are fulfilled over a long period of time" (Walker, 2013, p. 40). This first stage of defining what sustainability is, or isn't, is an important early step in designing for

sustainability. To understand what is unsustainable about the issue/topic, and what a designer's respective sustainable aspirations are, should be an important benchmark for evaluating research and design when it comes to approaching issues of sustainability/unsustainability.

When it comes to designing for sustainability/unsustainability, there are three main factors to consider, so that the designer can achieve sustainable outputs with their creation (Walker, 2013). In particular, a design has to consider "the environmental and social impacts of a product, service or system at the same level that economic concerns are considered" (Walker, 2013, p. 130). While this statement seems to apply more to a business worried about the economic sustainability of a product more than the environmental and/or social, this consideration of all three facets of sustainability can apply to any product, design, artwork, performance, piece of music, and so on. In terms of environmental sustainability, a brand/designer/business has to think about selecting low-impact materials, reducing material usage, optimising production techniques and the distribution system, reducing the user impact, and optimising the initial lifetime and the end-of-life system (Walker, 2013). Furthermore, a brand/designer/business should consider how their product can achieve social benefits, such as addressing human needs, socially responsible use of products and services, and perhaps most importantly, designing to change behaviours and attitudes in relation to a sustainability issue (Walker, 2013). Overall, the purpose of designing for sustainability is to "satisfy people's needs in environmentally efficient, socially equitable and profitable ways" (Walker, 2013, p. 130).

Helen Walker (2013) outlines 4 key ways in which someone can approach designing for sustainability: improvement, redesign, new concepts, and system innovations. Within these 4 key approaches, improvements and redesigns of products are considered incremental changes, while new concepts and system innovations are considered radical innovations (Walker, 2013). For this project in particular, a 'new concept' will be used to design for sustainability, which means that the designer must think about "the underlying needs and how they can be fulfilled, rather than focusing on methods of improving the current design" (Walker, 2013, p. 138). In the case of this research project, the underlying needs of sustainable design include designing with the intention of changing people's behaviours and attitudes in relation to the Australian drought.

2.3 Problems in Social Sustainability

The main sustainability issue being addressed in this project is the current Australian drought, and the effect it is having on rural outback communities. While it is not the focus of this project, climate change is another sustainability issue which is not only talked about in relation to the Australian drought, but it is also talked about frequently all over the world, and it is constantly being approached by businesses and designers with new concepts, re-designs, and improvements on concepts/designs, with the intention of designing for sustainability. Rehema White and Hamid van Koten (2016) approach the issue of climate change using a new concept, hoping to "implement radical changes in social as well as environmental arenas" (White, R. M., van Koten, H., 2016, p. 2). To design for sustainability around this issue, White and van Koten developed a community engagement strategy to reduce carbon emissions for a local Scottish authority (White, R. M., van Koten, H., 2016). To achieve this, the research team used ethnographic observation and participatory design methods as part of their methodological approach to developing this strategy. After conducting this research project, White and van Koten found that these co-design methods were successful in "promoting interactions between people that enabled both the development of a strategy to engage communities in reducing carbon emissions and the acceptance and implementation of the strategy" (White, R. M., van Koten, H., 2016, p. 18). While the topics of co-design, participatory design, and the methods used within these topics are not used to achieve the

aims of my project, it is important to not how a sustainability problem such as climate change has been addressed by designing for social sustainability. Furthermore, this article makes an interesting point on engaging the community on such issues, in a bid to design for sustainability. This relates to the aims I have for this project, which is to raise awareness for social sustainability by showing the audience/community an evocative visual data story, and urging the audience to think about how they can support these rural outback communities. White and van Koten make it clear that engaging the community using their methods that they've discussed was successful in raising awareness for the issue they were addressing, and attempting to get the community to reduce carbon emissions using this strategy (White, R. M., van Koten, H., 2016). This case study shows that it is possible to have success designing for social sustainability by engaging the outside community. While the project White and van Koten presents is different from how I aim to address the Australian drought, the concept is the same, which is to design for social sustainability, and aim to get the audience to think about how they can help.

2.4 Visual Storytelling, and its Role in Designing for Sustainability

The first method which I look at in relation to designing for social sustainability is visual storytelling. To put it simply, while storytelling has no single agreed-upon definition, storytelling can refer to the "controlled delivery or presentation of information" (Bongshin et al., 2015, p. 1). Elements used within storytelling can include structures, concepts, people, tools, and channels (Bongshin et al., 2015). In addition, as Margaret Robertson explains in her book, 'Communicating Sustainability' (2018), a good narrative has a 'cause and effect', engaging characters which the audience can relate to, emotion, and a good combination of words and images (Robertson, 2018). As she states, "images enhance memory and deliver emotional impact" (Robertson, 2018, p. 38). This leads us into the realm of visual storytelling/narrative visualisation (Bongshin et al., 2015). A narrative visualisation emphasizes "visual stories that include a narrative, or a series of causally related events" (Bongshin et al., 2015, para. 6). This relates to what Robertson says makes a good story, which is having a 'cause and effect' narrative (Robertson, 2018). From this, three key aspects to creating a good visual storytelling are realised. This includes using 'cause and effect' narrative, using images that are memorable, evocative, and emotional, and finally having a medium that controls the delivery and presents the information appropriately. In the case of my project, the cause and effect narrative in my visual data story shows how the low national rainfall averages has affected the outback landscape, in the form of memorable and evocative images. Furthermore, the medium which is being used to control the delivery and present the information includes a physical data visualisation piece to showcase the cause (the rainfall averages), and a visual story video to showcase the effect (the images of the drought).

In addition, Robertson makes it well known that to tell a visual story about sustainability, the right images must be chosen and thought about very deeply (Robertson, 2018). To choose the right images, Robertson (2018) suggests planning, determining the goals of the message you want to convey (relates to the underlying needs of the sustainable design and the aims of the project), and then developing a theme for it, with some text included. Once a designer knows the theme and goals of their message/the aim of the project/the needs of their sustainable design, they can choose illustrations/photos that support these messages (Robertson, 2018). Perhaps most importantly however, Robertson (2018) explains the significance of using "positive images", which "allow the viewer to connect in a specific and positive manner" (Robertson, 2018, p. 113). The example of climate change is once again used here, with Robertson explaining that these images are effective if they show the effects of climate change in a local community, as it allows the viewer to connect to the image (Robertson, 2018) more easily. Another good example of images being used to

communicate sustainability issues is the 'before-and-after' photograph, as they are able to "convey evidence without words or logical argument" (Robertson, 2018, p. 111). This relates back to the point Robertson (2018, p. 38) makes earlier on in her book, where she explains how "images enhance memory and deliver emotional impact". Overall, if the audience can remember evocative images of the drought which are shown to them, then the visual story in the design starts to deliver emotional impact to the user/audience. If images are able to enhance the memory of the viewer, as well as deliver emotional impact while more easily connecting them to what they're being presented with, then it can be argued that the visual data story is an effective means of achieving the aims for this project.

A specific example of researchers using visual storytelling mediums such as videos to achieve the aims they have for their sustainability project is particularly interesting (Baytar & Ashdown, 2014). In this example, the researchers start out by detailing the impact the clothing and textile industry has on the environment. Furthermore, they then explain why it is so important that students in this industry know about the impacts they can potentially have on the environment (Baytar & Ashdown, 2014). To approach this issue using visual storytelling, the research team used an educational video as the medium "to establish a sense of urgency with respect to sustainability and to convince viewers that change is necessary and possible" (Baytar & Ashdown, 2014, p. 34). After showing this visual storytelling video to clothing and textile students, the research team found that the narrative structure of the video stimulated and challenged students' thinking in relation to this sustainability issue (Baytar & Ashdown, 2014). The authors also note that these results relate to a previous study conducted, which showed that it was important to target emotions and beliefs in relation to environmental and social sustainability (Baytar & Ashdown, 2014). Therefore, in terms of my project, it will be important to think about how the visual storytelling video can target emotions and actions in relation to social sustainability, as well as how a sense of urgency can be established so that the audience feels a need to support these rural outback communities as quickly as possible.

Overall, the literature talked about in this section shows that visual storytelling has quite an important role in designing for social sustainability in this project. Mediums such as images (Robertson, 2018) and videos (Baytar & Ashdown, 2014) can be used to target user's emotions and actions, something which has been noted as important multiple times. While visual stories have the same elements and concepts as written stories, these narrative visualisation mediums have the ability to enhance memory and deliver emotional impact (Robertson, 2018). Having the audience/viewer more easily remember what they are looking at, as well as be emotionally impacted by the data and visual story, will be important in achieving the project aims, which is to raise awareness for the current Australian drought and have the audience think about how they can support rural outback communities struggling through the drought.

2.5 Using Visual Storytelling to Visualise and Represent Data

In addition to using purely visual storytelling to design for social sustainability, data visualisation is the next method which will be discussed, and combining the two methods will be important in achieving the aims of this project. Using storytelling to visualise and explain data has been common for centuries now. One of the earliest examples is Florence Nightingale's chart which showed the number of deaths from the Crimean war, with emphasise on how big the problem was at the time (Kosara & Mackinlay, 2013). This sort of chart was used to show and explain the problem to the audience using visuals, rather than just analysing the numbers, and presenting them in their original and confusing form (Kosara & Mackinlay, 2013). The point of showing and explaining, rather than just analysing the data has become an important staple of communicating data to an audience. Once again, this relates back to the point Margaret Robertson makes in her book, where she explains how

“images enhance memory and deliver emotional impact” (Robertson, 2018, p. 38). This means that using visuals to display data will also be useful in helping people remember the data that they look at. To further communicate this data in a more evocative and easily understandable way, visual storytelling elements will be employed, therefore introducing the concept of a ‘visual data story’ (Bongshin et al., 2015). Much like other terms for ‘storytelling’, there is no single agreed-upon definition for a visual data story (Bongshin et al., 2015). However, it is argued that any shared data visualisation would be considered to be a data story, “given that visualisation is by definition focused on making data visible and thus on presenting data to a viewer” (Bongshin et al., 2015, para. 5).

The roles needed for communicating visual data stories include; a data analyst to explore and analyse the data, a scripter that builds the plot of the story, an editor who prepares the story material, the presenter (the designer) who is responsible for delivering the content, and finally the audience that experiences this story (Bongshin et al., 2015). In the case of my project, the presenter/designer also takes on the roles of the data analyst, scripter, and editor. As Kosara and Mackinlay (2013, p. 50) state, “there is no point in creating a story if there is no audience”. This relates to White and van Koten’s work, where they explain how important it is to engage and support the community/audience in relation to designing for social sustainability (White & van Koten, 2016). This point of engaging the community is where visual data storytelling starts to become a key benchmark for designing for social sustainability. Therefore, one of the first things a designer should perhaps think about when approaching socially sustainable design is how they can most effectively engage the community/audience using visual data storytelling.

A good example of visual storytelling being used to display data is the ‘CitySensing’ system, which was created by a team of researchers in response to seeing if they could use visual storytelling and social media data to show the audience emerging patterns in relation to their digital footprint (Balduini et al., 2015). After designing and implementing this system, the research team found that the visual storytelling methods used allowed the user to “perceive emerging patterns in the data and observe their dynamics” (Balduini et al., 2015, p. 52). This is an important point, because these findings back up the statement of visual data representations making storylines easier to understand, as well as have emotional impact for audiences. Furthermore, this study is also very useful because it shows a real-life example of visual storytelling and data visualisation being used to design for sustainability.

Overall, just as visual storytelling has an important role in designing for sustainability, these visual storytelling methods also have an important role in displaying data for users in a way that is easily understandable. An important point emerging in designing for sustainability (using visual storytelling and data) is that engaging the community/audience with stories and data is a key factor.

2.6 The Importance of Data Visualisation and using it to Communicate Sustainability Issues

The next area to discuss in relation to the topics of sustainability, data visualisation, and visual storytelling, is how important data visualisation is when communicating sustainability issues. This section will explore the importance of data visualisation by looking at three pieces of academic literature which address sustainability issues through data visualisation.

The first example saw a team of researchers design and evaluate a social visualisation aimed at encouraging sustainable behaviour (Grevet et al., 2010). In particular, the research team focused on visualising energy-saving behaviours, specifically including a function where the user can self-report their green actions (energy-saving behaviours) and view visualised data showing their personal savings over time (Grevet et al., 2010). They enabled users to interact with this data by embedding

basic visualisations and interactive functions into a website. From this, the research team found that "this type of visualisation was well liked and used", and that "the addition of social information may lead to increased participation in the site" (Grevet et al., 2010, p. 7).

The second example closely relates to the first example, as it saw a team of researchers look at "enhancing urban sustainability using 3D visualisation" (Isaacs et al., 2011, p. 163). What makes this example different is that they looked at not only aiming this data at the general public, but also local authorities, and stakeholders, as they wanted to "enable the real inclusion of valid and measurable indicators of sustainability in the decision-making process" (Isaacs et al., 2011, p. 164). Overall, this device, called 'S-City VT', looks at displaying interactive visualisations of complex information to those target groups listed above, with the goal of allowing those users to understand how their duties contribute/don't contribute to achieving a sustainable development (Isaacs et al., 2011). After designing this and testing it with users, the research team found that these visualisation methods which they used provided an "effective means of demonstrating relative sustainability changes to a wide range of stakeholders in the urban design and planning process" (Isaacs et al., 2011, p. 172).

The third and final example looked at visualising energy, resource management, and sustainable living. The challenge for this team of researchers was not only to find visualisations which were the most effective, but also find how they could use those visualisations to help residents' decisions in regard to their energy use (Bartram et al., 2010). From this, the team of researchers designed an interactive neighbourhood network for 'NorthHouse'. This application allows residents from the same neighbourhood to view their individual, and overall energy consumption compared to the community average and the 'set conservation goal', in the form of data visualisations (Bartram et al., 2010). If a user is consistently performing well in terms of energy consumption, then they receive "digital awards" which other members of the community/neighbourhood can view (Bartram et al., 2010). This application takes a different approach to sustainability compared to the first two examples, as it encourages comparison and competition to achieve environmental and social sustainability, rather than simply encouraging sustainable behaviours (Grevet et al., 2010).

Overall, these examples discussed show positive results as to why data visualisation is a very important method when designing for social and environmental sustainability. These examples have shown these visualisations are "well-liked and used" (Grevet et al., 2010, p. 7), and that they provide an effective way of demonstrating sustainability (Issacs et al., 2011). This relates to how visual storytelling and visual data stories also have an important role in making sustainability issues easier for the user to understand and comprehend, as discussed already in this review.

2.7 Using a Physical Device to Represent Data

Finally, the last topic which needs to be discussed in this project is physical data representation, and the benefits of using to visualise data. In the world of data visualisation, there are a number of ways in which a visualisation or "physicalization" can be described (Willett et al., 2017). Firstly, it is important to note the different between the physical referent, and the physical presentation (Willett et al., 2017). As Willett, Jansen, and Dragicevic explain in their paper (2017), the physical referent is the "physical object or physical space to which the data refers" (Willett et al., 2017, p. 2), while the physical presentation is the "physical instantiation of the visualisation produced by the visualisation pipeline" (Willett et al., 2017, p. 2), which basically means how the visualisation takes physical form (Willett et al., 2017). While there are many terms for many different types of data representations, for this project I want to focus on situated data representations, specifically situated physicalizations (Willett et al., 2017). As the authors explain in this paper, a situated physicalization is "a physical artifacts whose geometry or material properties encode data, as opposed to traditional

visualisations where data is mapped to pixels or ink" (Willett et al., 2017, p. 3). This refers to data representations that reside in the physical world, using different kinds of physical materials to communicate data (Willett et al., 2017). In relation to my project, I use 3D bar graph shapes constructed out of MDF board to encode and communicate the data I'm using, therefore making it a situated physicalization. This is different from an embedded data physicalization because the physical materials (the 3D bar graph) in my data presentation aren't directly associated with the physical referent (the Australian drought) (Willett et al., 2017). Overall, a situated visualisation/physicalization in my project means that the audience can look at the data and compare it to the physical referent on the screen, which takes the form of a visual story. This allows the audience to focus on the data in a local context (Willett et al., 2017). However, what is most important about using a situated physicalization is that the audience is able to make that connection between the physical presentation and the physical referent (Willett et al., 2017). This connection is something which will be noted when playtesting, and evaluating the device using the framework for project evaluation.

While an embedded data representation can change the way an audience and/or analyst interacts with data (Willett et al., 2017), there are still benefits to using a situated physicalization in this project. Firstly, situated physicalizations are flexible in their design (Willett et al., 2017). For this project, this means that these representations can be designed to run at any location (Willett et al., 2017). More specifically, the use of 3D bar graphs and a visual story in this project means that the data and message can still be understood, no matter what location or space the data is presented in. However, what is important is that contextual information is provided so the audience can more easily connect the presentation to the referent (Willett et al., 2017). Furthermore, situated representations are sometimes preferable because the datasets are usually more visually and physically accessible to the audience, which is important if the entire dataset is required for the audience to understand the message (Willett et al., 2017). Finally, there is only one minor argument for using a physicalization over a visualisation, which is that virtual representations can sometimes be weak, and lack an "object presence", mostly because of technical requirements and the level of difficulty required in creating certain virtual objects, meaning the audience "may not strongly experience the embedded visualisations as being connected to the environment" (physical referent) (Willett et al., 2017, p. 9). Therefore, while there is really no major argument for using situated physicalizations over visualisations, and vice versa, I believe there are reasons more closely related to the issue of the Australian drought that are good justification for representing rainfall data using a physicalization, which will be discussed in section 4.12.

2.8 The Principles of Designing for Sustainability, using Data Visualisation and Visual Storytelling Methods

Throughout this literature review, the high concept topics of sustainability, visual storytelling, and data visualisation have been discussed in detail. In addition, the methods for designing for sustainability have been explained as well, with academic examples of these methods being used. From this, a list of principles for designing for sustainability, using data visualisation and visual storytelling methods, have been discovered after reviewing this literature, and they will be used as benchmarks for reflecting on design concepts, as well as for a project evaluation framework.

The first thing which was discovered when designing for sustainability is that the sustainable goals of a project can only be realised when the designer understands what is unsustainable about the issue that is being approached (Thiele, 2013). Once this is the done, the designer can then think about the underlying needs of their sustainable design, based on what is already unsustainable about the issue they are designing for (Walker, 2013). Therefore, when reflecting on designs and/or evaluating a

project which approaches a sustainability problem, a designer should think about whether or not their design has served the needs of sustainability that have already been thought about. This will include thinking about the social, environmental, and economic factors of the design as well (Walker, 2013). Furthermore, authors White and van Koten (2016) make an important point of engaging and supporting the community when it comes to designing for sustainability. Thinking about how a design engages the community in relation to sustainability will be another important benchmark to refer back to when evaluating a project like this.

Secondly, when using visual storytelling as a method to design for sustainability, a number of benchmarks must also be understood as well. For example, when choosing mediums such as images or videos to use for a visual story, the designer must think about the sustainable message they want to convey, and whether or not the chosen mediums support the message/theme of their project (Robertson, 2018). Furthermore, a designer should think about whether the imagery they use is "positive imagery" (Robertson, 2018). That is, does the imagery in this story allow the audience to connect to the imagery and the story contained within it in a "specific and positive manner" (Robertson, 2018, p. 113). While something so subjective like this is harder to judge as a designer, a benchmark like this can still be addressed in something like user experience testing. Finally, narrative benchmarks which should also be addressed in project evaluation should include thinking about the structure of the story, as well as whether or not the story is evocative and has themes/characters/messages which the audience can relate to (Robertson, 2018).

Finally, when using data visualisation to design for sustainability, a few key principles must also be addressed when evaluating projects like this. When using data representation methods, the designer must first think about what their physical referent and presentation is (Willett et al., 2017). In addition, the designer should also think about how they want to present the data, and whether they want to use an embedded or situated visualisation/physicalization to do this (Willett et al., 2017). Going into more specifics (in terms of this project), if the designer is using a situated physicalization, does the presentation allow the audience to make a meaningful connection between the data and the physical referent (Willett et al., 2017). Moving away from the specifics of certain data representations, after looking at academic examples of data visualisation being used to design for sustainability, it was realised that interactive visualisations were the most liked out of users in relation to learning about sustainability issues (Grevet et al., 2010). Furthermore, with sustainability being an issue which is communicated effectively when presented evocatively, data visualisation has the potential to merge with visual storytelling, creating visual data stories. Based on this, the designer should then think about if their design engages the community in an effective and evocative manner using data. In relation to this, they should also think about how the audience can connect to the data in an interactive manner.

2.9 Examples of Problems and Themes Situated Around Sustainability Being Addressed Using Data

In order to further understand how a device could be designed for sustainability in an evocative manner, I decided to look at some examples which addressed sustainability issues using data and/or evocative visual storytelling.

The first example, 'Silent Tides' by Nori Takagi, is an interactive installation which aims to raise awareness of the impact of climate change on coastal communities, showing how rising sea levels would affect communities such as Lennox Heads (figure 2) (Takagi, 2019). The biggest strength of this piece is how it uses data to inform how the 'water table' can alter the user's surroundings when interacting with it (Takagi, 2019). Takagi uses this interaction with the intention of "encouraging self-

reflection on how we are impacting the environment" (Takagi, 2019). This is a good example of designing with the intention of changing attitudes and behaviours towards a sustainability issue (social sustainability), and provides inspiration on how data could be used to inform an evocative device which is designed for tangible interaction and social sustainability.

Figure 2: 'Silent Tides' data visualisation example

The second example, 'Australia is Burning', by Anthony Hearsey (figure 3) is a 3D rendered visualisation of a map of Australia, showing all the bushfires which occurred from the 5th of December 2019, to the 5th of January 2020 (Hearsey, 2019). Much like 'Silent Tides', this design uses data relating to a sustainability issue to create an evocative image which shows Australia "on fire". This use of data to convey how bad the bushfires were in an evocative manner is particularly inspiring. However, a negative for this visualisation was that it looked too realistic, meaning that many users thought this was a single image taken from space by NASA, rather than a visualisation of data which spanned across a month. Once users discovered this wasn't a single photo taken from space, this visualisation was labelled as "fake news". This negative implication of making a visualisation too realistic is something which may have to be considered when designing an artefact for this research project.

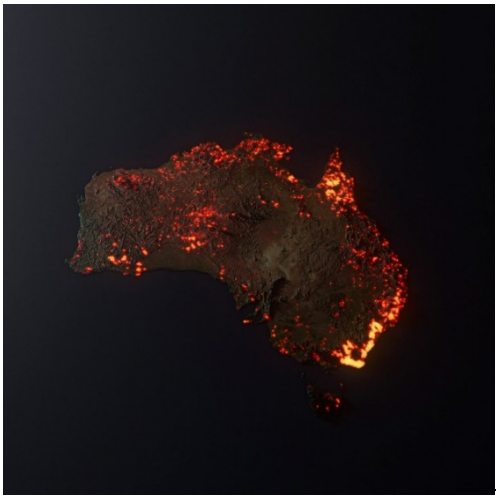


Figure 3: ‘Australia is Burning’ 3D visualisation

These contextual examples above show how methods such as visual storytelling and/or data visualisation can be used to design for social sustainability in an evocative and effective manner. Furthermore, these examples also relate to Australian sustainability issues, and show how these designers have been able to make their visualisations connect to the audience.

While these examples quite closely relate to topics and the gap in the research being approached, the project being discussed in this research proposal will be different as it will make use of both data visualisation and visual storytelling to design for sustainability, rather than just one of those methods on their own.

2.10 Summary

Overall, this literature review has discussed the high concept areas of sustainability, the importance of designing for social sustainability, visual storytelling, and data visualisation. Furthermore, the methods used in these specific disciplines have also been discussed as well. This has been done by reviewing literature surrounding these topics and gathering insights and benchmarks. These insights and benchmarks will be used to form the framework for project evaluation, which will be used to evaluate and reflect on different design concepts, iterations, and prototypes.

3 Methodology, Design Process

3.1 Methodology and Process

The methodology which I will be using in this project is based on a practice-based research methodology (Candy, 2006). A practice-based research methodology means that a creative design piece is used as the basis of contribution to knowledge (Candy, 2006). This can be done through the use of many creative design artefacts; however this project focuses on using a physical, interactive, and performative piece/artefact as the basis of contribution to knowledge (Candy, 2006). Ultimately, a practice-based research methodology means that while the context, significance, and claims of the research can be written down, the creative outcomes (the artefact) of the research are required to gain a full understanding (Candy, 2006). Therefore, this research methodology will be used to create a device that is designed for social sustainability, through the use of data visualisation and evocative visual storytelling.

The design process which I am using for this project has been formulated over my 4 years of study at university, and is also based around Bill Moggridge's cyclical design process which he details in his book, 'Designing Interactions' (2006). In addition, more specific research tools and methods will be mainly used to gather the necessary data/visual story content needed to complete this project. Firstly, in Moggridge's process, the designer synthesizes a design problem and question, which is done to properly understand the client's constraints they have outline in the brief (Moggridge, 2006). In the case of this research project, there is no client or brief that needs to be understood by the designer, but synthesizing a proper design problem and question is still necessary. The next step of this process is to frame the design problem/question around high concepts that relate to the research topic. These high concept topics are then further researched using peer-reviewed/academic sources, which will be discussed in the form of a full literature review (found in chapter 2 of this document). This literature review will be used to clarify the issues/topics discussed in this project, as well as gather and apply insights (Moggridge, 2006). These insights will then be used to form the basis of a framework for project evaluation, which can be found in the 'Analysis' section (section 3.3) in this chapter. At this stage of the process, it is important to note that this is where it starts to become cyclical. The next steps of the process then include brainstorming, conceptualising, iterating and refining, prototyping, and testing (Moggridge, 2006). Throughout these cyclical stages of the design process, the framework for project evaluation previously mentioned will be used to benchmark key aspects of the different methods I'm using, as well as help with reflecting on the different stages of the process I go through in this project. This research done into Moggridge's iterative design process has helped me form my own design process that I have used for this project, which includes 7 stages (examine and understand brief, brainstorm, conceptualise, iterate and refine, prototype/build, test, and final build). This iterative design process and its stages are detailed in the graphic below (figure 4).

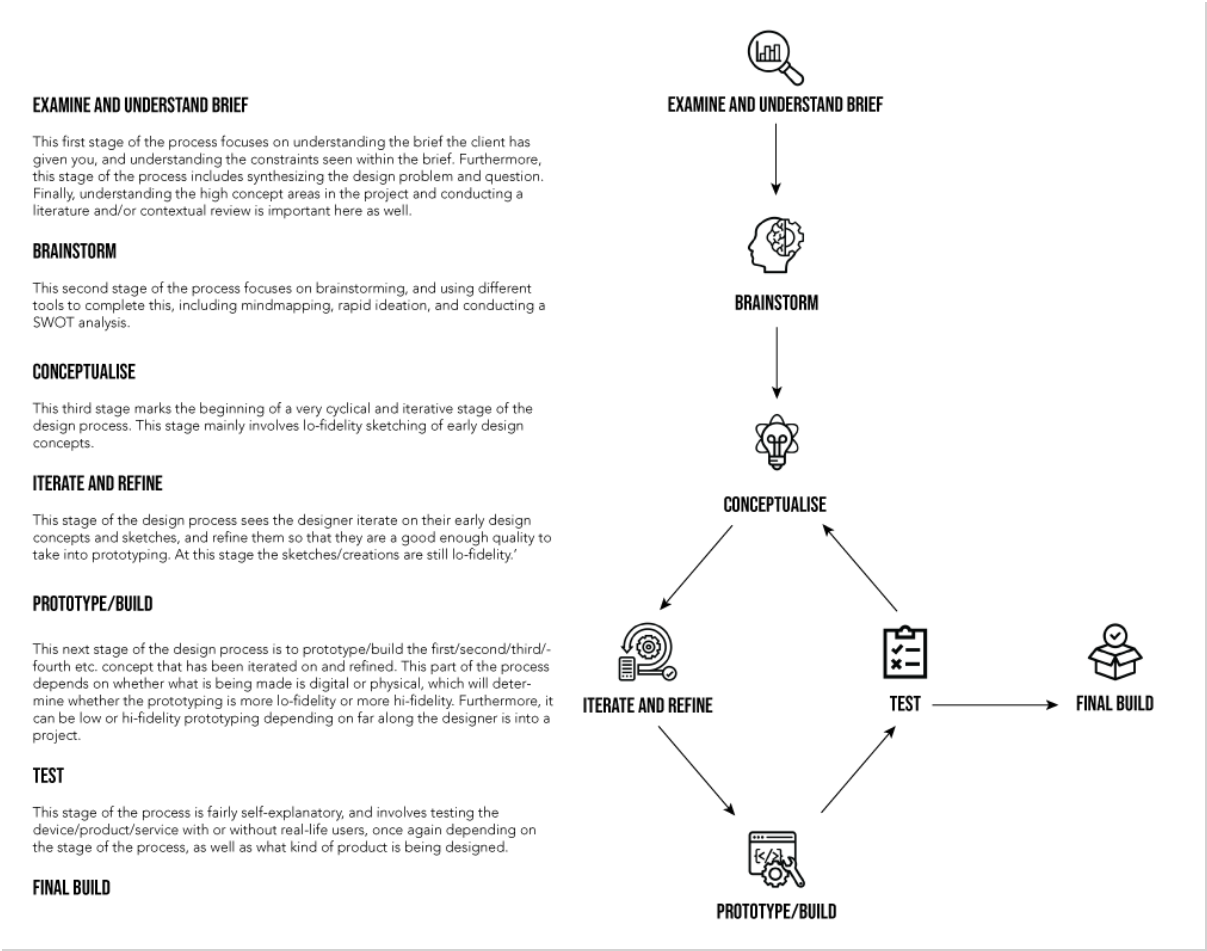


Figure 4: My Design Process

Furthermore, now going into more specific methods being used throughout the project, photographic observations will be conducted in the prototyping stage of the process. In particular, this will involve going to outback Queensland towns such as Roma, Wallumbilla, St George, and Dirranbandi, and taking high quality photographs and videos of drought-ridden landscapes. Furthermore, where possible, photographs of contrasting (healthy landscapes, full of water) landscapes will be taken to show the audience/community both sides of the drought. From this point, the cyclical process of iterating, prototyping, and testing/evaluating will continue until a final device is reached. Overall, this iterative design process is very cyclical and flexible in nature (Moggridge, 2006), meaning that many iterations of the design concept will be conceptualised and prototyped upon. Ultimately, many different steps of the design process will be re-visited multiple times.

3.2 Production Timelines

As mentioned in section 3.1 ('Methodology/Design Process'), the process for this project is a cyclical and iterative design process based off of Bill Moggridge's iterative design process (2006). The stages in my design process include examining and understanding the brief, brainstorming, conceptualising, iterating and refining, prototyping/building, testing, and building the final device. The cyclical parts of this process (refer to figure 4) include conceptualising, iterating and refining, prototyping/building, and testing. This process has also been used to inform how I plan my project and build the timelines which would help me organise my time for the project throughout the year.

The first timeline which I had used at the start of the year was a month-by-month framework for how my project should be tracking at different major milestones throughout the year (refer to figure 5 below).

Figure 5: Project Evaluation Timeline, with Major Milestones from March to November 2020

The next timeline is the production timeline, which was created with the aim of planning the second half of the year, with more specific milestones that related to the work that would need to be completed to finish this project (refer to figure 6 below).

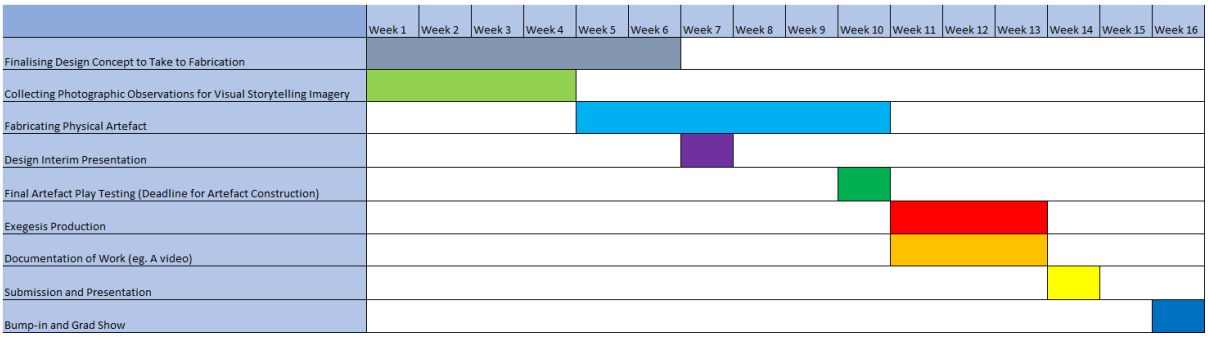


Figure 6: Production Timeline for the Second Half of the Year

The final timelines which I have used towards the end of the project includes the exegesis production timeline and the making schedule. Both of these were created once I had a finalised concept and knew what I would be creating for this project, to support the claims of my research. The exegesis production timeline (refer to figure 7 below) was used to plan how I would finish the writing of my exegesis (to a high standard) before submission. The making schedule (refer to figure 8 below) was used to plan how I would construct the physical device and visual story video in time for final artefact play testing, and most importantly, the formal artefact submission and review. This included thinking about laser cutting different pieces, wiring and soldering Arduino technology with LEDs, constructing the device using the laser cut pieces, making the visual story video, constructing the device using the laser cut pieces and putting all the Arduino technology and LEDs in the device, and finally play-testing.

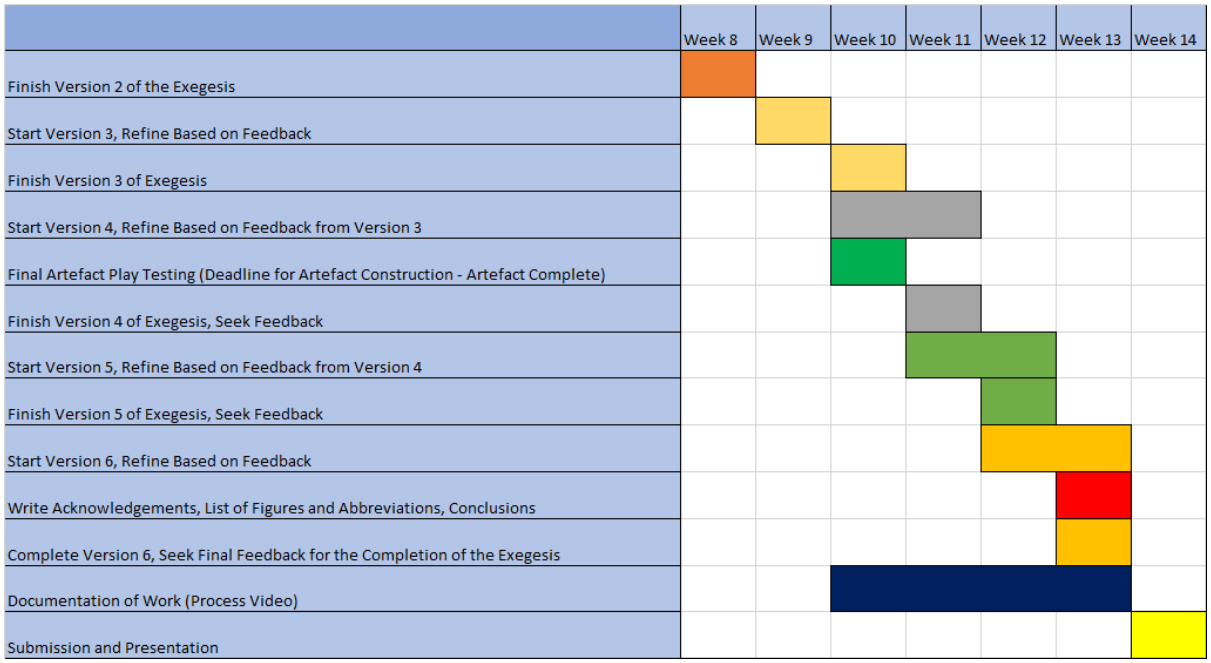


Figure 7: Exegesis Production Timeline

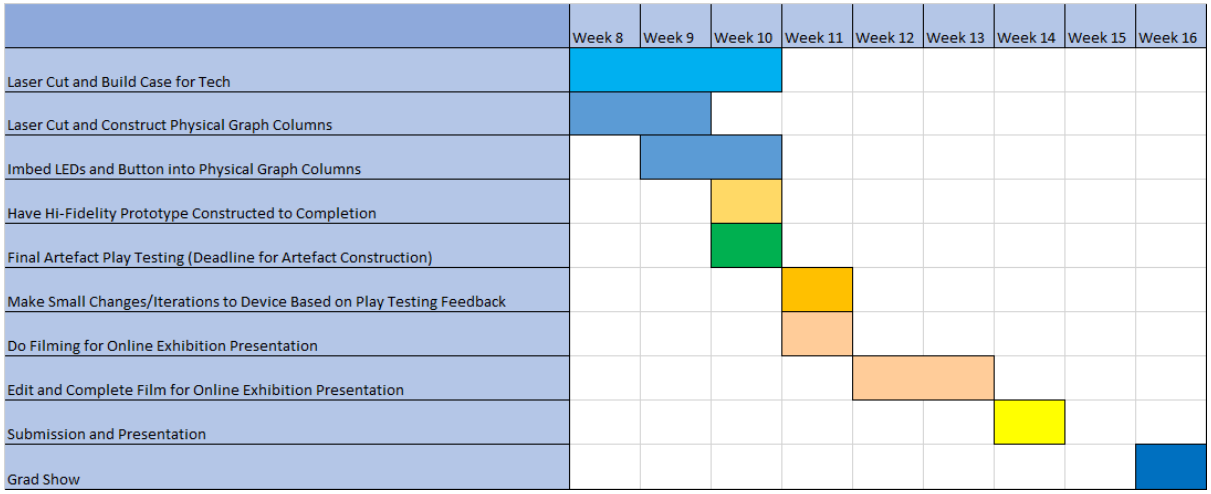


Figure 8: Making Schedule

3.3 Framework for Project Evaluation

As mentioned, the aim for this project is to raise awareness for the Australian drought and get a conversation started around supporting local outback communities, using evocative visual data storytelling. To analyse the final reference design and its effectiveness in raising awareness for social sustainability in relation to this issue and the aims associated with it, a focus will be placed on developing a framework for project evaluation through the extensive research done in the literature review. This framework for project evaluation will then be used as a checklist to analyse the device's effectiveness in presenting an evocative visual data story that shows the audience the effects of the drought through data and imagery. While adjectives such as "evocative" are subjective for each member of the audience, and are therefore hard to design for, methods and examples from successful case studies looked at in the literature review will be used as benchmarks when reflecting on the different concepts, iterations, and prototypes in this project.

Therefore, after researching the different topics and methods discussed in this project in depth, I came up with a list of key aspects that would be needed to use the methods in this project in an effective manner. This list would ultimately make up the framework for project evaluation, which would not only be used to benchmark and analyse the prototypes and iterations, but also help reflect on these iterations and concepts in the process section of this document (section 4).

This framework for project evaluation is also roughly based on the design process used in this project, and includes:

- Conceptualising (designing for sustainability, and data visualisation)
    - Has the designer thought about what is unsustainable about the issue that is being pursued?
    - Based on what is unsustainable about their issue, has the designer then outlined the underlying needs of the sustainable design?
    - Has their design then served the underlying needs of the sustainable design issue that they've outlined. Based on how specific the designer chooses to be with sustainability, this includes thinking about social, economic, and environmental factors.
    - What is the physical referent and physical presentation of the data?
- Prototyping, iterating, and refining (the key aspects of the methods used to create the device)
    - Data visualisation
        - Make the data visualisation interactive. Research showed that the most successful visualisations were the ones that engaged the audience when they were learning about/being shown a particular sustainability issue.
        - The data visualisation should effectively engage the community, therefore making the audience want to think about how they can support the sustainability issue. This can be measured through feedback in artefact play testing.
        - The visualisation should also be easily readable and understandable for the audience. That is, can the audience understand what data they are looking at and be able to read it without difficulty. This can also be measured through feedback in artefact play testing.
        - In relation to the concept of this project, does the data visualisation still reflect the metaphor of rainfall.
        - For situated physicalizations, does the physical presentation allow the audience to make a meaningful connection between the data to the physical referent?
        - Does the design of the physical presentation allow the data to be presented in any location or space?
        - Is the dataset in the situated representation visibly and/or physically accessible for the audience to look at? This is crucial in having the audience understand the data and the sustainability message.
    - Visual storytelling
        - Does the visual story use the key elements needed to make a good story? This includes narrative structures, concepts, and people/engaging characters.
        - Does the chosen medium (image, video, physical visualisation etc.) support the sustainable message the designer wants to convey?

- Does the chosen medium control the delivery and present the information appropriately?
- Does the visual story use “positive imagery”? That is, does the image allow the audience to connect to the imagery? This can be measured throughout play testing.
- Does the visual story have evocative themes/characters/messages that the audience can relate to?
- Does the story use a good combination of words and images?
- Does the visual story use a ‘cause and effect’ narrative?
- Does the visual story contribute to engaging the community/audience, along with the data visualisation?

4 Project Process

4.1 Initial Design Concepts from First Proposal

The process of designing a device for this project started with sketching initial design concepts. These early ideation sketches aimed to showcased how data could be visualised in an interactive device. Considering this was very early in the project, I wanted to conceptualise devices like these because they related to the interests I had in sustainability, interactive/tangible design, and data visualisation.

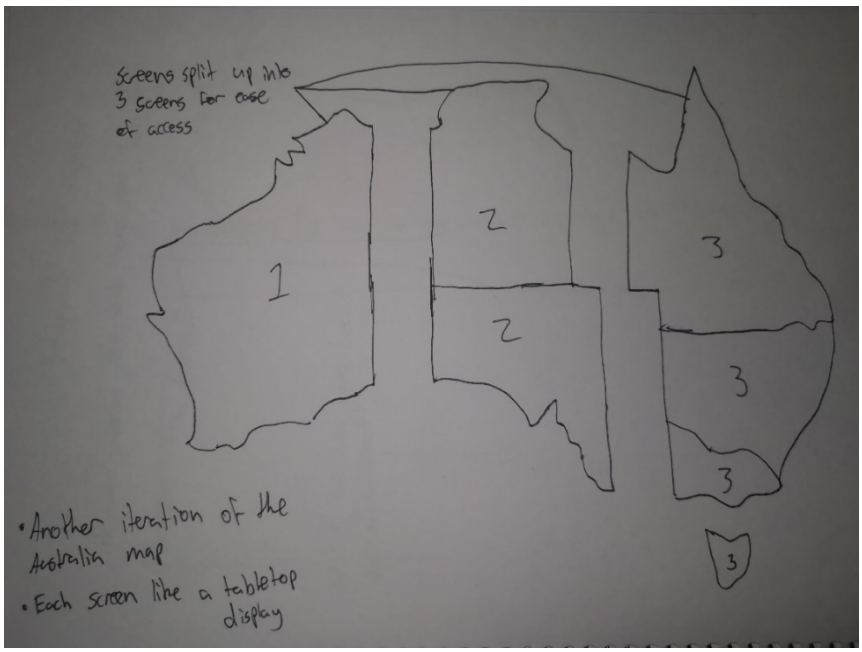


Figure 9: Australian map visualisation

Figure 9 above is the first example of these physical data visualisations that I wanted to conceptualise. This particular visualisation uses an outline of Australia separated into three sections, with each section showing data for one part of a whole story. For example, part one would details average temperature and rainfall, part two would show how climate change had affected the drought, and part three would explain how the drought has affected outback people and communities. When conceptualising this visualisation, I believed that this tabletop display could present data and images in a structured, effective, and evocative manner. I particularly liked how this concept could be interactive for users, therefore further engaging the audience in the sustainable design. This is then where I started to incorporate the idea of a visual story into my concepts, and started researching the high concept area. In terms of mediums, this concept would

use digital screens, so the audience could interact with the data through touch. The main problem with this concept was scope of creation, which means that creating digital touch screens in the shape of Australia would be very difficult. After reflecting on this problem, I realised that I would have to narrow my scope of creation, particularly in terms of difficulty. This would include thinking about using different mediums, or most likely, using different shapes for data visualisation in new iterations/concepts.

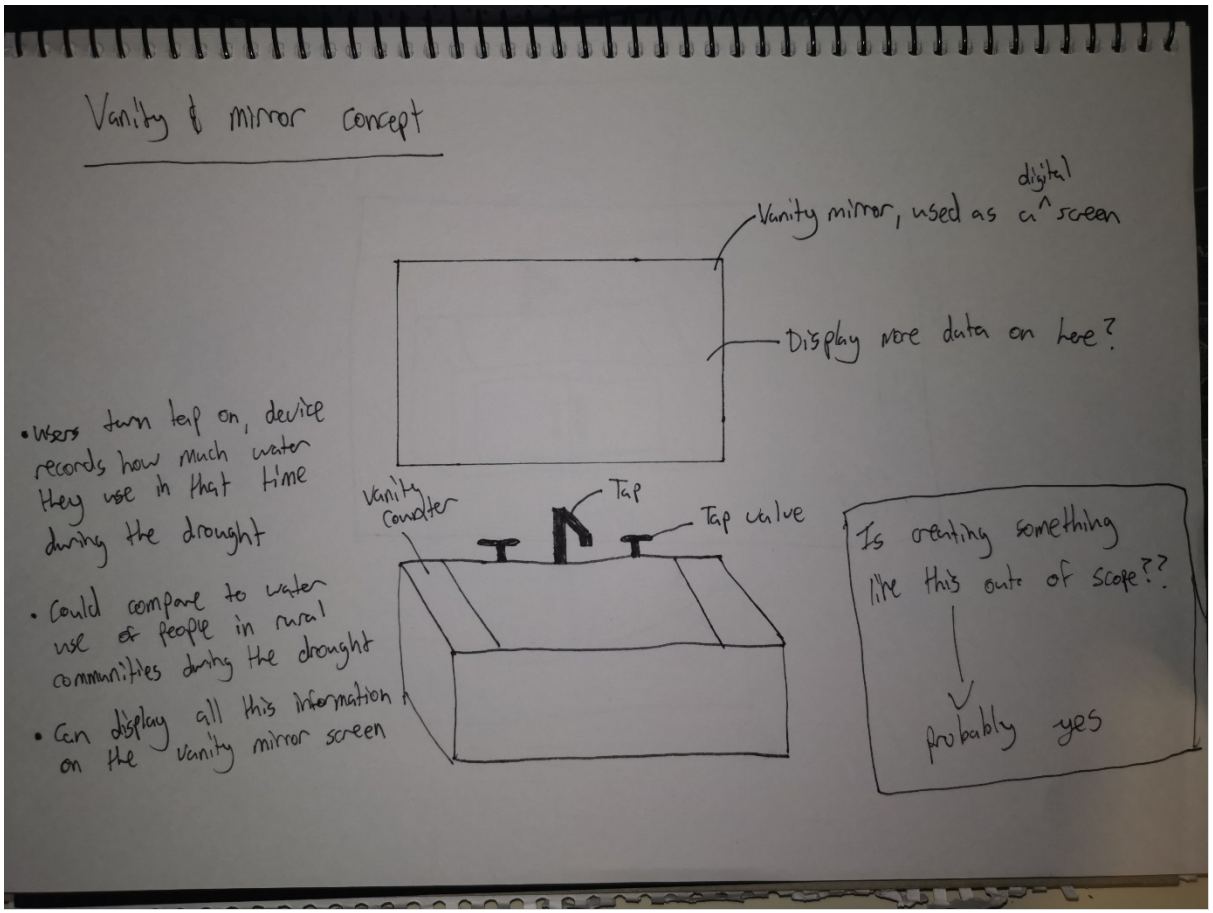


Figure 10: Vanity and mirror concept

Figure 10 above is an extension of the thoughts and reflections discussed with the previous concept. This vanity and tap device was conceptualised to represent average water usage for an individual person and how it affects the country in terms of the drought. In particular, the user would be instructed to turn on the tap for how long they think they use water each day. This action would activate a sensor which would track how long the user has left the tap on, and this data would be displayed on a screen in front of the user. This data would be accompanied by images which would show the user how their water usage affects the drought-stricken communities that are desperate for water. Personally, I liked this concept because it made the users one of the main characters in this visual data story. Because the users would be contributing their own water habits and seeing how it affects outback communities, I believe they would be able to engage themselves in the issue in a more emotional and personal manner. In addition, I believe this concept would be much easier to create. Finally, this concept also relates to the project aims, as it raises awareness for the drought by showing people how their own behaviour is affecting rural communities struggling through the drought, and perhaps encourages them to think about changing their behaviours or supporting these outback communities.

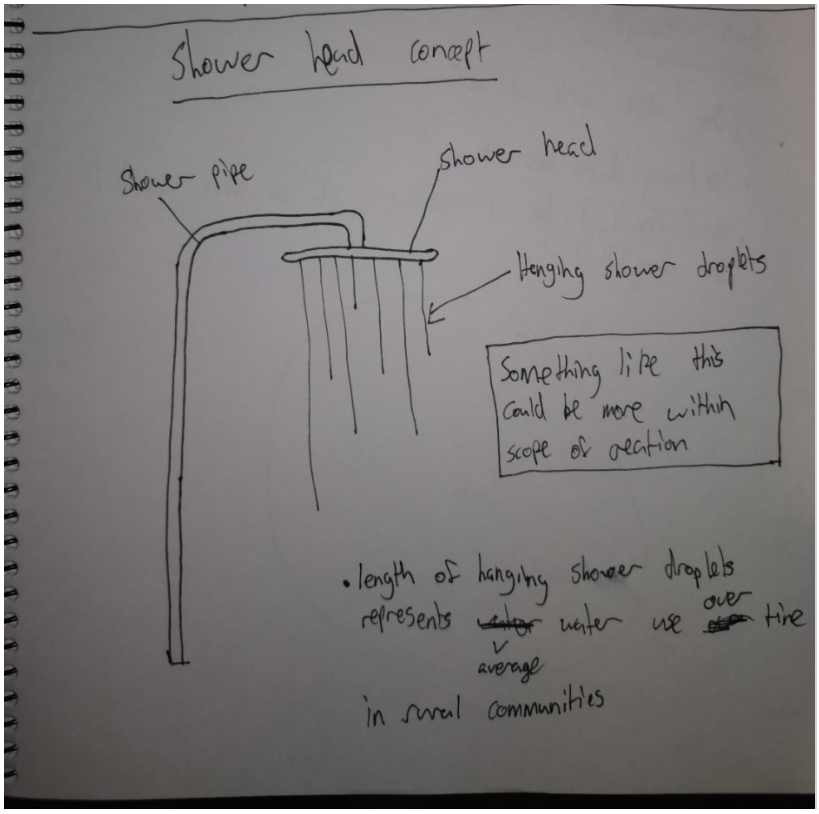


Figure 11: Shower-head concept

The concept in figure 11 is a close iteration of the vanity device, with the only difference being the medium in which the data is presented. In particular, the length of the water droplets coming out of the showerhead represents average water use throughout Australia over a set period of time. This data would also be compared to images of the drought, showing the audience how their water usage has affected rural communities. Much like the previous concept, I liked this device because it made the user one of the main characters in the visual data story, automatically giving the story an engaging character for the user. However, one thing I didn't like about this concept is that it didn't originally afford tangible interaction. Thinking about this, I decided to add tangible interaction to the concept, as it was one of my main interests from the start. In particular, the users would be able to push or pull the water droplets to change the data for the better or worse. When the data is changed, the user would then be able to see how the change would affect the drought for the rural communities. I believe that this interactive feature would add another layer of depth to the visual data story, because the user would be able to see how their changes in behaviour (in regard to water usage) would affect the drought for rural communities, in real time.

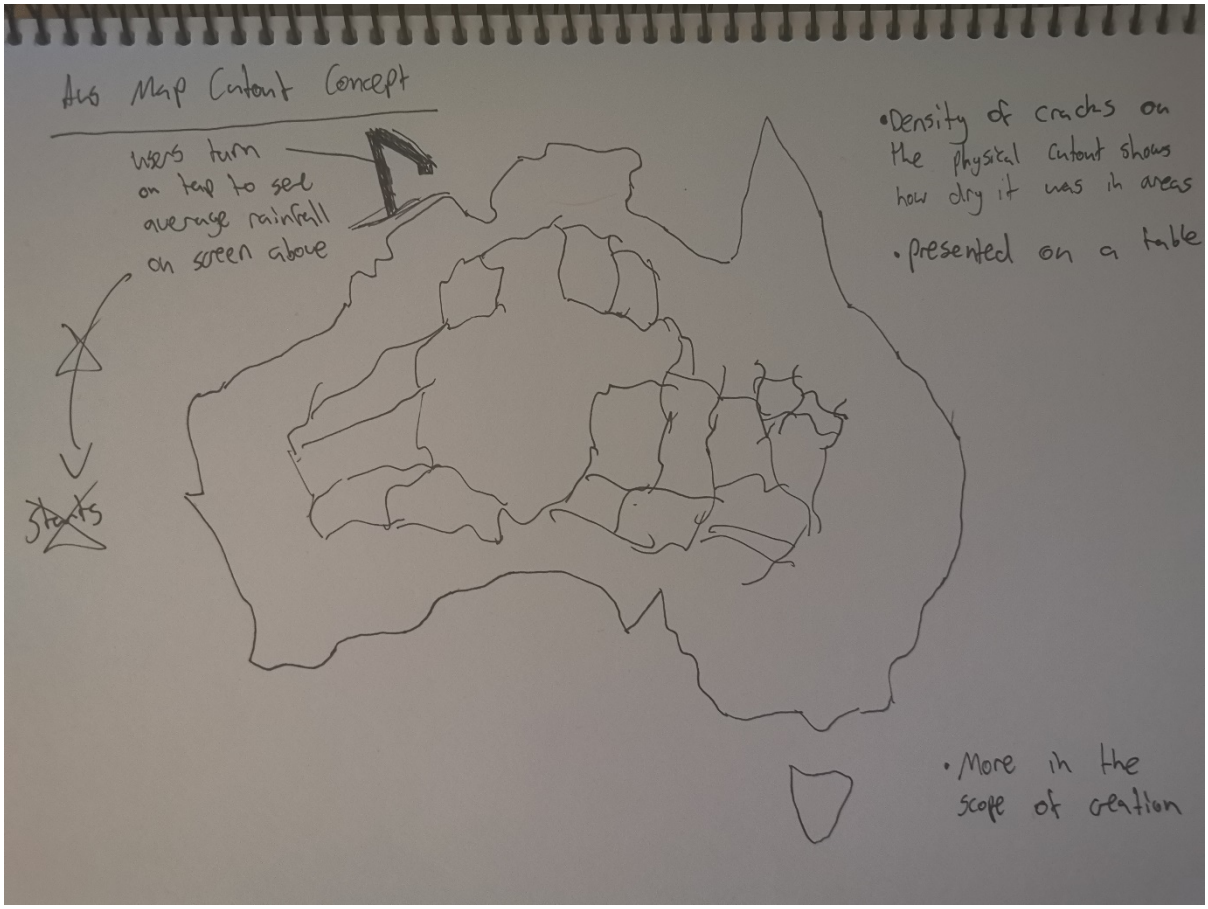


Figure 12: Australian map cutout concept

The concept in figure 12 is a call-back to the concept in figure 9, as it is a tabletop device that uses the density of dry cracks to show how dry it has been on average in Australia throughout the drought. The data in this visualisation was informed by a digital visualisation taken from a Sydney Morning Herald article (Hannam, 2019) (see figure 13 below). This concept also includes an interactive button (in this case, a water tap, representing water/rainfall) that the user can press to trigger a visual story on a screen above the tabletop visualisation. This visual story would be presented in three parts, explaining how bad the drought has gotten in terms of rainfall/temperature, how climate change has affected it, and how it has affected rural communities. In addition, the medium for this concept would mainly include MDF board cut in the shape of Australia, as well as a visual story video displayed on a projector screen. I initially liked this concept because it allowed the audience to easily compare a large amount of data with imagery of the effects of the drought, on the screen above the visualisation. Furthermore, I believe the colour and texture of the MDF board would also give the physical visualisation a more authentic and environmental feel. One negative thought I had is that perhaps the physical visualisation could afford more buttons for the user to interact with. This could include one button for each part of the story etc.

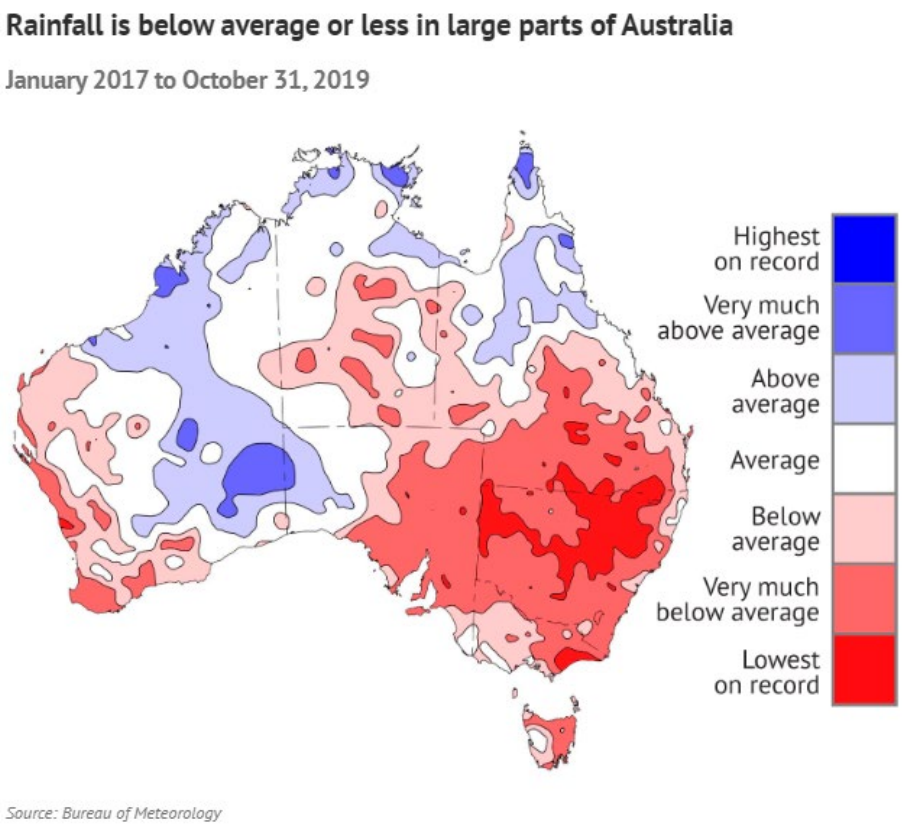


Figure 13: Rainfall averages for Australia from January 2017 to October 2019 (Hannam, 2019)

4.2 Developing Further Iterations and Design Concepts

This section of the project process looked at iterating on feedback and self-reflections from the initial design concept proposals (section 4.1). In particular, this stage of the process aimed to go into further detail with concept sketches, as well as move into more developed, lo-fidelity prototypes.

The first task I completed in this stage of the process was moving some visualisations from sketches to Adobe Illustrator. Figure 14 shows a screenshot of the visualisation from figure 12 (found in section 4.1) in Adobe Illustrator. This Illustrator sketch has hand-drawn dry cracks placed over the top of the original data, giving an early indication of what this kind of visualisation would look like. As mentioned before, the dry cracks represent the below-average rainfall seen across Australia. I liked how this visualisation looked in Illustrator because it used a well-known symbol of the drought (the dry cracks) to show the audience how much of Australia has been affected by below-average rainfall. While I was initially a fan of this concept, very helpful feedback encouraged me to think about whether a map was the best to way to represent this data or not. In particular, it was noted that something which the audience could more easily relate to would be better for representing data which occurs on such a large scale like this rainfall data. For example, I was told about a data visualisation which represented the number of asbestos deaths across Australia. To represent this, the designer visualised the number of deaths by showing them as the length of the bus route from the QUT Garden's Point campus to the QUT Kelvin Grove campus. This meant that the university students who looked at this visualisation (because the visualisation was presented mainly on campus) could understand the scale of it more easily. After thinking about this feedback and the example I was given, I decided to go back to sketching more concepts/iterations.

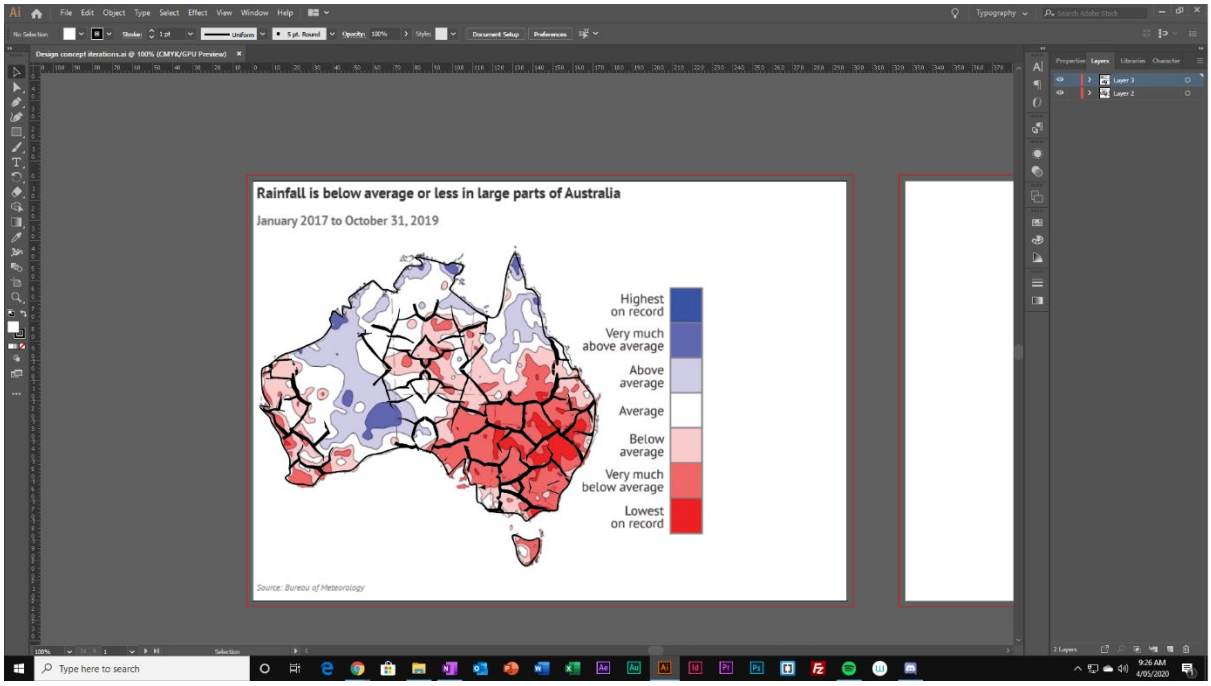


Figure 14: Visualisation of below-average rainfall data in Australia throughout the drought

The design below (figure 15) was conceptualised based on the feedback from the design in figure 14. The water tank would be used to hold a small amount of water to represent the below-average rainfall that was seen across Australia during the drought, with a full tank representing what the national average should be. To make this device tangibly interactive, the user would be able to turn on the tap/hose that would fill the tank to the amount that represents the data. Then, the water would go down a drain and back into the original tank where the next user would be able to turn the tap on again. What I liked about this concept is that I believe it addressed the feedback from the previous concept. More specifically, this concept allowed the audience to easily relate to how the data was being presented, mostly because turning on a tap and having it fill a tank with water is something that most people would have done every day for almost their whole life.

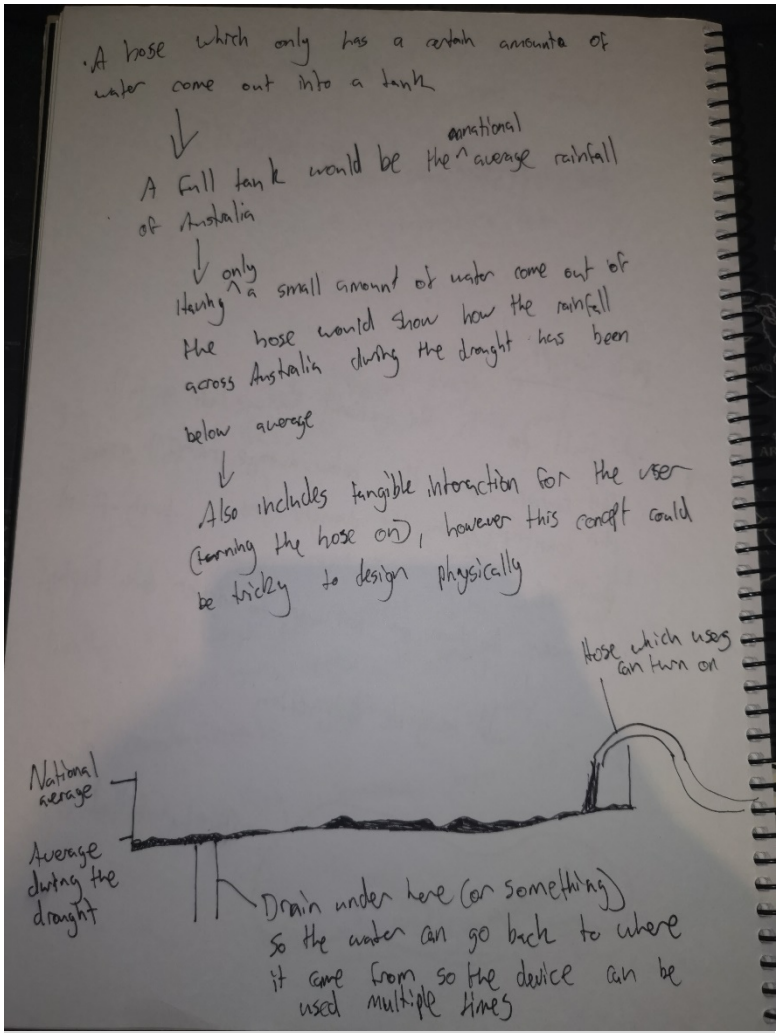


Figure 15: Water tank concept

The next concept (figure 16 below) uses a clock as the medium, and it makes use of more visual imagery, rather than a physical visualisation like the water tank in figure 15. The 12 numbers on the clock would represent each month of the year, and once the clock goes through the hour, then a new year would be displayed in the middle of the clock. In the background of the clock, or perhaps on a different screen, a visual imagery and statistics display would take the user through each month of the drought. While I believe this medium for data visualisation made it easy for the audience to connect with the data, I just had a feeling this wasn't the concept that could be used for a final prototype. Furthermore, at this point in the process, I was in a "designer's block", struggling to come up with new concepts that reflected the high concept topics, and the project aims I was looking to achieve. Therefore, I do believe that this concept was more or less a "filler concept" at the time of conceptualisation.

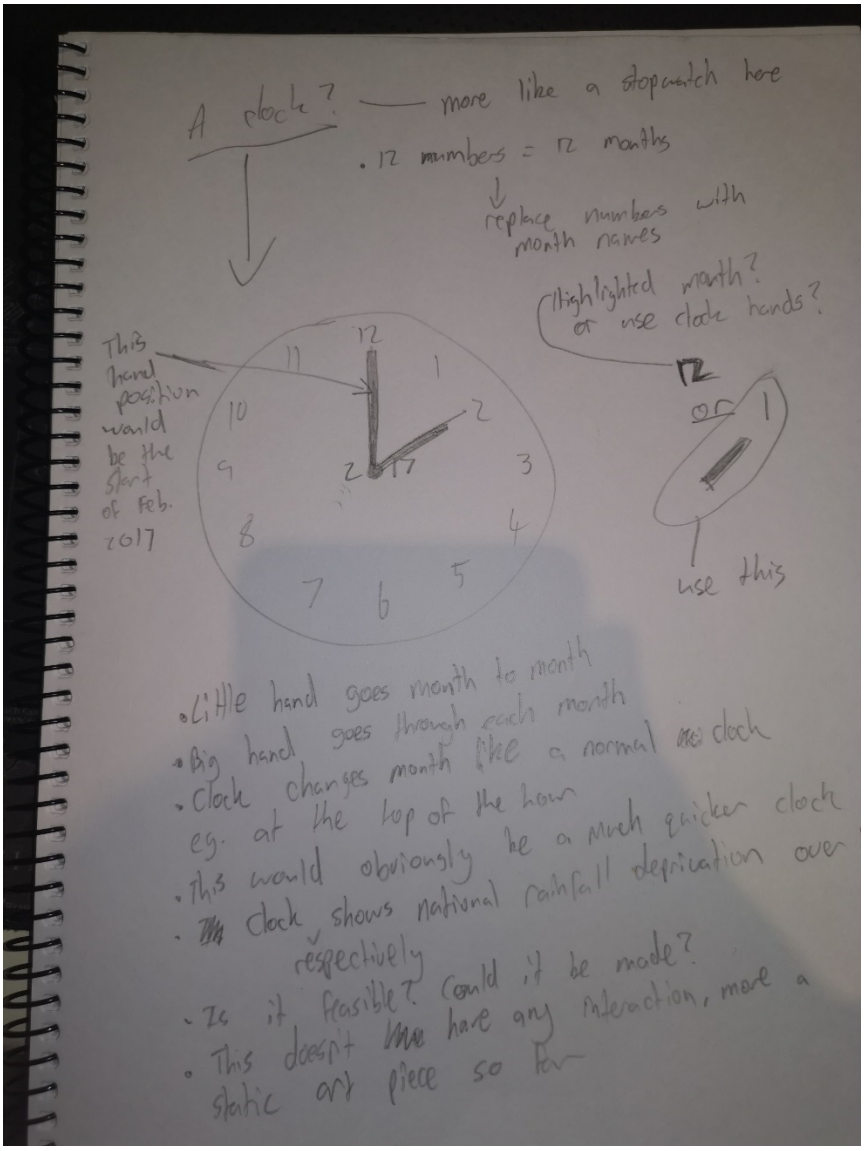


Figure 16: Clock Concept

4.3 Photographic Observations from the Outback

At this stage of the project, I wanted to start gathering images of a drought-stricken outback Queensland for the visual data story. While most of these images in this section would not be part of the final visual story, they were key in providing inspiration for the kind of images I wanted to gather in order to produce an evocative narrative. Besides the pictures which can be seen below in figures 17 to 22, a link to a time-lapse of the journey between Roma and Wallumbilla (roughly 20 minutes) can be found here: https://www.youtube.com/watch?v=jp4_y8vwwzE&feature=youtu.be. This timelapse details a truly heartbreaking scene, which shows how dry the landscape still is in the outback, even after good rains in late January/early February. For myself, looking at these photos, I still find them heartbreaking and emotional to look at, simply because of the dry landscape and dead fauna. When showing these images to others, words which were thrown around included "nostalgic", "eye-opening", "illuminating", "frightening", "emotional", and "upsetting". These sorts of words suggest that people already start to connect to the imagery here. One word that was particularly interesting was "nostalgic". This suggested that people have travelled through a landscape like this at some point in their life, meaning that people who don't permanently live in the outback will be able to connect with these images because of past experiences.

Figure 17

Figure 18

Figure 19

Figure 20

Figure 21

Figure 22

4.4 Developing Physical Prototypes

This section in the project process looked at combining ideas of data visualisation and visual storytelling, with the goal of designing a concept/prototype to present at the first design proposal, which was at the halfway point in the project. In particular, I got inspiration for the visual imagery aspect of these ideas from the photographic observations I conducted in outback Queensland. The emotional/evocative aspects of this media will be a key part in telling this visual data story.

At this stage of the design process, I started working with lo-fidelity, physical prototypes, rather than concept sketches. I wanted to start prototyping so I could more easily visualise what these concepts would look like in real life. Furthermore, I also wanted to explore how data could be visualised in a 3D space, and also see how a visual story could be constructed in real life as well. In particular, I wanted to work on prototyping the water tank concept seen in figure 15 (section 4.2). Firstly, to make a lo-fidelity prototype of this concept, I needed to gather the necessary data to inform the visualisation. The screenshot below (figure 23) shows data from the Bureau of Meteorology, which shows how total rainfall across Australia for 2019 was 40% below average (Bureau of Meteorology, 2020). This 40% difference is represented in the tub of water in figure 24, which shows the tub filled to 60% capacity. Furthermore, I also put a blank projector screen in the background, so that I could see what a visual story would look like with the data, using Adobe Illustrator to put an image on the projector after the image of the set-up had been taken.

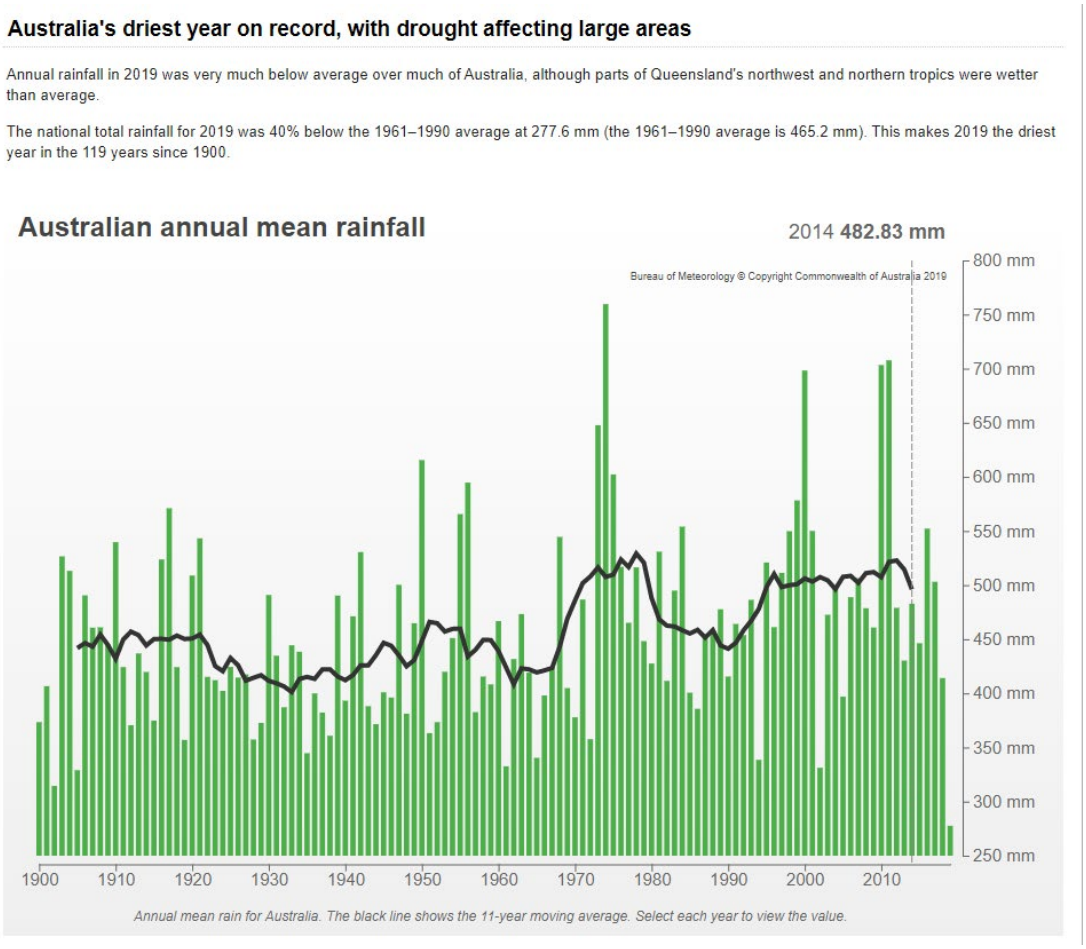


Figure 23: Australian annual average rainfall (note the 2019 average on the far right) (Bureau of Meteorology, 2020)

Figure 24: Lo-fidelity physical prototype of a tub of water

Figure 25: A lo-fidelity prototype showing the visual imagery on the screen above in relation to the below-average rainfall visualisation

What I like most about this concept iteration is that I started to feel that something like this tells a linear and understandable, yet effective and emotional story. Specifically, the story in this concept shows the audience how the extreme lack of rainfall throughout 2019 effected the dry landscape in the imagery on the projector screen. In future iterations, the water visualisation would obviously be contained in a custom-built tank, with buttons for tangible interaction being available as well. However, upon reflection, I soon realised that this concept was very similar to Nori Takagi's "Silent Tides" sustainability prototype (discussed in section 2.9), even though the sustainability issue being approached was different. This concept was very similar to Takagi's device for a few reasons. Firstly, the concept was similar because it used a tub of water as the medium. Secondly, the concept used projected visuals on a screen above the water to help the audience understand the issue, and finally, the concept also used these mediums to explain a sustainability issue and raise awareness on the importance of social sustainability. Therefore, I decided that in future iterations I would have to change how the data is visualised. Overall though, I still believe that this was a good physical visualisation that showcased how something like this would look in real life. Further feedback addressed the fact that I needed to narrow the scope of what I was focusing on, rather than targeting a broad area of what is already a very broad subject (the Australian drought). Therefore, at this stage of the project, I decided that I wanted to focus on man-made climate change. Overall, what I learnt from this prototyping is that using physical data visualisation and imagery to make a visual data story is at least a very real possibility.

4.5 Addressing the Feedback from the Previous Prototype

The main thing I wanted to address from the previous prototype was the medium and design that I would be using to create the physical data visualisation. What I liked most about the previous concept was that it used actual water to represent rainfall data. However, what I didn't like about the concept was that it was more or less a waste of water, therefore having a negative impact on environmental sustainability. Furthermore, it was very similar to Nori Takagi's "Silent Tides" project, which was discussed in the previous section. Therefore, my first thought when designing a new concept for this project was to make a device that used purely physical materials, while keeping with a structure that represented the rainfall metaphor. The sketches below (figures 26 and 27) introduce a new concept; a physical, tabletop data visualisation piece that takes the form of a wave (representing a metaphorical wave) through the use of 3D bar graph columns. The data in this visualisation would detail the monthly rainfall averages for Australia from January 2017 (the start of the drought) to August 2020 (present) using the previously mentioned bar graph columns. In particular, the bar graph columns would be arranged so each year would have its own row (eg. Rainfall averages for 2017 in the back, rainfall averages for 2018 and 2019 in the middle, and rainfall averages for 2020 in the front).

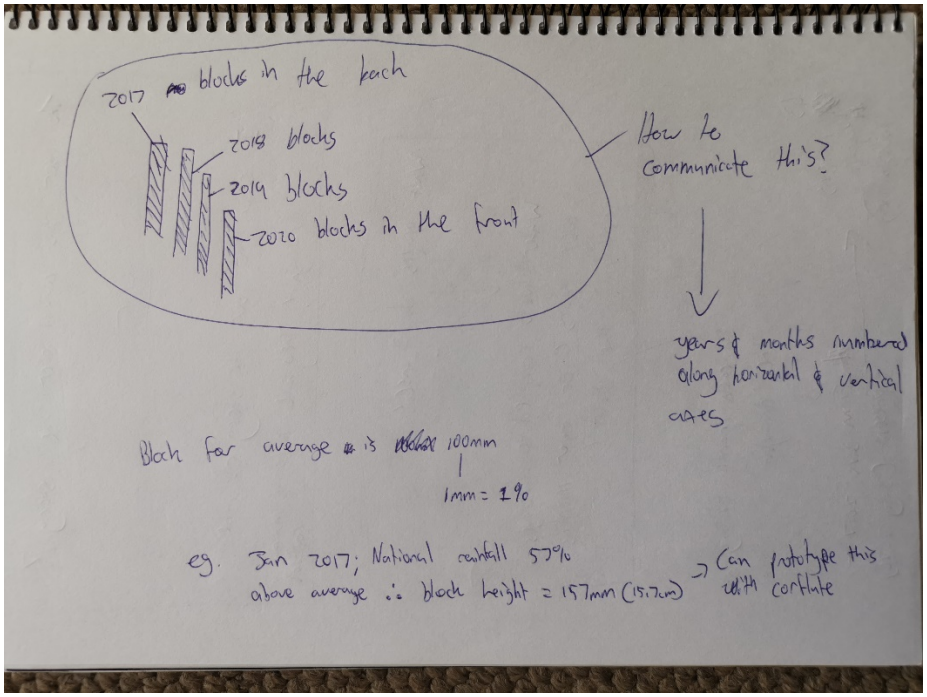


Figure 26: Initial sketches of the new prototype

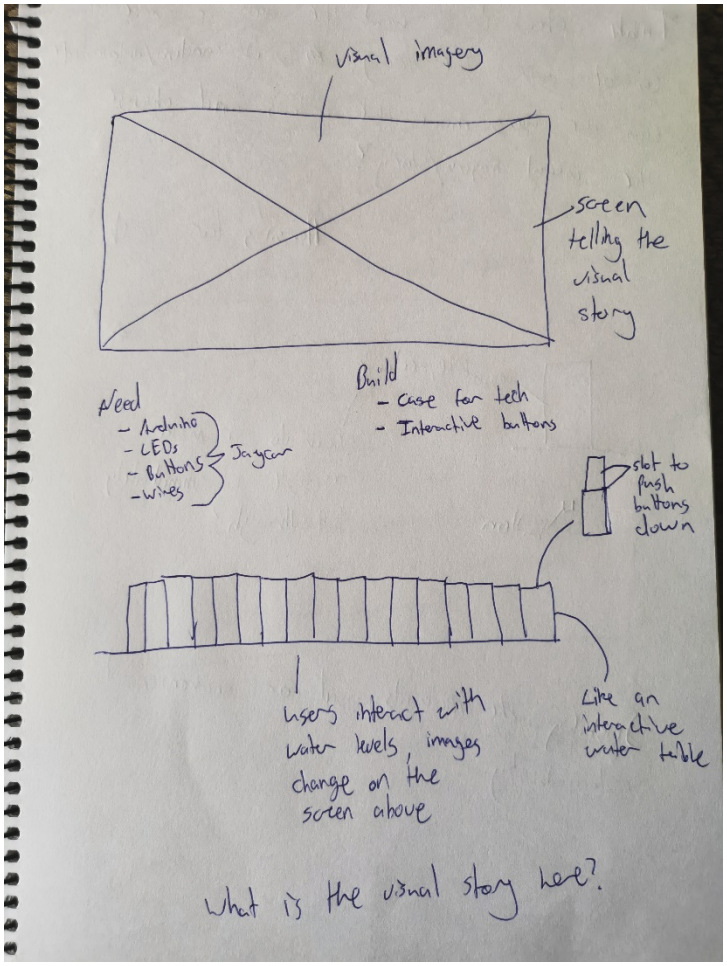


Figure 27: Initial sketches of the new concept

To properly measure how high the bar graphs should be, the data would be informed by the Bureau of Meteorology's Climate Summaries Archive (2020), which represents average rainfall for each month as a percentage. Firstly, this meant using an "average" column which would be exactly 100mm high (representing 100%). Then, I would go through every month from January 2017 to August 2020, recording the percentage of area-average rainfall across Australia for that month. As an example, the average rainfall for Australia throughout the month of August in 2019 was 54% below average (see figure 28), meaning I would make the height of the bar graph column for that month 54mm (54%) below the average column (100mm/100%) mentioned earlier. This ultimately means that the column for August 2019 would be 46mm in height. I used this "formula" for making the bar graph columns because I believed it would be the best way to compare the different months to each other.

Area-average rainfall

	Rank (of 120)	Average (mm)	Departure from mean	Comment
Australia	6	8.6	−54%	6th lowest; lowest since 2006
Queensland	17	2.8	−80%	
New South Wales	5	8.5	−77%	5th lowest; lowest since 1995
Victoria	28	52.5	−29%	
Tasmania	55	147.0	−3%	
South Australia	12	6.2	−66%	
Western Australia	27	10.5	−31%	
Northern Territory	17	0.0	−99%	
Murray-Darling Basin	8	11.0	−71%	8th lowest; lowest since 2006

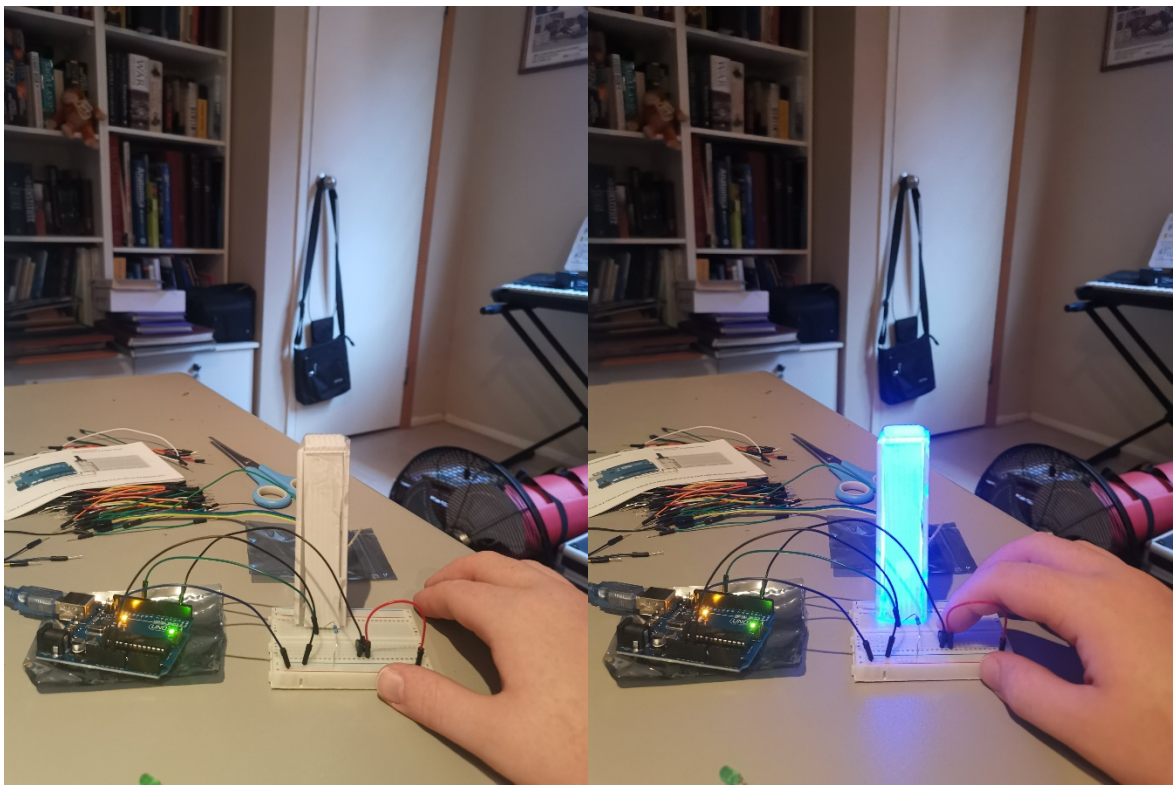
***Rank** ranges from 1 (lowest) to 120 (highest). A rank marked with '=' indicates the value is tied for that rank. **Departure from mean** is relative to the long-term (1961–1990) average.*

Figure 28: A screenshot of the data used to inform this particular prototype. The percentage in the "departure from mean" column is used to inform how high the bar graph column is.

What I liked most about this new concept was that it represented a large amount of rainfall data using a physical "wave", rather than actual water. Furthermore, this concept allows the audience to view significant stages of the drought using this data. For example, this data shows how bad the rainfall has been in the crucial winter months, as well as the whole year of 2019. With this concept, I would be able to use materials that are environmentally sustainable as well. Overall, I believe that this data visualisation concept will allow the audience to connect the evocative imagery to the extremely worrying data, which will create a powerful visual data story.

4.6 Prototyping the New Concept

To prototype this new concept (discussed in section 4.5), I started by using a material called corflute to construct an “average” column, which I made exactly 100mm in height, and 20mm in width and length. I made this first column as a test to see what the best way would be to construct a completed lo-fidelity graph using this material. Figures 29 and 30 (below) show the first lo-fidelity column being put over the top of an LED that has been turned on after a button press.



Figures 29 and 30: The “average” column put over an LED that has been turned on

After making the initial corflute bar graph column, I then went to work constructing columns for every month from January 2017 to August 2020, based on the data from the Bureau of Meteorology’s Climate Summaries Archive (2020). Figures 31 to 33 show the progression of the construction of this lo-fidelity prototype. The main reason I wanted to prototype this concept in physical 3D form so soon was because I wanted to see if this data visualisation would actually look like a wave (representing the metaphor of rainfall). Figure 33 shows the fully constructed prototype, with the data columns representing a physical wave, as expected. What I like most about this prototype is that the data is easily readable. More specifically, I believe that the audience can understand the data that is being presented, and connect that data with the visual story.

Figure 31: The average national rainfall for 2017 and 2018 prototyped using corflute

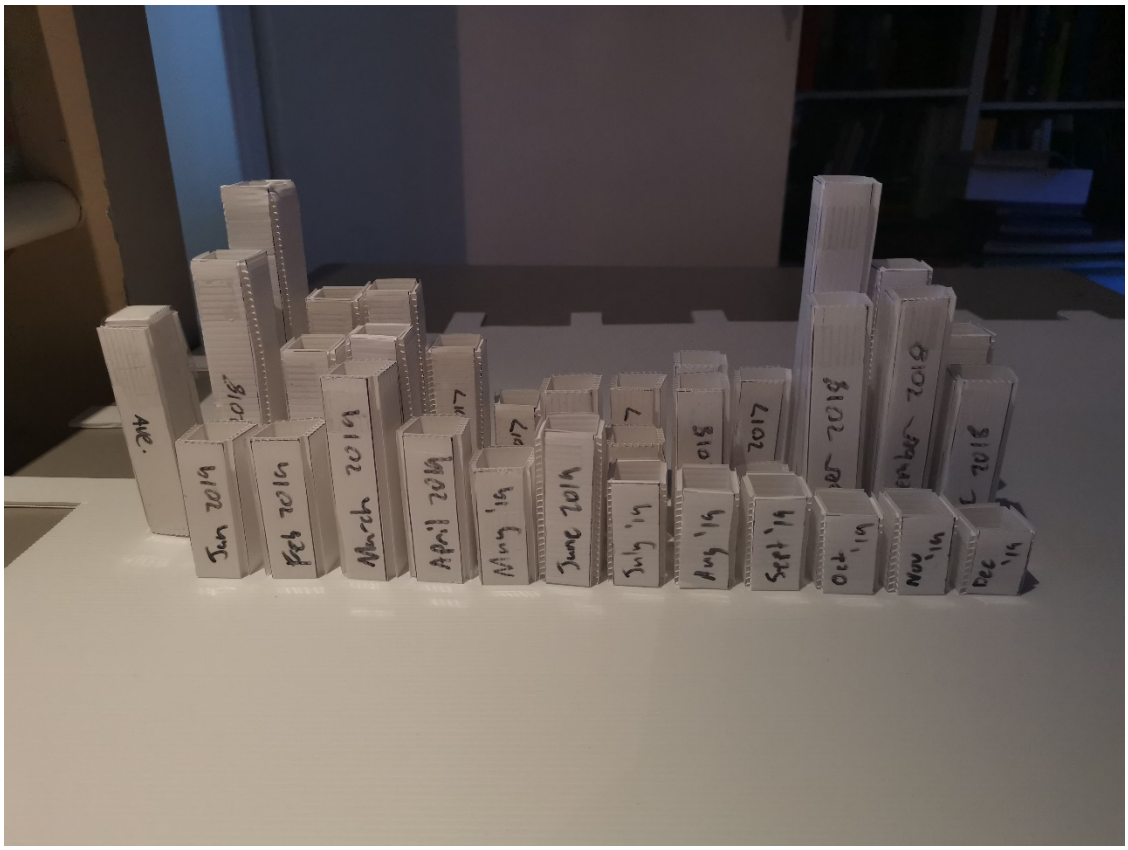


Figure 32: The national rainfall average for 2019 prototyped using corflute

Figure 33: The national rainfall average rainfall for 2020 prototyped using corflute. This is also the completed lo-fidelity prototype as well

4.7 Arduino Technology and Coding

This stage of the project saw myself stay in the prototyping/building phase of the process, as I moved into working with Arduino technology, coding, and wiring. Firstly, I wanted to use Arduino technology for this project/concept because I had worked with it before, and knew it would be the best way to achieve the technical aims I had for this concept. In particular, I wanted to wire blue (representing rainfall) LEDs for each column that had an image in the visual story. Furthermore, I also wanted to code these LEDs with a button, so that when the user presses the button, the LEDs light up in a specific sequence, and the visual story plays at the same time on a computer screen. This section of the process will detail the steps I went through to wire these LEDs and write code that did what I wanted for this concept.

Firstly, I started playing around with simple Arduino technology and code, such as just turning on one LED with a button. Figures 29 and 30 in section 4.6 show this action being performed with a lo-fidelity column placed over the top of it. From here, I then tried connecting two LEDs to the Arduino, and attempted to write a code which made the second LED turn on 5 seconds after the first LED turned on. After a few attempts, this was also successful, with the help from some code from the internet that I adapted to suit my own technical needs. The biggest challenge was then writing code that made the LEDs turn on in sequence, while also playing a video on the computer screen, when the button is pressed. To achieve this, I had to write two separate pieces of code: one in Arduino, and one in Processing. In the Arduino code, I had to open up a serial port using the code, which would allow the two programs (Arduino and Processing) to talk to each other. After doing the same thing on the Processing end, I was able to write up code that allowed the video to play from Processing. After completing the code on both ends, I then had a program which allowed me to play

the video while turning on the LEDs at the push of a button. Over time, I would develop this code to include every LED, as well as time when they turn on and off based on the complete visual story video. Figure 34 below shows a video being played on the computer screen in Processing, while the LEDs light up when the button has been pressed.

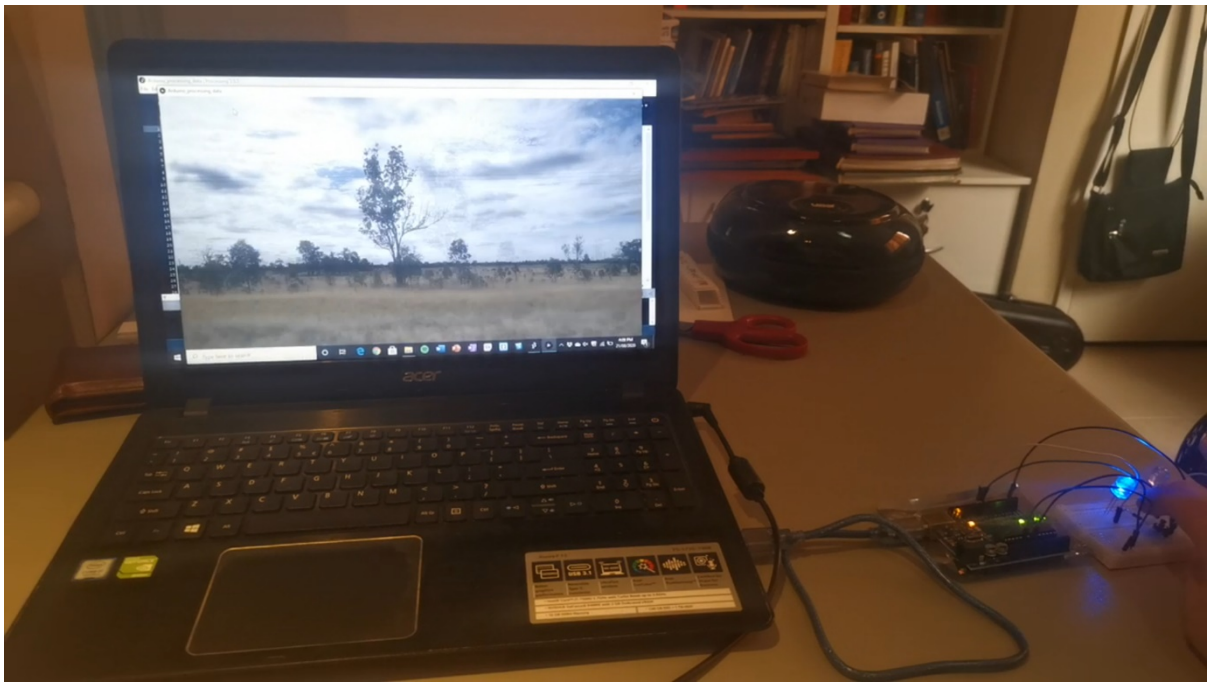


Figure 34: The first working version of the code used in this project

Figure 35 below also show the original code which was used to make this prototype work. This is the code which would be developed into to the final prototype over a few weeks. For reference, below are links to the codes on the internet that I adapted to help write my own piece of code for this project:

- http://youTu.be/2WwedCRwmgA (used to turn the LEDs on and off in a sequence)
- https://www.youtube.com/watch?v=NhyB00J6PiM&t=4s (used to connect Arduino to Processing)
- https://processing.org/reference/libraries/video/Movie.html (used to play the video)

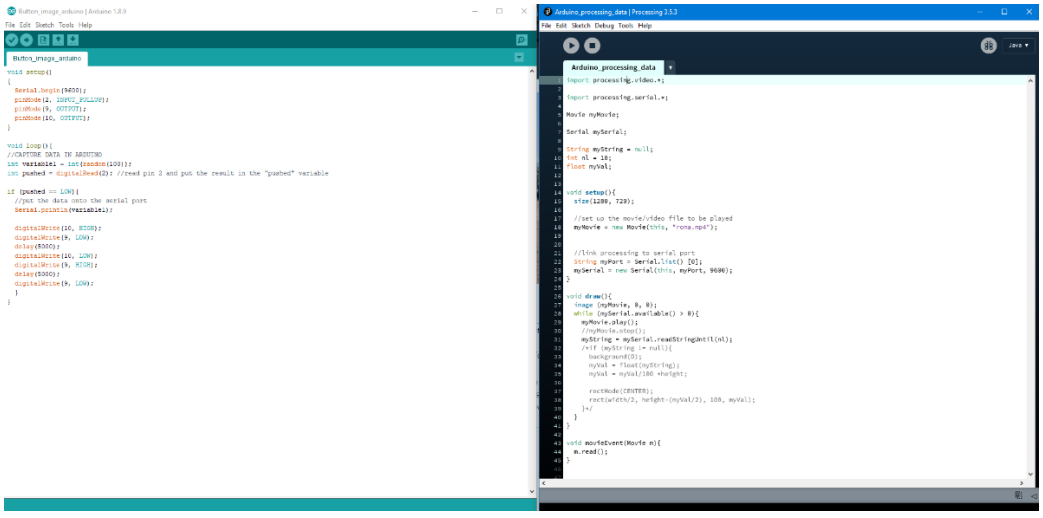


Figure 35: The two codes used to make LEDs turn on while a video plays, when a button is pressed

4.8 Play-Testing the First Lo-Fidelity Prototype, and Addressing the Feedback

After coding, wiring, and lo-fidelity construction had been completed, it was time to conduct the first round of playtesting with this concept. This was done on campus with a couple of peers, and it provided me with great insight into how this concept could be developed and improved.

Firstly, one minor and easily fixable problem with the device for users was that they found the timelapse in the visual story video went too quickly. The play-tester believed that because of the speed of the timelapse video, they couldn't effectively comprehend the emotional images they were being shown in this video. To combat this, I would simply slow down the timelapse, so that it would roughly take 5 minutes for the video to be completed, rather than 1 minute, like it previously was. While I did like that the video was now longer and the drought-stricken landscapes in the video could be easily seen, I was still worried that it would make the overall video longer and the audience viewing the video could perhaps lose interest. However, after conducting playtesting with the updated version of the timelapse video, users told me that they very much liked how they could see the landscapes at a slower, more realistic pace, which eased my concerns.

Secondly, the next piece of feedback I took from playtesting was that I needed to provide further research into why it was better to use physical graphs (a physicalization), rather than just buttons and a screen (a visualisation). This research which I conducted after this playtesting is discussed in section 2.7. In this section, I make note that while there are arguments for using a situated representation over an embedded representation, there doesn't seem to be any major arguments for using a physicalization over a visualisation, and vice versa. Instead, I explain that I believe I have justifiable reasons for using a physicalization over a visualisation, which are more closely related to the outback, and the sustainable issue I'm pursuing, which will be discussed in section 4.11.

Thirdly, another key piece of feedback was that the user found it fairly hard to tell what the data was in the physical graph. While I didn't have the full visual story video ready for this first round of play-testing, I already had plans to make a screen at the start of the video, which would tell the user what the data was, and what the user had to do to start the visual story video.

Finally, the most important piece of feedback I received is that the physicalization would make more sense if the graph looked more chronological. What the user meant by this is that the data could be more easily understood if the bar graph columns were in one, big chronological line, rather than having a different row for each year of data. Immediately after hearing this piece of feedback, I already very much liked it, and was extremely excited by the possibility of constructing a prototype like this. Over the next few days, I would work on constructing this new iteration of the prototype, and this construction will be discussed in the next section.

The main piece of feedback I would be addressing from the first round of playtesting was how the actual prototype was presented. Throughout this stage of the process, I worked with corflute again, and constructed an iteration of the concept that saw the graph columns in one, big chronological line, rather than using a new row for each year. Figure 36 on the next page shows this new lo-fidelity iteration in completion. What I liked most about this iteration is that the data was most definitely more readable. Furthermore, I believe that this prototype also still kept the shape of a wave, representing the metaphor of rainfall. However, one thing I didn't like about this prototype is the fact I thought it would make it more difficult to construct, considering the length of the presentation, which was 147cm (1.47m).

Figure 36: The second lo-fidelity prototype

4.9 Play-Testing the Second Prototype

The second round of playtesting was conducted on the second iteration of the lo-fidelity prototype, and was done at home, and on campus. For reference, the second iteration of the lo-fidelity prototype can be found in section 4.8 (figure 36). For this round of play testing, I included the Arduino tech, and also built a singular LED into one of the columns. Therefore, the user would be able to press the button themselves, and see how the LED lights up in the column and view the (still incomplete) visual story video on the computer screen. Figure 37 (on the next page) shows the device being set up for playtesting, while figure 38 shows the device in use throughout the playtesting at home. The main piece of feedback I got from this round of playtesting was that they found the button too small to press, meaning I would have to source a bigger button to use. Overall however, the feedback was mostly positive. The users expressed that they understood what the data was saying and what it was referring to. Furthermore, users also made it clear that they liked how they could the imagery of the drought alongside the data that was in front of them. This made one crucial thing clear to me, which was that the audience could make the connection between the physical presentation (the physical device, the data) and the physical referent (the Australian drought). Considering this connection is crucial in creating a situated visualisation, I was extremely happy with this feedback. After completing this stage of the process once again, I now felt confident that I could move on to hi-fidelity prototyping with this concept.

Figure 37: The device set up for playtesting

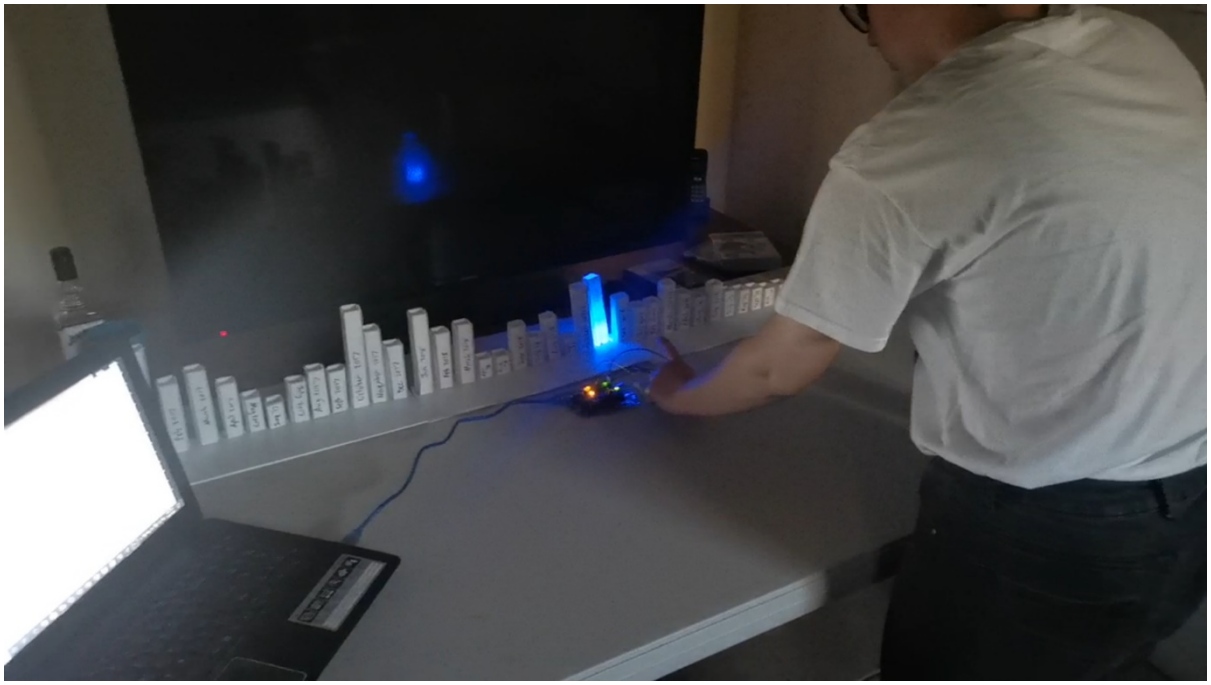


Figure 38: Device in use throughout playtesting

4.10 Constructing the Hi-Fidelity Prototype

4.10.1 Creating Illustrator Sketches, Laser Cutting the Pieces, and Constructing the Device

The first step in constructing the hi-fidelity prototype, was designing the pieces to be laser cut in Adobe Illustrator, and constructing them. Figure 39 below shows the Illustrator file used to design the bar graph columns that would laser cut using MDF board. Figure 40 shows the first iteration of the case design I made in Illustrator to be laser cut. After I realised this design wouldn't work for this prototype, I made a new version, which made use of two modular pieces that get pieced together when the final device is put together (this can be seen in figure 41).

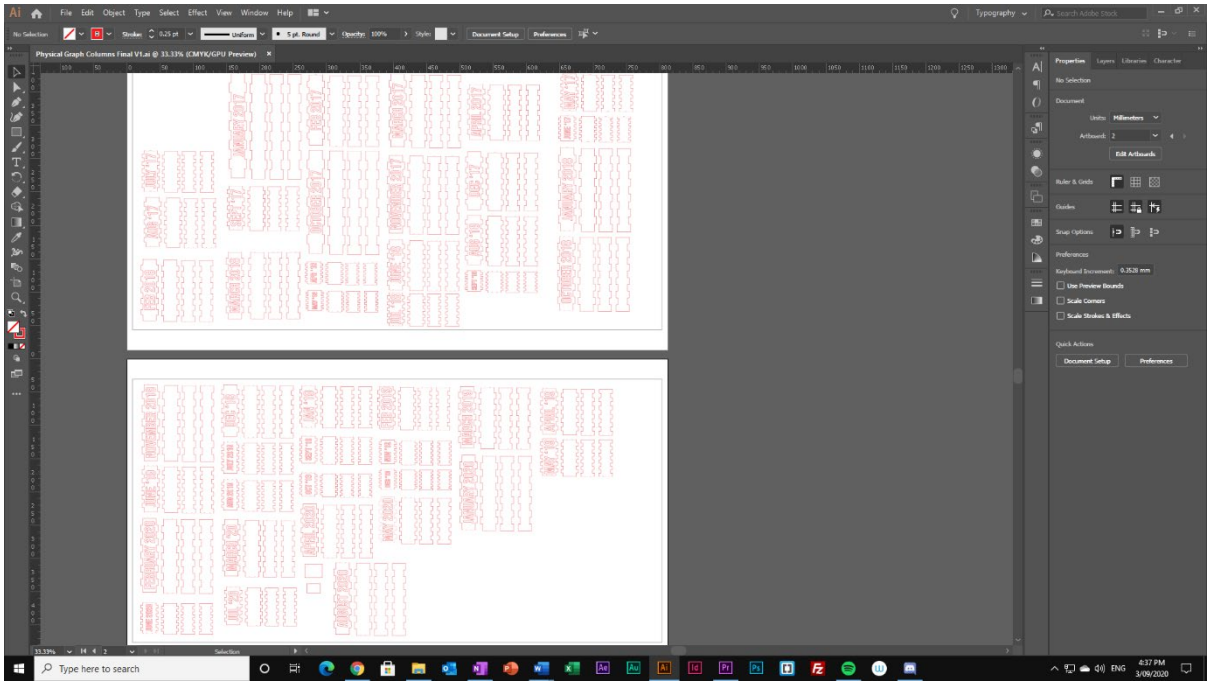


Figure 39: Illustrator file of bar graph columns

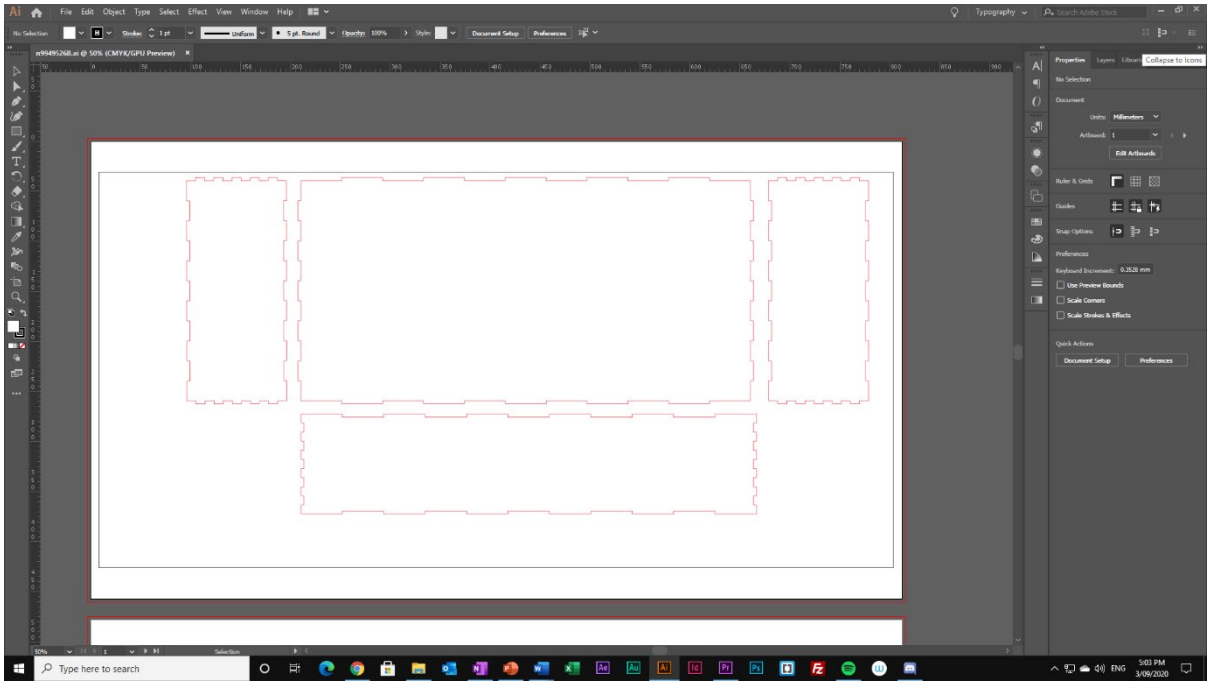


Figure 40: First iteration of case design in Illustrator

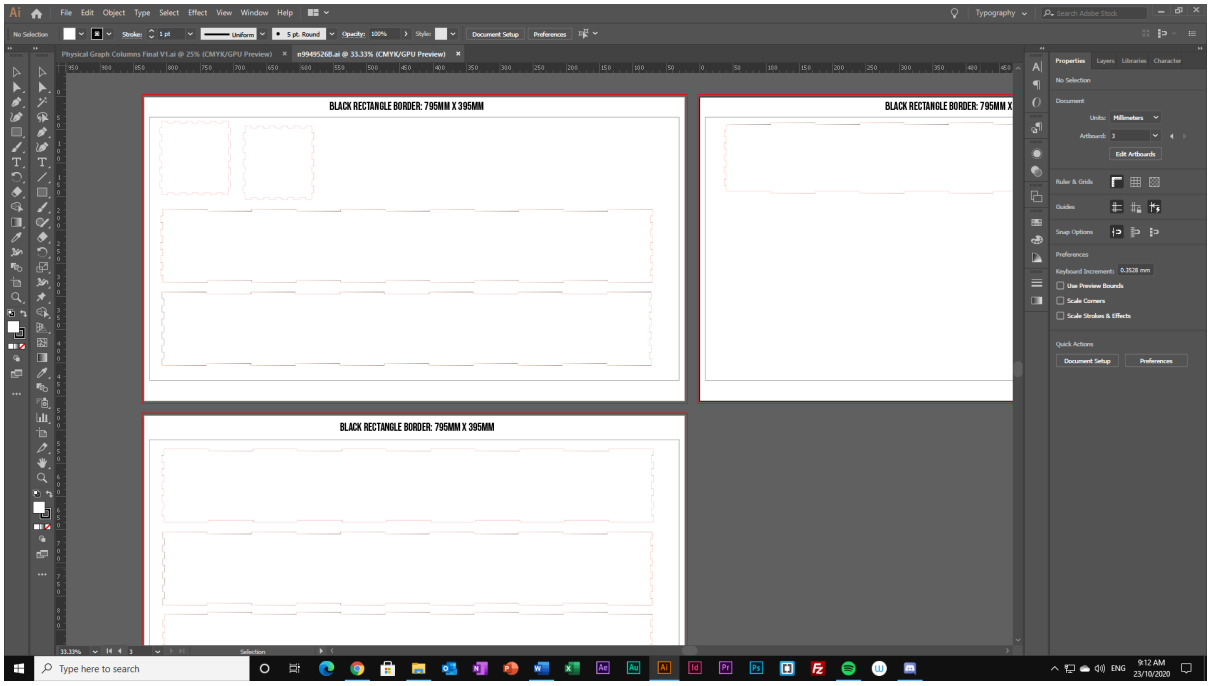


Figure 41: Final iteration of case design in Illustrator

In terms of my project, I decided to use MDF board because I believe that its look of authenticity relates to the authenticity of outback Australia, which is definitely what I liked most about using this material. Furthermore, I liked using this material because it very practical and easy to work with, making this part of the process much easier than first expected. After laser cutting all the pieces I needed for this device, I went to work on putting together all the pieces and constructing the hi-fidelity prototype. To do this, I made jigsaw-like cuts on the edges of the MDF pieces so they could be glued together with ease. Figure 42 below shows these MDF pieces being put together, with some columns not being glued to the case until the LEDs, wiring, and Arduino has been rigged up inside. This picture also shows the markings and measurements on the top of the case to place the columns with precision, as well as holes which were drilled in the top of the case to accommodate the LEDs and wiring. Once the appropriate pieces were glued together, the LEDs were rigged inside of the case (this is further discussed in section 4.10.2), which can be seen in figure 43. After completing this first stage of construction, I found that it was much easier than I first expected. In particular, I was extremely happy to see that all the measurements were correct, and the pieces fit together when I first constructed the prototype. Furthermore, I was also very happy to see that the graph columns still had the look of a wave (representing rainfall) in real life. Overall, I was very much filled with confidence heading into the next stage of construction.

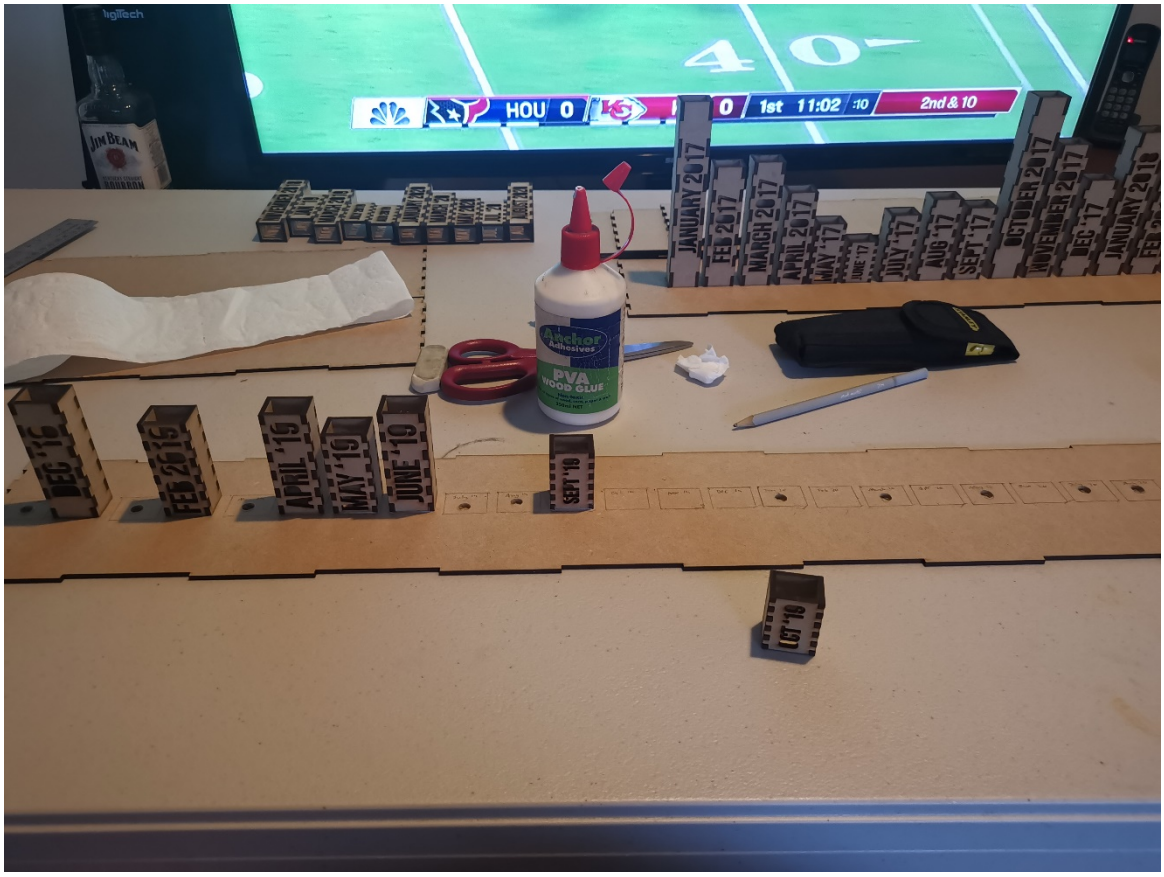


Figure 42: Gluing together the hi-fidelity prototype pieces

Figure 43: The first stage of construction completed

4.10.2 Wiring and Soldering Arduino Technology with LEDs

This stage of constructing the hi-fidelity prototype was by far the most challenging part of the process. This stage of the process included soldering blue LEDs, resistors, and wires together, and then wiring them up to the Arduino which was inside of the device case. Furthermore, I also had to figure out a way I could wire up a button so it could sit in the middle of the device and work with a button press on the top of the case.

Firstly, I did a soldering and wiring test on one LED, just to make sure that what I was doing would definitely work with Arduino, before proceeding with soldering for 10 LEDs. Figure 44 below shows this first test, which has a resistor soldered to the positive LED pin, a wire soldered to the resistor, and another wire soldered to the negative LED pin, which allows the wire to be grounded.

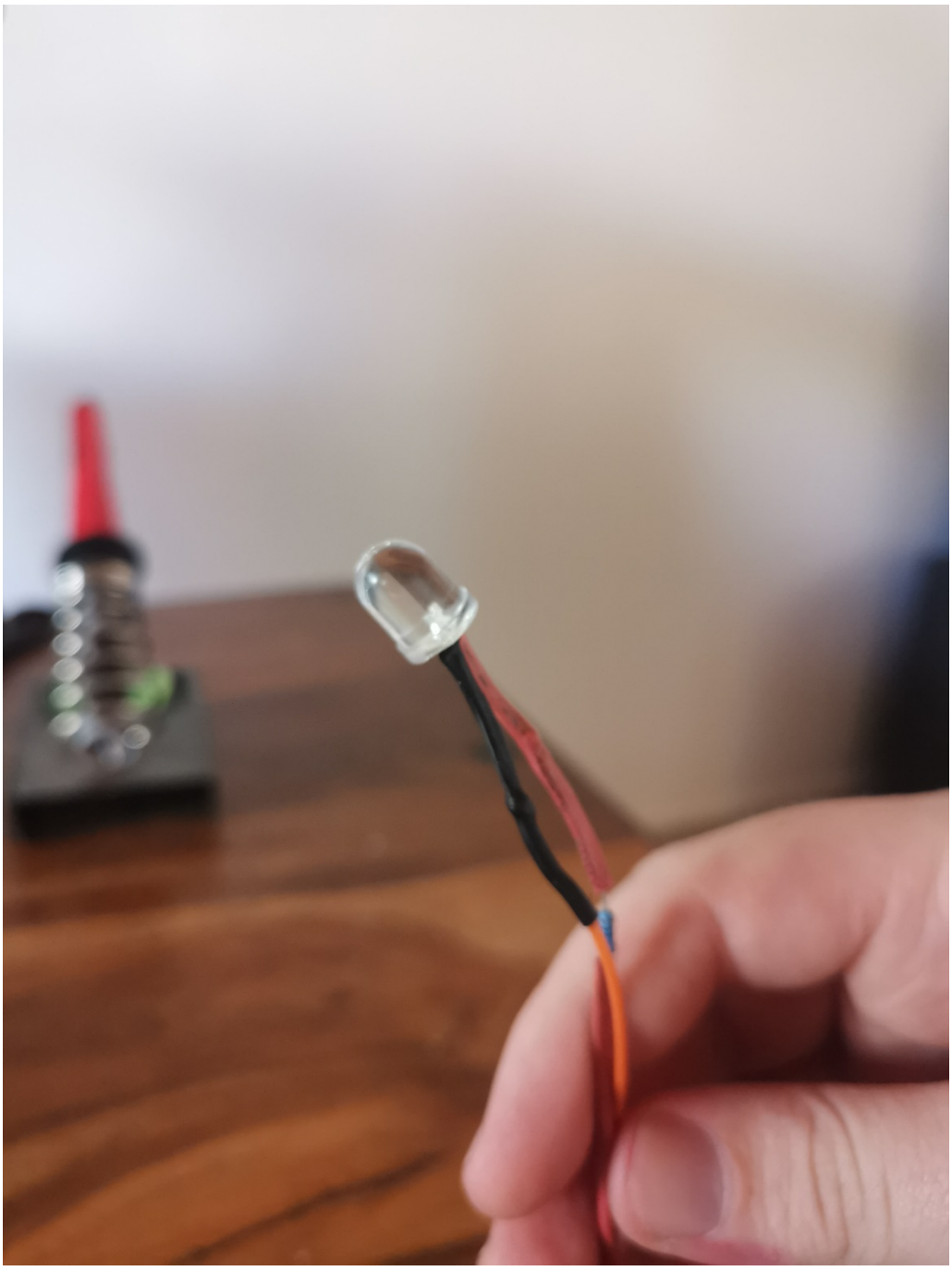


Figure 44: The first test of wiring and soldering with an LED

After I knew that this method would definitely work on a large scale with Arduino, I began soldering all 10 LEDs and wiring/inserting them inside the prototype case. The only thing that was different when wiring the LEDs on a large scale was that I had to connect all the ground wires together (the wires on the negative LED pins, making a chain. This was done not only because the Arduino board didn't have enough ground pins, but also because creating a ground chain saved more time and was easier to solder and put together. Figure 45 below shows half of the LEDs soldered together, placed permanently inside the top of the case, and connected to the Arduino. For reference, a short timelapse video showing myself soldering some of the wires together can be found here: https://youtu.be/_V7FLshnKcg.

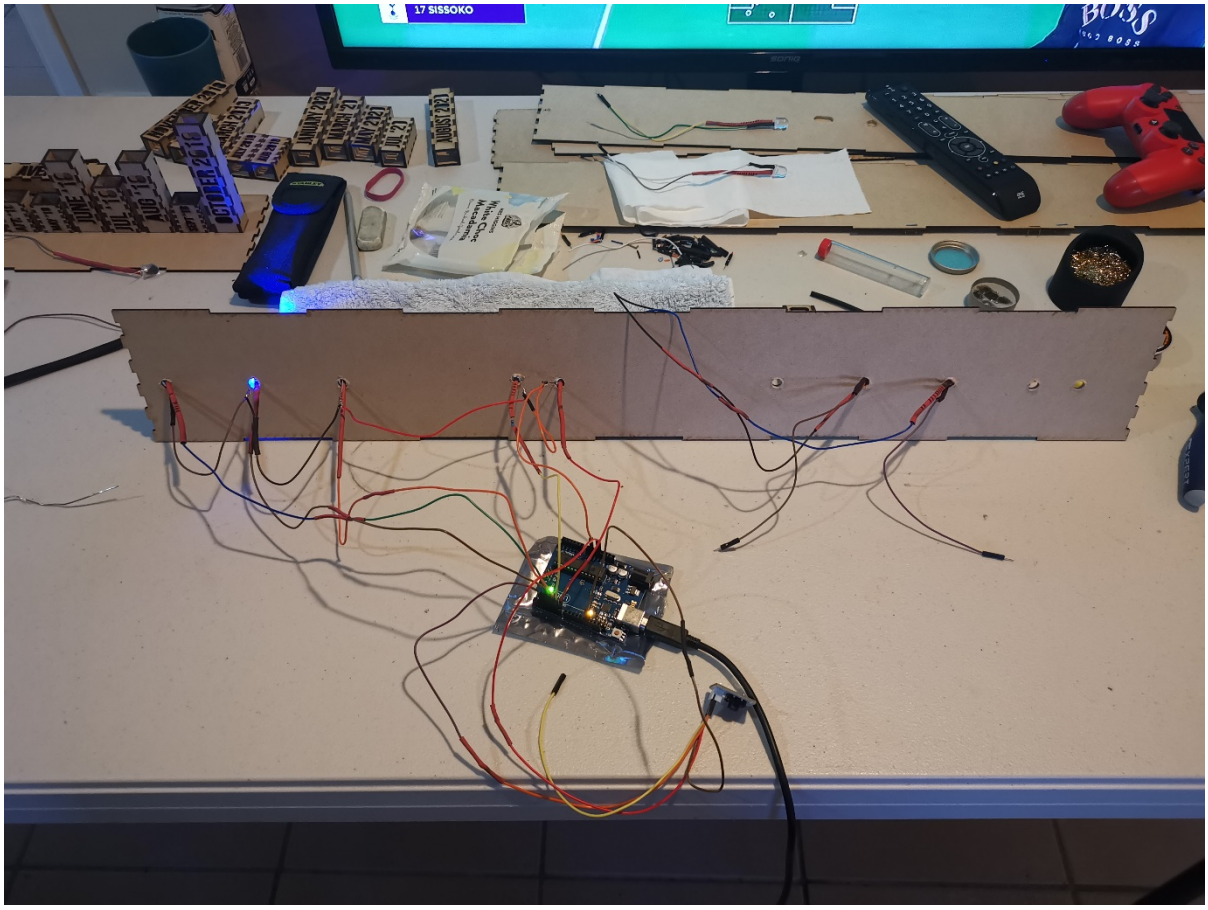
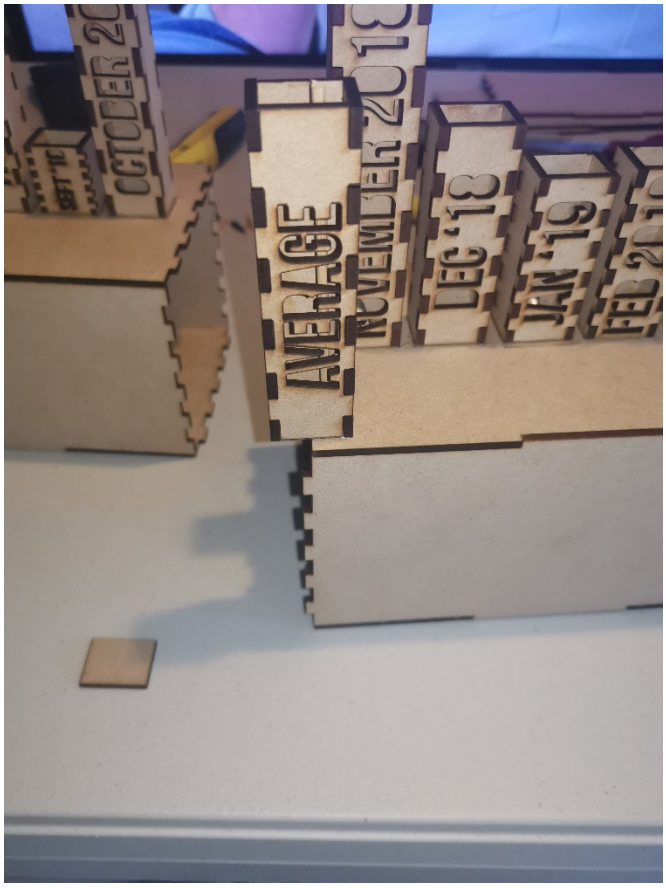
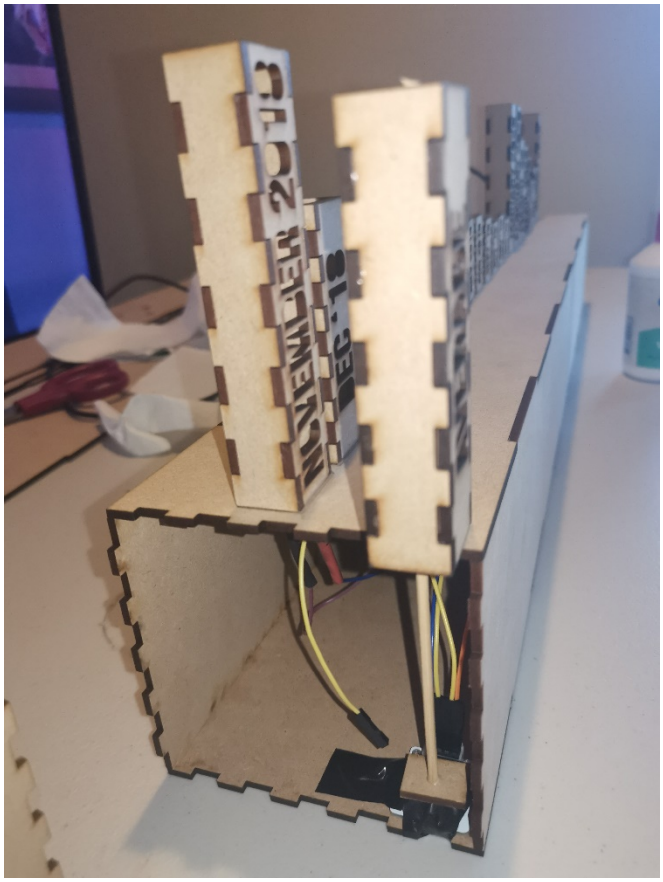


Figure 45: The LEDs being soldered and rigged up to be placed inside the prototype case

While soldering all the wires with the LEDs was technically simple, it was very time consuming. However, the most challenging part of this stage of the process was figuring out a way to wire up the button so that it could be placed in the middle of the device for the users convenience. I went through the testing of a few concepts to see how this could be done. Firstly, I tried putting the average column in the middle of the device, and having a stick run through the column and to the bottom of the case where the button is. Furthermore, this concept would also require the average column to have a small square at the top that the user could use to press the button. At first, it seemed like this concept was working, but because of the modular nature of the device's structure, only half the column could be glued onto the case, meaning it was unstable and soon fell off after a short period of time. Refer figure 46 and 47 on the next page to see what this first button iteration looked like.





Figures 46 and 47: The first iteration of the button design

After I realised this wouldn't work, I came up with another concept which saw the average column on the far-left side of the device, with the cylindrical button on its own in the middle of the device. This worked much better because the device kept a sturdy structure, and the button could be pressed very easily. This was once again another very time-consuming part of the process, mostly because it look me so long to figure out how I would design this button to be practical and user friendly. However, once I had figured out the problem and got it to work, it was very rewarding.

4.10.3 Creating the Visual Story Video

The final part of creating this project artefact was making the visual story video using all the imagery I had collected over the last 4 months (May to August). All that was needed to compile all the images and edit them into an evocative video was Adobe Premiere Pro. Using this program, I was able to add all the images and videos, fade them in and out, add text to give a bit of context to the audience, and also add some evocative, royalty-free music. After creating the video and having all the necessary timings for the images finalised, I then had to take those timings and apply them to the code, so that the LEDs in certain columns would light up when their respective month was shown in the visual story video. A small timelapse showing the process of creating this video can be found by following this link: https://youtu.be/CE-6Mgb-QeU. For reference as well, the full album that includes all the images and videos that were used in the visual story video can be found in Appendix A (section 8.1).

Overall, this was one of the easiest parts of the entire process. While it was time consuming because of the amount of content I had to sort through and edit, it was extremely in doing so, and I never ran into any problems while creating the video. What I like most about this video is that I believe it does

a good job in connecting the images to the data, because of the LEDs in the device, the powerful images, and the context given to the audience through the text in the video.

4.11 The Final Prototype, Play Testing, and Feedback

After all the iterating, developing, and construction was completed, I finally had a completed, working prototype ready for final playtesting and feedback. This working prototype shows the audience a graph which details the monthly rainfall averages for Australia from January 2017 to August 2020 (the length of the drought), with a screen above the device telling the audience what they are looking at and what to do to start the device. Once the audience understands what they have to do, a user presses the button in the middle of the device, which triggers the timed LED sequence and the visual story video, creating a visual data story.

Because this final prototype was completed only a week before the honours class exhibition, the playtesting for this prototype was fairly brief, mostly because I wouldn't have time to make any major changes. Therefore, playtesting was completed in class with peers, and I made use of the big projector to show it on the screen, replicating what it would look like in the exhibition. I got a couple of students to come up, look at the data and the screen, and then press the button and watch the video.

The feedback I got from this final round of playtesting was almost all positive. Most play-testers said that they liked the new inclusion of the screen at the start of the interaction, because it allowed them to understand more clearly what the data was before viewing the visual story video. Furthermore, users also expressed that they particularly liked the powerfulness of the images, however they also said that they didn't get the same powerful stillness (like that experienced with the images) from the timelapse of the bus ride from Roma to Wallumbilla.

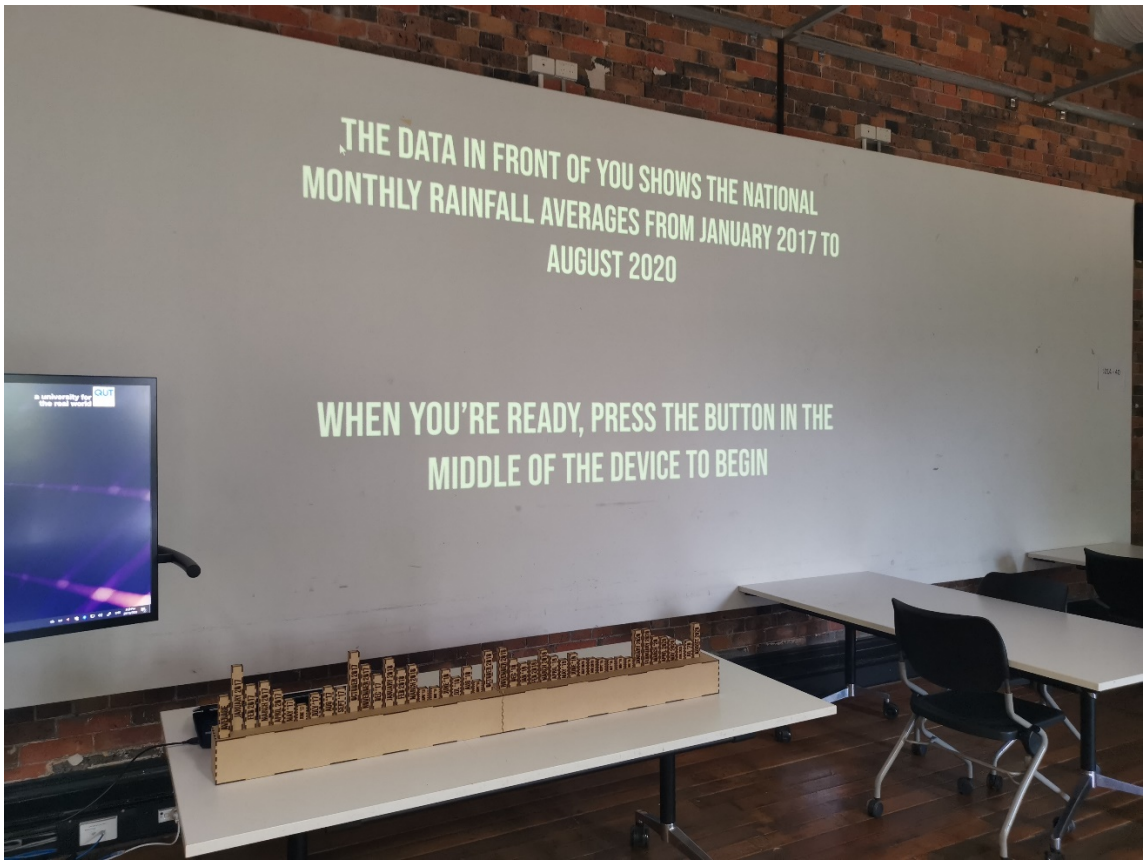


Figure 48: The final prototype set up for play testing

5 The Final Work/The Final Reference Design

5.1 The Artefact

This artefact is the final device made in fulfillment of the aims I had for this project, titled “Drought Devastation”. As a final, brief overview, I aimed to make a physical and visual data story that raised awareness for the importance of sustainability. In particular, I wanted to focus on the current Australian drought, and raise awareness for the drought, and get people to think about supporting rural outback communities through charity, or travelling outback to support these rural businesses in the flesh. This is what social sustainability is; attempting to change peoples’ opinions and behaviours in relation to a sustainability issue/problem. Therefore, getting people to understand what is happening in these outback communities, and convincing them to help these people, was paramount. The final artefact for this project is made up of two parts (the data visualisation, and visual story), that forms one whole when viewed (a visual data story). The first part is the physical data visualisation, which uses 3D bar graph columns to show the national rainfall averages in Australia for every month from January 2017 to August 2020. From November 2018 to August 2020, some columns have blue LEDs inside of them that light up in relation to the visual story video. This is the main connection between the data and the imagery; a connection which is so important in this project. The second part of this artefact is the visual story, which is made up of images and videos collected around outback Queensland, showcasing the devastating effect the drought has had on the outback landscape in the last 4 years. Overall, I believe I have created an artefact that allows the audience to see how low rainfall in the outback over the last 4 years has affected the land. Figure 49 shows the final project artefact staged at the honours class exhibition, with the appropriate exhibition didactic (project description, artist statement, and charities the audience can donate to) presented along with it. A link to the final prototype being used can be found here: https://youtu.be/jhLNiuxz_Fs.

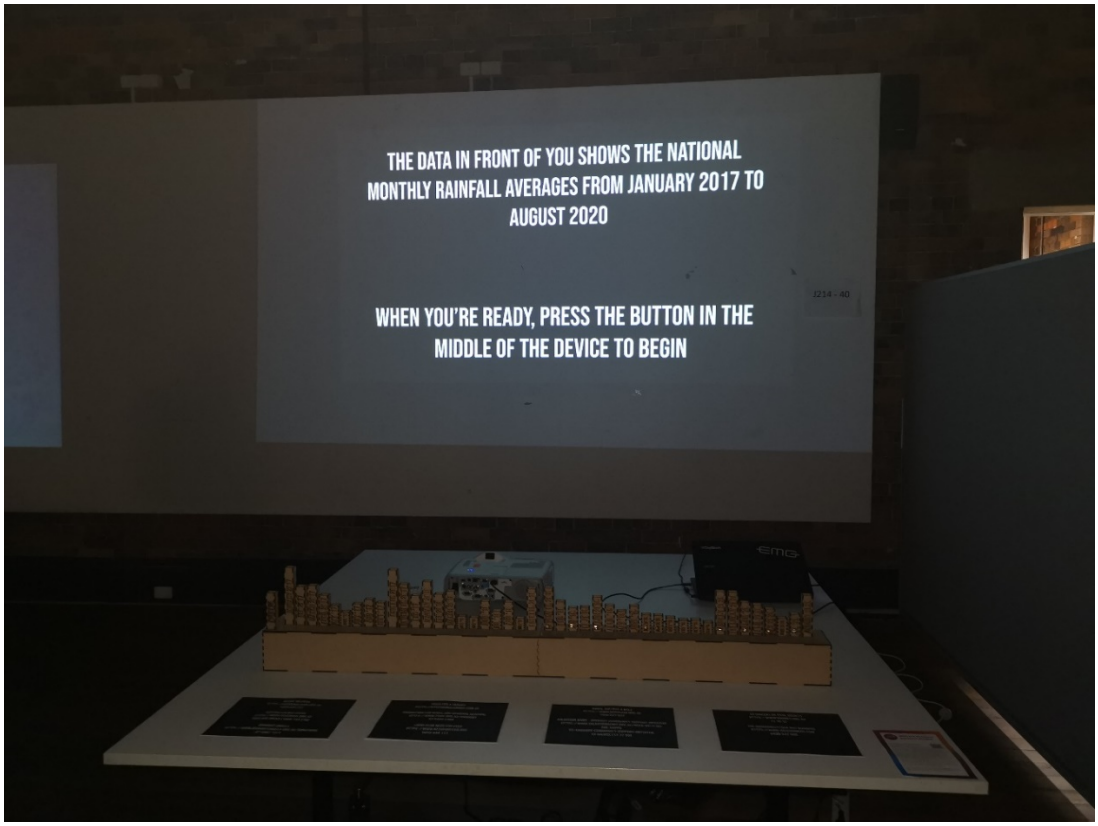


Figure 49: The final prototype/device staged at the honours class exhibition

5.2 Evaluation, Reflections, and Future Directions

To evaluate this project, I came up with a framework for project evaluation, which is a checklist that I made after researching and reviewing the topics and methods discussed in the literature review. This framework summarises the key principles of designing for social sustainability, using methods such as data visualisation and visual storytelling. The full framework for project evaluation can be found in section 3.3.

The first area which needs to be evaluated in relation to this project and artefact is the concept. This involves looking at topics such as designing for sustainability and raising awareness for social sustainability, as well as data visualisation. This includes looking at what is unsustainable about the issue the designer is pursuing (Thiele, 2013), and if the designer has outlined the underlying needs of their design based of what is unsustainable about their problem (Walker, 2013). Furthermore, in terms of data visualisation conceptualisation, their concept must show that it has a physical referent, and a physical presentation, particularly when it comes to designing a situated physicalization (Willett et al., 2017). For this project, it has been made clear that the sustainability issue I am pursuing is the Australian drought. What is unsustainable about this issue is that it is badly affecting the environment in outback Australia (environmental sustainability), and not enough people are supporting these communities that desperately need help (social sustainability). It is the social sustainability aspect of this issue which I mainly focus on, therefore making it the underlying need of the sustainable design. The question which must be asked then is does this concept serve the underlying need of sustainability, which is to raise awareness for the importance of social sustainability, by getting people to support rural outback communities? Considering this is a deeply subjective question, it is hard to evaluate if a concept achieves this, which is why playtesting and feedback has been particularly important in this project. Therefore, based on the playtesting of the final artefact, users said that they definitely felt moved by the images on the screen (refer to section 4.3 for keywords that users used when looking at the images in this concept). This means that a connection has possibly been created between audience members and the issue being presented, meaning people may feel motivated to try and help support these outback communities because of this device and its concept. Finally, in terms of data visualisation, it can be seen that this concept has a physical referent (the Australian drought) and an appropriate physical presentation (the visual data story).

The second area which needs to be evaluated is whether or not the key principles of the methods used in this project are followed in the iterating, developing, and prototyping stages of this project. The first method which will be looked at is data visualisation. Firstly, research showed that the data visualisation needs to effectively engage the community. Through playtesting, I found that, at first, people from the audience found it hard to understand, because of the original design of the concept, and the lack of context. Once the shape of the visualisation had been changed into one big chronological line, play-testers expressed how they already thought the data was much more engaging because it was easier to read. Furthermore, the addition of a starting screen telling the user what the data is was also very helpful in that respect. Moving on, a more personal benchmark (a benchmark not based off of research) I had for this visualisation was that it still had to represent the metaphor of rainfall. I believe that this has been achieved because of the wave-like shape of the physical graph. Finally, in terms of data visualisation, does the physical presentation allow the data to be presented in any location or space, and is the dataset in the situated physicalization visibly and physically accessible (Willett et al., 2017)? As can be seen, the design of the physical presentation allows the data to be presented in any space, because of the simplicity of the bar graph model.

Furthermore, because the data is presented in one big chronological line, it is very easy for the audience to read and understand, making it visibly and physically accessible for the audience.

In terms of visual storytelling, there are also a few benchmarks which must be met in order to produce an evocative story that fulfills the aims of this project. Firstly, a good story always needs a narrative structure, concepts, and engaging characters (Robertson, 2018). In my visual story, the structure follows a 'cause and effect' narrative, showing the audience the cause of the drought (the low rainfall averages), and the effect it has had on the land (the imagery). In addition, the main characters of this story are the people that reside in these rural communities struggling through the drought. Furthermore, the chosen medium for this story (a video) allows the information to be presented/delivered in a controlled manner, because it is presented in chronological order, at a pace where the audience has plenty of time to understand what is being shown to them. To add on, for a visual story to be engaging, it must use "positive imagery" (images that allow the audience to relate to the imagery) (Robertson, 2018). As discussed in section 4.3, I found that when I showed some of the images I had collected to different people, I discovered keywords that showed they were connecting the imagery in an evocative manner. Keywords that supported this included "nostalgic", "eye-opening", "illuminating", "frightening", "emotional", and "upsetting". This also closely relates to the next visual storytelling benchmark, which asks whether or not the story has evocative characters and messages that the audience can relate to. Finally, the last benchmark for visual storytelling asks if they story uses a good combination of words and images (Robertson, 2018). As can be seen in the visual story, the video uses the imagery, along with text displayed over the top of it, which tells the user the month, year, and location, and provides the audience with some brief context. I believe this makes a good and well-balanced mix of words and images in this visual story.

Upon reflection, there is only one major thing I would change about this artefact moving forward. The whole time throughout making this device, I felt that the timelapse video in the visual story was too long, even though play-testers had expressed that they liked the pace of the video. Therefore, for a future iteration of this final prototype, I want to cut up the timelapse and edit it into the overall story, so that audience feels like they're on this bus ride, with the powerful, still images displaying over the top of this bus ride at a reasonable pace. I believe that a change like this to the video would still deliver the nostalgic feel of the bus ride to the audience, while allowing them to view the powerful images that best communicate the effects of the drought.

In terms of future directions, I want to take this project to the charities and organisations that I have outlined in the visual data story. In particular, I believe this artefact could be effectively used at drought fundraisers, which could be supported by these charities. I believe something like this in the real world would be particularly useful in shining a light on the devastation that is happening in outback Australia, especially for people living on the coast who have never seen or experienced anything like it before. Overall, because this issue is extremely personal and significant to me, inside and outside of my work, it is definitely something which I will be pursuing in the future.

6 Conclusion

In conclusion, I believe that I have designed an artefact which fulfills the aims that I had for this project, which was to raise awareness for the importance of social sustainability, in relation to a modern sustainability issue, which in this case, is the current Australian drought. The social sustainability methods I urge the audience to employ in relation to this issue is to support rural outback communities by donating to charities that help them, or directly supporting the businesses in these towns by travelling outback. I achieved this by addressing theories such as designing for sustainability, and using methods such as physical data visualisation, and visual storytelling.

Overall, based on the framework for project evaluation, I believe I have created a visual data story that creates an evocative connection between the audience and the data, through the use of imagery that relates to the data being displayed. While it is hard to measure a connection that is so subjective for each person, I am confident that this connection can manifest into the audience wanting to take action, and support the people and communities suffering through this terrible weather event.

7 Bibliography

Balduini, M., Della Valle, E., Ciuccarelli, P., Azzi, M., Larcher, R., & Antonelli, F. (2015). CitySensing: Fusing City Data for Visual Storytelling. *IEEE MultiMedia, 22*(3), 44-53. https://doi.org/10.1109/MMUL.2015.54

Bartram, L., Rodgers, J., & Muise, K. (2010). Chasing the Negawatt: Visualization for Sustainable Living. *IEEE Computer Graphics and Applications, 30*(3), 8-14. https://doi.org/10.1109/MCG.2010.50

Baytar, F., & Ashdown, S. P. (2014). Using video as a storytelling medium to influence textile and clothing students' environmental knowledge and attitudes. *International Journal of Fashion Design, Technology and Education, 7*(1), 31-41. https://doi.org/10.1080/17543266.2013.864339

BBC News. (2020). *Australia Fires: A Visual Guide to the Bushfire Crisis.* https://www.bbc.com/news/world-australia-50951043

Bongshin, L., Riche, N. H., Isenberg, P., & Carpendale, S. (2015). More Than Telling a Story: Transforming Data into Visually Shared Stories. *IEEE Computer Graphics and Applications, 35*(5), 84-90. https://doi.org/10.1109/MCG.2015.99

Bureau of Meteorology. (2020). *Annual Climate Statement 2019.* http://www.bom.gov.au/climate/current/annual/aus/#tabs=Rainfall

Bureau of Meteorology. (2020). *Australia in August 2020.* http://www.bom.gov.au/climate/current/month/aus/archive/202008.summary.shtml

Bureau of Meteorology. (2019). *Australia in March 2019.* http://www.bom.gov.au/climate/current/month/aus/archive/201903.summary.shtml

Bureau of Meteorology. (2020). *Australia in June 2020.* http://www.bom.gov.au/climate/current/month/aus/archive/202006.summary.shtml

Bureau of Meteorology. (2020). *Australia in July 2020.* http://www.bom.gov.au/climate/current/month/aus/archive/202007.summary.shtml

Bureau of Meteorology. (2020). *Climate Summaries Archive.* http://www.bom.gov.au/climate/current/statement_archives.shtml

Bureau of Meteorology. (2012). *Record-Breaking La Nina Events.* http://www.bom.gov.au/climate/enso/history/La-Nina-2010-12.pdf

Candy, L. (2006). Practice based research: A guide. *CCS Report, 1,* 1-19. https://www.creativityandcognition.com/resources/PBR%20Guide-1.1-2006.pdf

Deacon, B. (2020). *The Chance of La Nina forming has Doubled, Bureau of Meteorology Says.* ABC Weather. https://www.abc.net.au/news/2020-06-24/la-nina-watch-issued-increasing-chance-of-rain-2020/12385876

Grevet, C., Mankoff, J., & Anderson, S. (2010). Design and Evaluation of a Social Visualization Aimed at Encouraging Sustainable Behaviour. 2010 43rd Hawaii International Conference on System Sciences, 1–8. https://doi.org/10.1109/HICSS.2010.135

Hannam, P. (2019). *How Bad is this Drought and is it Caused by Climate Change?.* The Sydney Morning Herald. https://www.smh.com.au/environment/climate-change/how-bad-is-this-drought-and-is-it-caused-by-climate-change-20191024-p533xc.html

Hannam, P. (2019). *How Bad is this Drought and is it Caused by Climate Change?* [Image]. The Sydney Morning Herald. https://www.smh.com.au/environment/climate-change/how-bad-is-this-drought-and-is-it-caused-by-climate-change-20191024-p533xc.html

Hearsey, A. (2019). *Australia is Burning / A 3D Visualisation*. Anthony Hearsey. https://anthonyhearsey.com/australia-is-burning-a-3d-visualisation

Hearsey, A. (2019). *Australia is Burning / A 3D Visualisation* [Image]. Anthony Hearsey. https://anthonyhearsey.com/australia-is-burning-a-3d-visualisation

Isaacs, J., Falconer, R., Gilmour, D., & Blackwood, D. (2011). Enhancing urban sustainability using 3D visualisation. Proceedings of the Institution of Civil Engineers, 164(3), 163-173. https://doi.org/10.1680/udap.900034

King, A., Pitman, A., Henley, B., Ukkola, A., & Brown, J. (2020). The role of climate variability in Australian drought. *Nature Climate Change, 10*(3), 177-179. https://doi.org/10.1038/s41558-020-0718-z

Kosara, R., & Mackinlay, J. (2013). Storytelling: The Next Step for Visualization. *Computer, 46*(5), 44-50. https://doi.org/10.1109/MC.2013.36

McDonnell, J. (2020). *'Desperately Looking at the Sky': Farmers Hope for Rain*. The Roma Western Star. https://www.westernstarnews.com.au/news/desperately-looking-at-the-sky-farmers-hope-for-wi/4019486/?utm_campaign=%5B%27user%27%5D&utm_medium=%5B%27email%27%5D&utm_source=%5B%27Roma+Western+Star%27%5D

Moggridge, B. (2006). *Designing Interactions*. MIT Press.

Owen, D. (2011). *The Conundrum: How Scientific Innovation, Increased Efficiency, and Good Intentions Can Make Our Energy and Climate Problems Worse.* Riverhead Books.

Robertson, M. (2018). *Communicating sustainability*. Routledge.

Takagi, N. (2019). *Silent Tides.* Imaginarium. https://imaginarium19.ci.qut.edu.au/silent-tides/

Takagi, N. (2019). *Silent Tides* [Image]. Imaginarium. https://imaginarium19.ci.qut.edu.au/silent-tides/

Thiele, L. P. (2013). *Sustainability* (1. ed.). Polity Press.

van Dijk, A. I. J. M., Beck, H. E., Crosbie, R. S., de Jeu, R. A. M., Liu, Y. Y., Podger, G. M., Timbal, B., & Viney, N. R. (2013). The Millennium Drought in southeast Australia (2001–2009): Natural and human causes and implications for water resources, ecosystems, economy, and society. *Water Resources Research, 49*(2), 1040-1057. https://doi.org/10.1002/wrcr.20123

Walker, H. L. (2013). *The Handbook of Design for Sustainability* (1st ed.). Bloomsbury Publishing.

White, R. M., & van Koten, H. (2016). Co-designing for Sustainability: Strategizing Community Carbon Emission Reduction Through Socio-ecological Innovation. *The Design Journal, 19*(1), 25-46. https://doi.org/10.1080/14606925.2015.1064219

Willett, W., Jansen, Y., & Dragicevic, P. (2017). Embedded Data Representations. *IEEE Transactions on Visualization and Computer Graphics, 23*(1), 461-470. https://doi.org/10.1109/TVCG.2016.2598608

8 Appendices

8.1 Appendix A: The Complete Visual Story Album (In Chronological Order)

The original version of the timelapse video seen in the visual story can be found by following this link: https://youtu.be/KxXPvkMX5UY

Roma, Queensland – November 2018 (McDonnell, 2018)

Giberoo Station, Queensland – January 2019 (McDonnell, 2019)

Giberoo Station, Queensland – January 2019 (McDonnell, 2019)

Giberoo Station, Queensland – January 2019 (McDonnell, 2019)

Giberoo Station, Queensland – January 2019 (McDonnell, 2019)

Dirranbandi, Queensland – March 2019 (Grant, 2019)

Dirranbandi, Queensland – July 2019 (Grant, 2019)

Dirranbandi, Queensland – August 2019 (Grant, 2019)

Dirranbandi, Queensland – August 2019 (Grant, 2019)

Roma, Queensland – January 2020

Dirranbandi, Queensland – March 2020 (Carroll, 2020)

Wallumbilla, Queensland – May 2020

St George, Queensland – July 2020

St George, Queensland – August 2020

8.2 Appendix B: All Other Images Collected from Photographic Observations

This appendix lists the images that were collected, but weren't used either because of low quality, or because there wasn't a date on the picture to match to the data. All the images from page 59 up to (and including) page 68 were taken from a trip back from Roma, in May 2020.


EXPLORERS
Restaurant

Dirranbandi, Queensland – No Date (Grant, n.d.)

Dirranbandi, Queensland – No Date (Grant, n.d.)

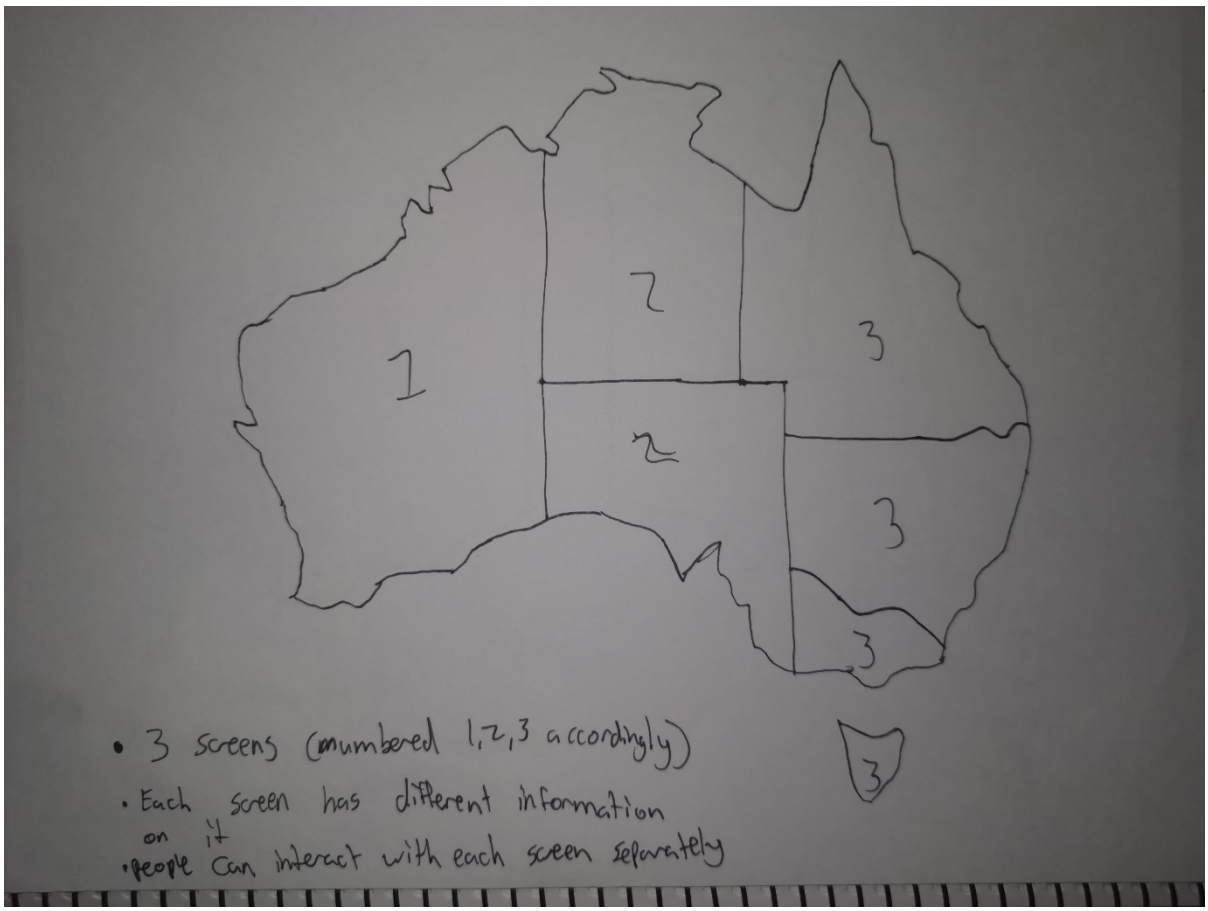
Dirranbandi, Queensland – No Date (Carroll, n.d.)

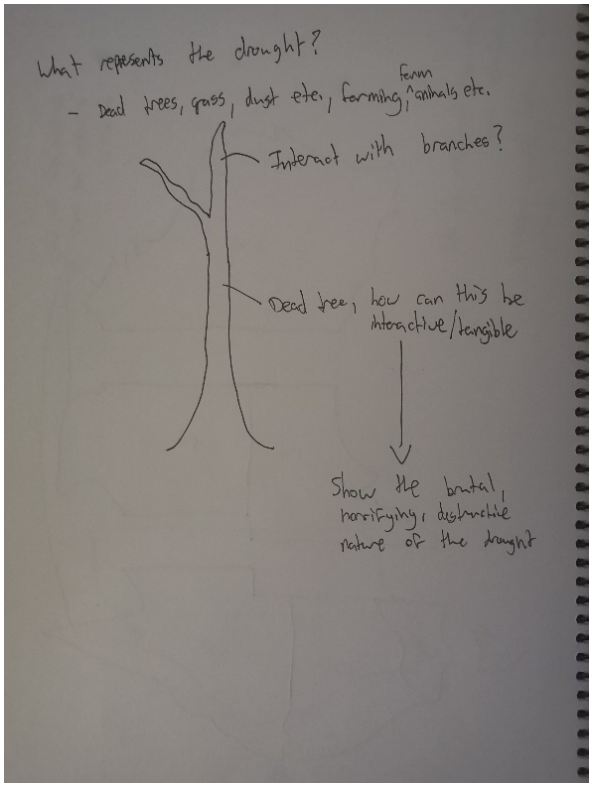
Dirranbandi, Queensland – No Date (Carroll, n.d.)

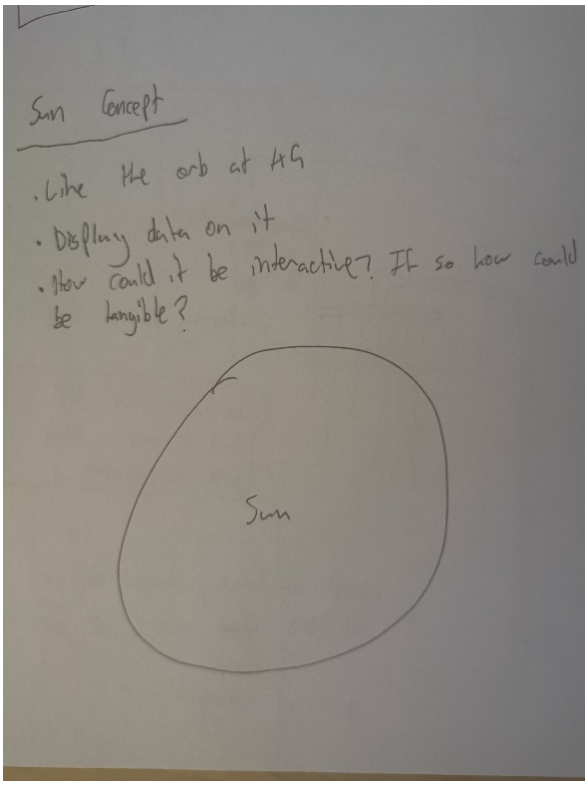
Dirranbandi, Queensland – No Date (Carroll, n.d.)

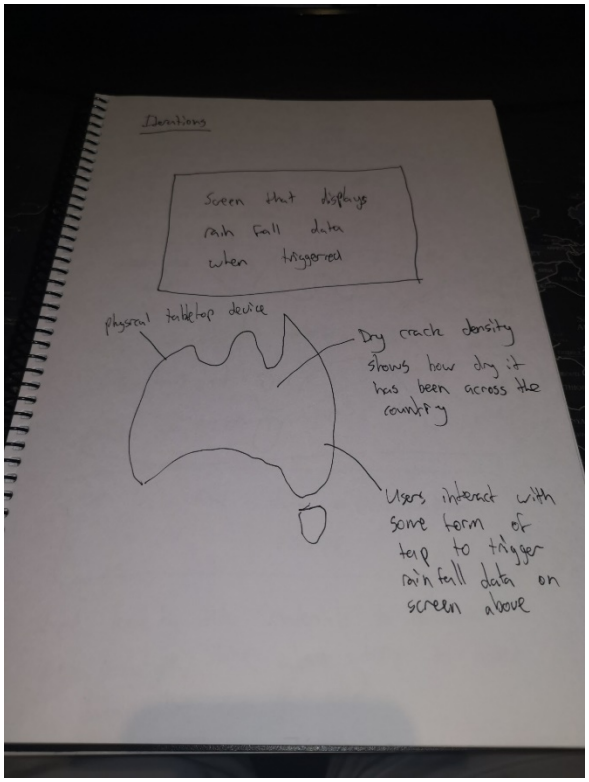
8.3 Appendix C: Additional Sketches

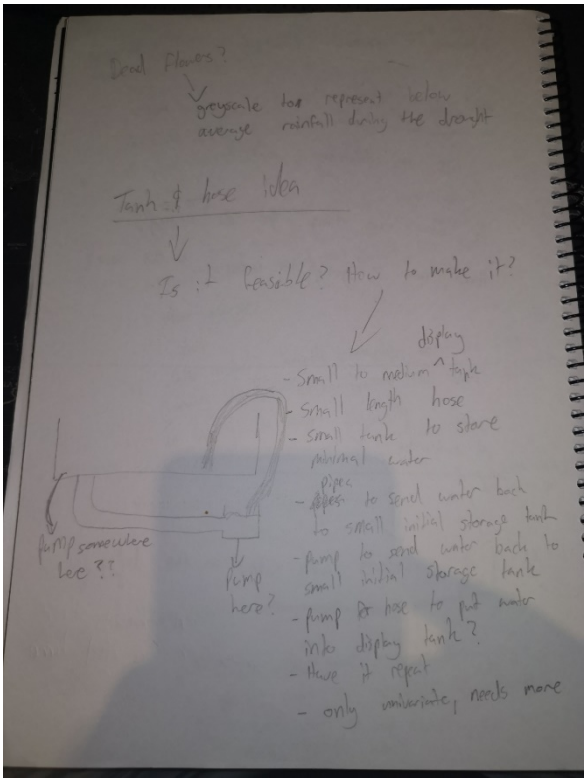
The following sketches are from both semester 1 and 2, and they show the iterative process I went through in creating the final artefact for this project. All other sketches used in this project have been discussed in the process section of this document (section 4).

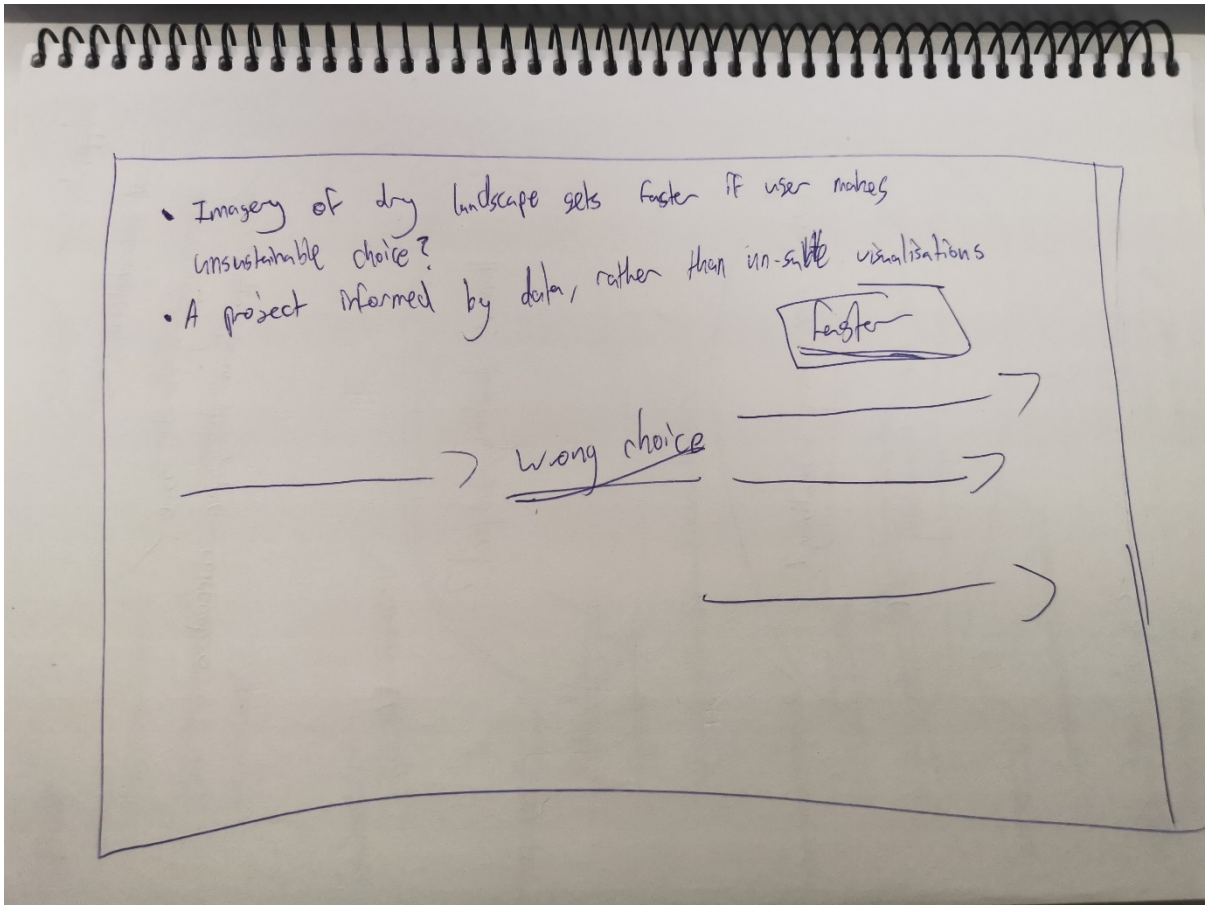


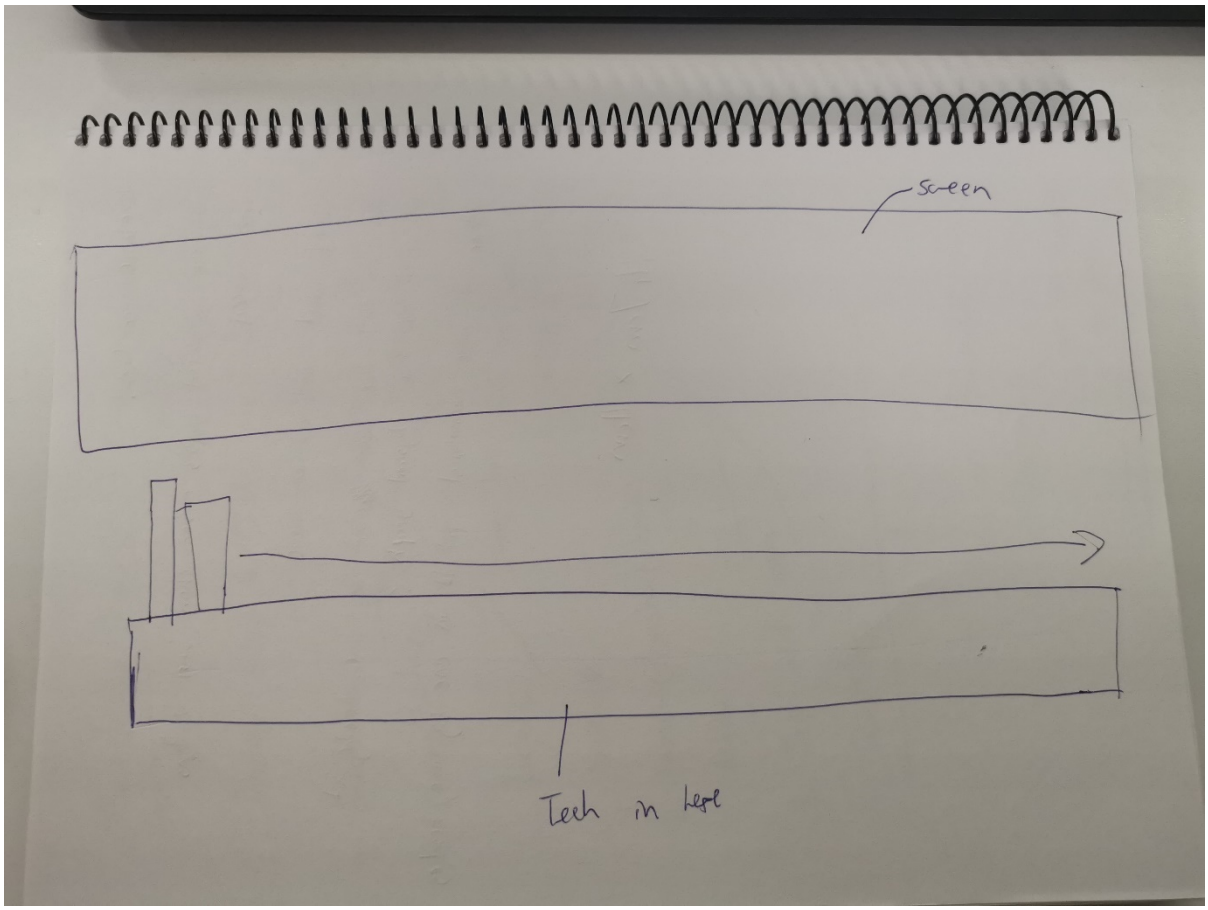

What represents the drought?
- Dead trees, grass, dust etc, farming, farm animals etc.
Interact with branches?
Dead tree, how can this be interactive/tangible
Show the brutal, horrifying, distinctive nature of the drought

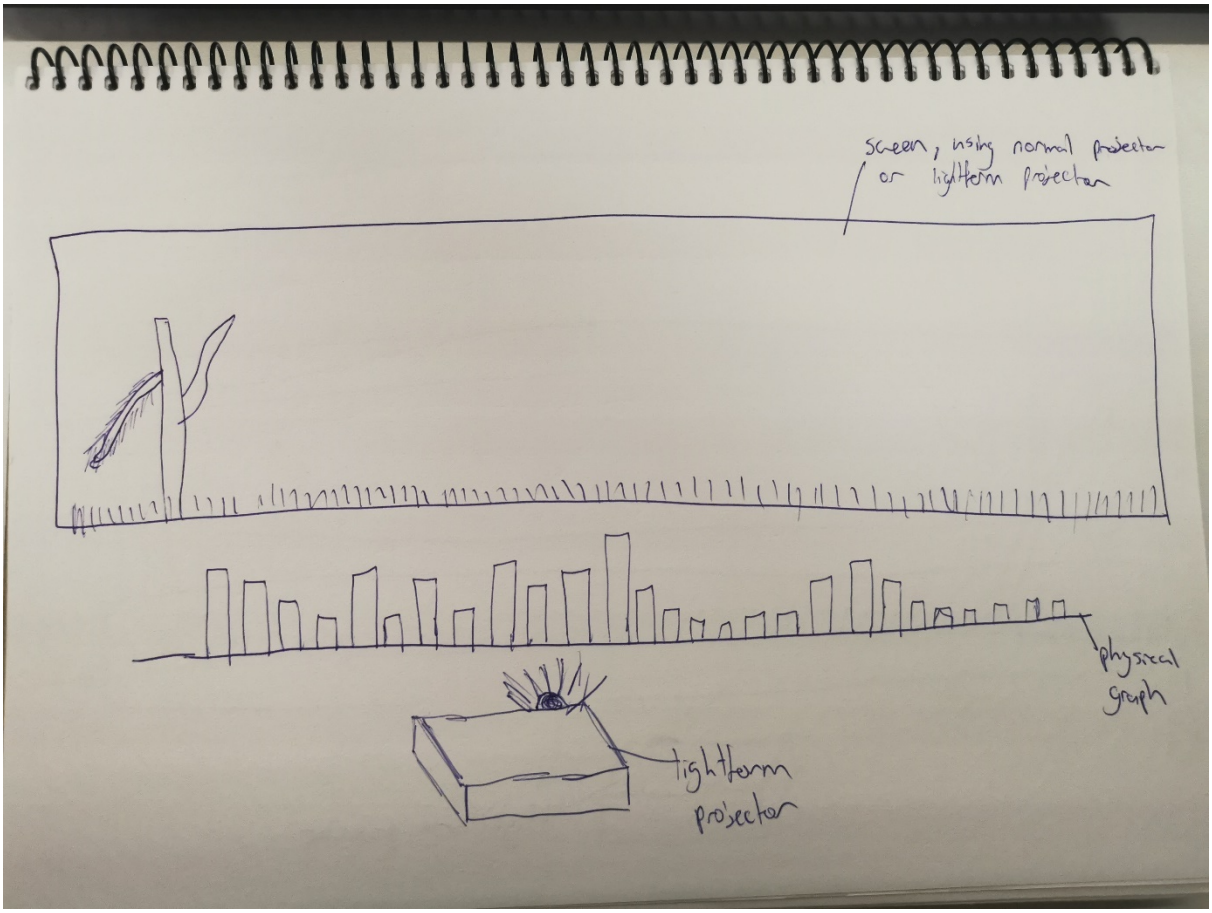

Sun Concept
. Like the orb at 4G
. Display data on it
. How could it be interactive? If so how could be tangible?
Sun


Questions
Screen that displays rain fall data when triggered
physical tabletop device
Dry cracks density shows how dry it has been across the country
Users interact with some form of trap to trigger rainfall data on screen above


Dead Flowers?
greyscale to represent below average rainfall during the drought
Tank & hose idea
Is it feasible? How to make it?
display
- Small to medium tank
- Small length hose
- Small tank to store minimal water
- Pipes to send water back to small initial storage tank
- Pump to send water back to small initial storage tank
- Pump & hose to put water into display tank?
- Have it repeat
- only unidirectional, needs more
pump somewhere here??
pump here?


• Imagery of dry landscape gets faster if user makes unsustainable choice?
• A project informed by data, rather than in-suite visualisations
faster
wrong choice

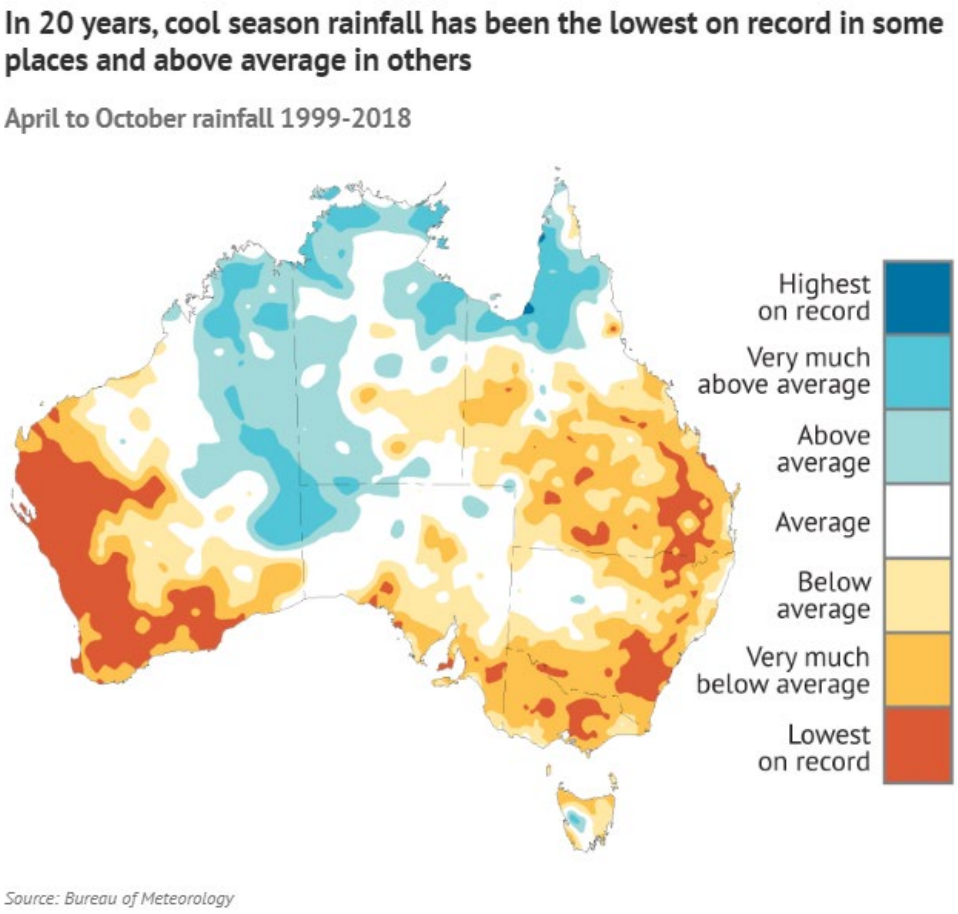

screen
Tech in Legal


screen, using normal projector
or lightform projector
physical
graph
lightform
projector

8.4 Appendix D: Data Relating to the Issue

All the data that was used to directly inform the data visualisation can be found by following this link: http://www.bom.gov.au/climate/current/statement_archives.shtml. This link goes to the Bureau of Meteorology's Climate Summaries Archive, which details the weather across Australia for every month, including rainfall. Every month in this archive from January 2017 to August 2020 was looked at, and the average rainfall across Australia for each month was used to create the bar graph columns.

The following data (below) was used to indirectly inform the project and the artefact. This means that while this data wasn't used in the final project data visualisation, this data was still very helpful, especially in the early iterative stages of the project when I was still figuring out what I was going to design. All other data used in relation to this project can be found throughout the document in sections 1 and 4.



Source: The Sydney Morning Herald (Hannam, 2019)

Water

Freshwater is essential to human existence, and to the functioning of the ecosystems that support us. Australia is the driest populated continent on earth and can yield only a limited amount of freshwater. The average annual rainfall in Australia of around 470mm a year is well below the global average. Despite this, Australians are the greatest per capita consumers of water, using an average of 100,000L of freshwater per person each year. This figure increases tenfold if the water embodied in the food and products we consume is included.

Source: Australian Government (McGee, 2013)

The role of climate change

Climate change doesn't cause fires directly but has caused an increase in the occurrence of extreme fire weather and in the length of the fire season across large parts of Australia since the 1950s. In addition to 2019 being the driest year since records began in 1900, it was Australia's warmest year. In 2019 the annual mean temperature was 1.52 °C above average[1].

Source: CSIRO (CSIRO, 2020)

Water used on Australian farms in 2017-18

10.5 million megalitres of water were used by Australian farming businesses in 2017-18.

- 2.3 million hectares of agricultural land was irrigated (up 2%)
- 9.7 million megalitres (ML) of water was used to irrigate crops and pastures (up 7%)
- 22 thousand farms applied water to their land (up 2%)

Source: ABS (Australian Bureau of Statistics, 2019)

Murray Darling Basin

More than two thirds (70%) of all Australian agricultural water use was within the Murray Darling Basin region in 2017-18.

In 2017-18 in the Murray Darling Basin

- 1.5 million hectares of agricultural land was irrigated (up 8%)
- 6.8 million ML of water was applied (up 7%)

Source: ABS (Australian Bureau of Statistics, 2019)

Australian Bureau of Statistics. (2019). *Water Use on Australian Farms, 2017-18.* https://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/4618.0Main+Features12017-18?OpenDocument

CSIRO. (2020). *The 2019-20 Bushfires: A CSIRO Explainer.* https://www.csiro.au/en/Research/Environment/Extreme-Events/Bushfire/preparing-for-climate-change/2019-20-bushfires-explainer

Hannam, P. (2019). *How Bad is this Drought and is it Caused by Climate Change?* [Image]. The Sydney Morning Herald. https://www.smh.com.au/environment/climate-change/how-bad-is-this-drought-and-is-it-caused-by-climate-change-20191024-p533xc.html

McGee, C. (2013). *Water* [Image]. Australian Government. https://www.yourhome.gov.au/water