Semester Two

B920752 Development Folio

Semester 1 Proposal - 'Discover' Section
Feedback

Primary research

- Several observations were conducted from interviews found in the public domain which is great. These have highlighted a range of issues which corroborate your secondary research and highlight new issues, such as the fit of nipple shields between different users. Again it's hard to appreciate what went on to inform your thinking as we are only given a summary of the data.
- It was great to see you engage in user interviews from recent mothers. These seems to have again re-enforced previous findings. It would have been good to hear some comments on how this informed your development rather than just framing the problem from a new lens.

Market analysis

- Some attempts have been made to quantify the market size based on the number of births per year and the volume of user making use of nipple shields. While this is a good start, it assumes 100% market share against existing products which is not realistic. I would suggest perhaps 5% share based as a new product in this busy space.
- Some of the stats presented here suggest breast feeding rates in the UK have risen since 2005 to 2010, albeit in the phases prior to 6 months. This would contradict the premise in the brief of a decline in breast feeding!

Secondary research

- A substantial volume of secondary research has been conducted examining a range of different sources. From this a range of great insights have been derived relating to the issues faces and possible places for a product solution, which mainly feature in the folio over the report i.e. table on pg 18.
- What is less clear is how the research has informed your thinking in terms of critical analysis of this data and synergy into a product function/specification. Often summaries are quite general, stating basic issues with pain or sore nipples, etc. Now that you know this how can this inform your product, e.g. should it be a pain relief system, is there benefit to some form of preventative solution, what ways could either of these be achieved? etc.
- Mental health was a reoccurring theme in the research yet did not seem to received much attention as a development point, which is a missed opportunity.
- The users of any product have been clearly identified, but the nuances surrounding the difference in experience and outcome had not been clearly articulated. For instance, Figures 2 and 3 in the report show two different continuation frequencies for mothers who exclusively and supplement breast feeding, why is this? What differences in experience does this translate to, what opportunities may arise here?
- What about the impact of sleep deprivation on bodily sensation, comfort, and the ability to undertake simple tasks?
- What about further exploration of the opportunities around post-collection of -breast milk – storage, traceability, reuse? It's a messy and time consuming process with two hands, what about for time-pressed parents when their minds are all over the place?
- The general environment in which a product solution could be implemented has not been clearly articulated and the nuances of these explored, i.e. product use at home, at work, out in public, etc.
- Great to see an overview of existing product, which seems to focus on pain, but the folio provides some insight into wider systems for sterilisation. The table providing pros and cons is good, but I'm not sure how you extrapolated opportunities for your product from these.

My Reflection:
Need to better communicate my thought process, explaining insights explicitly and fully.

Semester 1 Proposal - 'Define' Section
Feedback

Brief and PDS

- The brief clearly states the problem/opportunity, confirmed with references, highlighting complications with breast feeding and resulting physical issues. The user has been identified and metrics of concern communicated. One niggle is that it highlights several opportunities and so it is unclear which should be the focus, be it continued breast feeding or alleviation of the various physical symptom, although it is appreciated these are not always mutually exclusive. The specific point of innovation is also less clear as this is a very active product space.
- No updated PDS has been provided in the folio or report, which is a shame as one had initially been created, however we are unable to ascertain developments or changes.

Scenario

- The general user journey map is presented. This is only one of several scenarios, for instance a person may not be able to achieve effective latching from the offset or may have reasonable technique and not suffered issues until later in the breast feeding phase, all with different challenges and potential physiological impacts.
- Nice to see a storyboard of the problem however given the breadth of the problem and available user insights more than one persona development would have been expected, particularly to frame the different user journeys and resulting outcomes.

My Reflection:

Need to redefine the brief, specifically defining the opportnities and which I go with.

Should focus in on one specific pain point rahter than trying to address multiple.

Need to outline an updated PDS.

Consider multiple persona for different users and their journeys.

Semester 1 Proposal - 'Develop' Section
Feedback

Aesthetics

- The general aesthetics of the product are basic, comprising a simple hollow dome form. While devices of this classification are more function over form and have a simplistic form, the justification on these grounds is not clear.
- More would be expected for a final year design project but the issues feel systemic and come back to the confusion on the product function which then trickle back to limit the design potential.
- Give the device is concealed, could you have thought of this being integrated into a wearable, such as a bra?

Appropriateness of proposal/feasibility

- Ultimately the proposal is not entirely appropriate and feels both rushed and confused in terms of synergising the function to the issue it attempt to resolve.
- I am not confident such a product would appeal to women breast feeding or provide confidence in continuing breast feeding or provide pain relief. More thought is needed to establish a robust opportunity here.
- There is low confidence in the feasibility and viability of the product.

Functionality & interaction

- 3 primary concepts have been explored to tackle a range of possible issues when breastfeeding. While these seem reasonable, closer thought on each highlight a range of possible issues. It is also unclear how each of these either provide a substantial step improvement on existing products or manage some of the more serious issues, which arguably are the pain/soreness of the nipple and the psychological issues.
- The final concept aims to amalgamate several existing functions of products on the market with the inclusion of moisture sensors. The design ultimately feels flawed in several respects, namely the silver disc implies contact with the skin to operate which is at odds with relieving some of the soreness due to the risk of chaffing, while the sensors feel odd and are there to justify a haptic system, which also **feels odd as a user can readily inspect the system** and both appear to have been added to simply provide a technological solution. Lastly, as identified, the system would likely leak and the system does not seem to substantially provide universal fit beyond.
- A suitable concept selection seems to have been conducted with some attempt to rationalise importance. However, I find the choice of importance a little odd as it has ranked speed and ease of use higher than pain relief, healing or prevention which are the literal pain points of the user! I would rethink this.
- Materials seem reasonable but how will this be manufactured and how is the silver placed in the silicone?
- Interaction seems to not have been robustly considered.

My Reflection:

The product function needs to be reconsidered and honed in on

Aesthetics of the design needs developing, with priorities evaluated to justify form vs. function

Interaction will need to be considered carefully, for the different personas identified

Letdown on opposite breast???

Semester 1 Proposal - Suggestions moving forward
Feedback

The proposal presented has several highlighted flaws. There is still space to innovate in this topic but will require considerable effort to resolve.

There are some good existing products seeking to enhance the experiences of mothers during breast feeding. These existing products will not increase the percentage of women persisting with breastfeeding – this will only occur if there is a seismic improvement in post-partum health services. It feels like you have all the required information and data from your research but the appreciation and analysis of how this could translate to a product solution have not been well thought out.

Catching let-down is good, but **largely a passive activity assuming secure fitting etc**. There is however a good opportunity for innovation and product development to make the process of collection, storage and reuse a cleaner, intuitive, and less stressful process for parents.

Did you also consider some form of periodic pain dispensation system, a product to build confidence/tackle mental health issues in user resulting from a poor experience in breast feeding, or a system which could provide periodic delivery of breast milk to the nipple, as is stated as a potential remedy for sore nipples?

All of these have potential and may want to be considered moving into S2 as I believe the current line of inquiry is not going to yield a good outcome.

My Reflection/Next Steps:

I need to step back and revisit my research to consider how my findings can translate to a product. Going back over my research

Unpack my insights

Potential New Routes?

- Making the process of collection, storage and reuse a cleaner, intuitive, and less stressful process for parents.

- Did you also consider some form of periodic pain dispensation system

- A product to build confidence/tackle mental health issues in user resulting from a poor experience in breast feeding

- A system which could provide periodic delivery of breast milk to the nipple, as is stated as a potential remedy for sore nipples?

- What about further exploration of the opportunities around post-collection of -breast milk – storage, traceability, reuse? It's a messy and time consuming process with two hands, what about for time-pressed parents when their minds are all over the place?

Semester 2 Plan
Gantt Chart

	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7
Meetings with Tutors						
Redefine Focus Area						
Develop New Concepts						
Refine Concept						
Design Development						
Prototype Considerations						
CAD						
Engineering Drawings						
Prototyping Plan						
Risk Assessment						
Begin Prototyping						

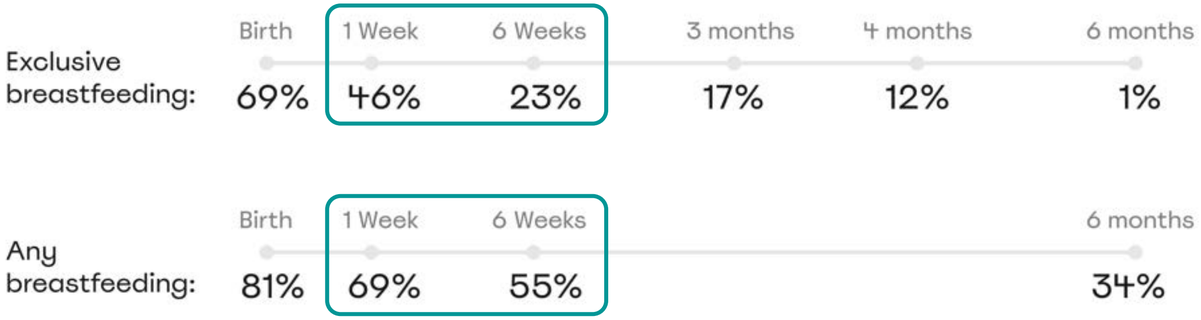
Breastfeeding in the UK
Secondary Research

Exclusive breastfeeding as defined by WHO and UNICEF is the practice whereby an infant receives only breast milk. This breast milk can come directly from the mother or a wet nurse, or can be expressed breast milk given to the baby with a bottle, cup or syringe.

Women can also partially breastfeed, using supplements as needed so their baby still benefits from breastmilk. This is usually achieved by offering the baby bottles of expressed milk or formula alongside breastfeeding. This practice is known as **mixed or combination feeding**.

UK Breastfeeding Figures, ONS Infant Feeding Survey 201

Percentage of exclusively breastfed babies falls by half between weeks 1 and 6 postpartum, this decrease is much less significant for babies that are combination fed.



British Journal of Midwifery online survey of UK-based women in 2020:

Table 1. Breastfeeding timeline for all respondents, mothers who exclusively breastfed and those who combination fed from the outset

Timeline	All respondents (*n*=1084)	Respondents who combination fed from birth (*n*=172)	Respondents who exclusively breastfed (*n*=480)
	100%	100%	100%
Still breastfeeding at 1 month	76%	71%	88%
Still breastfeeding at 3 months	62%	45%	77%
Still breastfeeding at 6 months	46%	23%	63%
Still breastfeeding at 9 months	28%	11%	41%
Still breastfeeding after 12 months	15%	5%	26%
Average breastfeeding length	28 weeks	15 weeks	35 weeks

Contradictory findings
- BJM study is more recent but has 10x fewer particpants than the ONS Infant Feeding Survey (1,084 compared to 10,768). ONS is more trustworthy.

Reasons for combination/mixed feeding:

- If there are difficulties getting breastfeeding established or if there are concerns about the baby's weight, you might be advised to give some formula feeds alongside breastfeeding.

- Baby needs to be left for periods of time and will need milk in the mother's absence (for example, if the mother is returning to work).

- Allowing a non-breastfeeding partner to be involved with feeding.

- Bottle feeding and wanting to start or resume breastfeeding.

- Perceived or actual decrease in breastmilk supply (however use of formula can decrease supply further

- Baby not taking to breastfeeding/losing interest.

Why might combination feeding rates be higher than those for exclusive breastfeeding?

- Feels easier to maintain
- Less of an 'all or nothing' mentality
- Less pressure on the mother than exclusive breastfeeding, the load can be shared with partners etc

Summary of key findings

The rate of exclusive breastfeeding decreases sharply and rapidly in the UK, despite a relatively high initial rate of 69%

The decline for babies that are combination fed is much less significant - combination feeding may feel more accessible to women

Not clear if the drop-off from exclusive feeding leads to combination feeding, or a cessation of breastfeeding altogether - **requires further research**

Can my product aim to encourage combination breastfeeding as a solution to support mothers struggling to breastfeed exclusively/ finding it overwhelming?

Pain when breastfeeding
Secondary Research

‘Exploring women’s perceptions of pain when breastfeeding using online forums’

One commonly cited barrier to longer breastfeeding duration is nipple and breast pain. The experience of pain associated with breastfeeding can differ between individuals, from intolerable pain to mild discomfort. However, this unappealing feeling, no matter how extreme, can be highly detrimental to the breastfeeding experience. For instance, experiences of pain have been strongly linked with breastfeeding cessation and this **pain-associated cessation is linked to feelings of guilt, dissatisfaction, upset and risk of postnatal depression**. Even in the most determined mothers who have a strong intention to breastfeed, pain is cited as a key reason for cessation.

Whilst pain is a common factor experienced during early days of breastfeeding, **the underlying reasons for pain and how women manage this experience are varied and not well understood**. Literature is also conflicting. Nipple-pain has been attributed to incorrect positioning of the baby, however, some evidence refutes this link, suggesting that **there may be additional physiological or psychological reasons why women commonly experience nipple pain**. Furthermore, research has mostly focused on the experience of nipple pain, with little known about the specific type or range of pain women experience when breastfeeding.

Qualitative research indicates that women express a **mismatch between their general expectations and realities of breastfeeding** and a **lack of support for emotional needs**. This mismatch of expectations and realities has been linked to a woman’s confidence, breastfeeding knowledge and social environment, hence past experience of breastfeeding and support from those around them are key components to meeting breastfeeding expectations and continuing with breastfeeding when presented with setbacks such as pain. **There is particularly little exploration of what women expect in relation to pain during breastfeeding or exactly how others influence coping with breastfeeding pain.** Furthermore, women actively use online social media to source breastfeeding information and support.

Themes identified in the study:

1. ‘Variation in types of pain’ - the variety of painful experiences and their descriptions. In particular, this theme reveals the large variety of different types of pain women experience at different stages throughout their breastfeeding journey, as well as the different pain characteristic they focus on in the description of their experience (i.e., location, sensory or physical aspects).

2. ‘Perceived causes and explanations for pain’ - how women interpret pain experiences either due to a recognised condition or behavioural cause.

3. ‘Cessation of breastfeeding related to pain’ - how women experience both physical and psychological struggles (e.g., guilt) related to breastfeeding cessation, with pain being a main factor in considering cessation of breastfeeding.

4. ‘Shared experiences and support’ - women’s strong need for both practical and emotional support to deal with pain. Many women look for this support through the knowledge exchange offered on the online forums.

Summary of key findings

Nipple and breast pain are commonly cited as barriers to longer breastfeeding duration

There isn’t enough research or understanding into the causes of pain; incorrect positioning is often to blame however there are other causes that may be physiological or psychological.

Prior expectations of breastfeeding vs reality is an interesting area, with women reporting surprise/shock at how painful breastfeeding can be.

Breastfeeding is an emotional process requiring a support network, both practically and emotionally.

Early Breastfeeding Cessation
Secondary Research

‘Reasons for Earlier Than Desired Cessation of Breastfeeding’

Approximately 60% of mothers who stopped breastfeeding did so earlier than desired.

Many of the reasons mothers cited for not breastfeeding as long as desired were related to concerns about maternal or child health and processes associated with breastfeeding, including concerns about: (1) lactation; (2) infant nutrition and weight; (3) the need to take medicine or illness; and (4) milk pumping. Improper latching may begin a cascade of negative events that undermine breastfeeding, including nipple pain, ineffective milk transfer, and insufficient milk production.

When a mother perceives that she is not providing an adequate quality or quantity of milk to her infant, she is likely to stop breastfeeding regardless of the infant’s age.

Yet, studies show that <5% of women are biologically incapable of producing a sufficient quantity of milk or are unable to accomplish adequate infant weight gain through breastfeeding alone.

Decision to breastfeed or formula feed
Secondary Research

[Healthcare professionals' and mothers' perceptions of factors that influence decisions to breastfeed or formula feed infants: a comparative study]

23 mothers completed the interview in 2007-2008. All mothers formula fed from birth or breastfed for 6 weeks or less. With regard to their youngest or only child, 15 mothers had initiated breastfeeding at birth, whilst eight had formula fed. Breastfeeding duration ranged from 3 days to 6 weeks.

Five main themes surrounding formula feed choice were identified:

1. Formula feeding is seen as the norm in the UK, with breastfeeding rarely represented

Professionals said that bottle feeding was integrated into society and breastfeeding was seen almost as an abnormal behaviour. In their experience, mothers have little experience of breastfeeding before they make the decision on how to feed their own infants. They do, however, **often see formula feeding and perhaps internalize this as the norm**. This belief also has an impact on successful breastfeeding as, even if it is initiated, **knowledge and understanding of breastfeeding is low.**

Mothers who initiated breastfeeding said that they were in the minority, and that the majority of friends and family used formula milk. This was often cited as an important trigger in stopping breastfeeding, because they said that they had **little support from others when they did try to breastfeed.**

"Mums have little knowledge about what breastfeeding is really like so make their choices based on what they know and have experienced – formula feeding. **It's so unusual to see breastfeeding when you are out and there are no positive role models.**" - Community Worker

2. The attitude that breastfeeding has a negative impact on maternal weight and body image, and that breasts should remain sexual and be for the mothers' partner rather than her infant

A second theme running through the interviews was the attitude that breastfeeding had a negative impact on maternal weight and body image. Professionals reported a number of mothers choosing to formula feed because of the immediate consequences of breastfeeding to their bodies. Breastfeeding changed the shape and function of a woman's breasts and meant that her body was still involved in the nurturing process, rather than returning to the prepregnant state. Moreover, **concerns about the supposed long-term effects of breastfeeding on breast shape and size encouraged formula use:**

"One of the main reasons, I think, is because of their body image. Mums are **acutely aware of how they look** and breastfeeding isn't compatible with that. They're trying to get their figure back, they associate their breasts with sexuality not feeding, they hear that it will make their breasts droop and so on" - Community Worker

Mothers reported feeling embarrassed by the changes in their bodies at a time when **they already felt conscious of their appearance after giving birth**. Although some tried to overcome these issues, they often proved too much and they felt happier using formula. Formula was often used from birth over the fear that breastfeeding would leave them misshapen and unattractive.

In addition to fears about the consequences of breastfeeding to their breasts and body shape, issues of embarrassment and sexuality were raised by both professionals and mothers. In particular, **the idea amongst mothers that breasts should remain sexual and be for the mothers' partner rather than her infant was strong**. Professionals were well aware of these attitudes:

"Bottle feeding is tied in with this stupid idea of breasts and sexuality. Women find it hard to relate that part of their bodies to feeding a baby. Partners also find it hard – they get jealous that their partner's breasts are not available just for them." - Midwife

3. Formula feeding is viewed as more convenient and less time-consuming and formula-fed infants as more settled, plus others can help feed

Both mothers who used formula and professionals raised the idea that formula was less demanding on maternal lifestyle than breastfeeding. Formula feeding was regarded as less time-consuming and more regular, and formula-fed infants as more settled. Professionals confirmed the idea that this is often attractive to new mothers as they can organize and predict their day-to-day lives more easily:

"A lot of mums just **don't realise the reality of having a newborn baby**. I mean, **it's exhausting and it's no wonder they chose what appears to be the easiest method**. Unfortunately, formula does seem to settle babies more quickly even though that's not necessarily good for them." - Midwife

Professionals in particular had a strong perception that many mothers chose to formula feed so that they were not solely responsible for feeding the infant. If the mother introduced formula, other people could care for the infant, allowing them to get on with other tasks. Formula feeding meant that mothers could get a welcome break from the exhausting cycle of infant care:

"If a mum feels overwhelmed by having a baby she will want to take any help she can get and feeding is often one area which people like helping with. She won't get that break if she breastfeeds." - Community Worker"

Indeed, this concept was supported by mothers who chose to formula feed from birth or switched to formula after a short period of breastfeeding. Formula allowed other people to feed the infant and this was not just beneficial to the mother. Other people wanted to share in the care of the infant, particularly feeding, and pressurized the mother into letting them do so:

"I knew breastfeeding was better but bottle feeding is easier and lets everyone else get involved. I could sleep, dad could feed." - Mother who breastfed for 3 days

Decision to breastfeed or formula feed (cont.)
Secondary Research

4. Breastfeeding can appear or be made more difficult through lack of knowledge and understanding

Formula feeding, on the other hand, was viewed as simple and free of difficulties. Professionals, in particular, highlighted how breastfeeding can appear or be made more difficult through lack of knowledge and understanding of how it works. They thought that mothers were **ill-equipped for the realities of breastfeeding**, which caused or exacerbated problems such as pain and soreness. Moreover, when they did face problems they **had no understanding of where to go for help and support**:

"Mothers who start out breastfeeding often don't have the right information and support at the right time. Breastfeeding isn't easy, and **when they then encounter difficulties they stop** rather than finding the right support." - Breastfeeding Counsellor

The belief that breastfeeding was difficult was strongly portrayed, particularly amongst mothers who initiated but stopped breastfeeding. They cited a range of problems which led to them changing to formula milk, centring on pain and discomfort. **Anger was often expressed that they had not been told about or supported with such problems**, and **many felt guilty about stopping breastfeeding.** Mothers said that there was no one to support them, and the common solution appeared to be to give formula milk:

"It was absolutely exhausting. It was difficult - I couldn't get him to latch, I didn't know when he would feed. I was feeding all the time, which was just ridiculous. I tried to get help, but people would just tell me it was normal or suggested formula." - Mother who breastfed for 8 weeks.

5. Lack of confidence and anxiety surrounding breastfeeding

A closely associated theme to breastfeeding being a difficult option was the **association between low levels of confidence and use of formula**. **A common fear amongst mothers who were breastfeeding was that they were not producing enough milk, that their infants was not growing fast enough or that they fed too frequently compared with formula-fed infants.** Professionals noted that others often exacerbated these fears by echoing them. Tied in with the belief that formula milk was the normal way to feed a baby, maternal confidence was reduced:

"Many people make breastfeeding mums feel inadequate, telling them they haven't got enough milk, which leads to confusion and lack of confidence in their ability to breastfeed." - Health Visitor

Indeed, mothers described how **so much emphasis was placed on child weight gain from both professionals and friends and family** that they **grew anxious about how much their infant was feeding and how much weight they gained**. **They doubted their milk supply and were uncomfortable not being able to see how much the infant had consumed.** Whilst breastfed infants were seen as difficult to feed, bottle feeding allowed mothers to coax their infants to feed more, thus filling them up. The consequence of this was increased weight gain, which **made mothers feel proud and secure** that their infants were growing well:

"I noticed within a few weeks of stopping breastfeeding that he had gone up the charts quite a bit. People started commenting on how much he had grown, **so I felt a lot better about stopping breastfeeding** as I knew I had done the right thing." - Mother who breastfed for 6 weeks

Suggestions to increase breastfeeding duration

Finally, a number of ideas were raised as to how mothers could be encouraged to initiate breastfeeding and to breastfeed for longer, and the role that professionals could play in this. Ideas centred on the concept of seeing breastfeeding as the normal, accepted and best way to feed an infant, coupled with the idea of increased support:

"Understanding that breastfeeding is the normal behaviour, anything else is different. People need to stop pushing the idea of the supposedly sleeping contented formula-fed infant as happy and healthy." - Breastfeeding Counsellor

Professionals especially believed that further support was needed and were eager to give this, but criticized lack of time and funding:

"**It frustrates me. I have the ability to help mums but I have so many other things to do** – paperwork, following things up, courses on irrelevant things – that **often I just don't have the time to sit and give the mum the time she needs** to position her baby, or to give more than a few words of reassurance when she is worried that her baby is feeding too much." - Health Visitor

On the basis of their own experiences, mothers had clear views about the ways in which they thought breastfeeding could be promoted and future support should be targeted. Again, more help with breastfeeding difficulties was highlighted:

"New mums really need more support. I tried to find it when I had difficulties, but there wasn't any, and everyone else was just telling me to use formula. I do regret stopping feeding her myself, and perhaps if I had support then I would have fed her for longer." - Mother who breastfed for 2 weeks

Summary of key findings

Formula feeding is often perceived to be the norm in the UK, with breastfeeding seen as the exception. Societal issues surrounding perception of breasts as sexual, coupled with low body image post-partum and successive concern about the impact of breastfeeding on their breasts and appearance, are factors contributing to women choosing to formula feed.

There is a perception that formula-fed babies are more settled, on top of the fact that formula feeding can be done by others to help an exhausted and/or overwhelmed mother out. Many mothers don't realise the reality of having a new born baby and understandably opt for what they perceive to be the easiest option.

Surprise at the difficulty of breastfeeding is common, with many of the challenges encountered coming unexpected. Low confidence amongst mothers, and specifically anxiety about how much milk their baby was getting and whether it was enough, were recurring themes in the study. Tied in with the belief that formula milk was the normal way to feed a baby, maternal confidence was reduced.

‘UK women’s experiences of breastfeeding and additional breastfeeding support’
Secondary Research

UK women’s experiences of breastfeeding and support - key themes

1. Antenatal Education
• Many of the women interviewed felt that they had been given **unrealistic expectations** of breastfeeding by professionals keen to promote its health benefits and expressed **anger about the lack of preparation** they had been given for potential difficulties.
• Dominant discourses that portray breastfeeding as ‘easy’ and ‘instinctive’ left mothers with **feelings of guilt and inadequacy** at their inability to master a **supposedly ‘natural’ skill.**
• **Lack of control over the situation** contrasted with women’s views of themselves and undermined their sense of self-efficacy.

2. Realistic Experiences
• Women felt that there was still a great deal of pressure upon mothers to breastfeed, but that this was n**ot always backed up by adequate practical support**. This led to **guilt** about making the **‘correct’ feeding decisions** and how to do the ‘best’ for their baby.

3. Postnatal Care
• Many women expressed dissatisfaction with routine postnatal care, reporting that advice was often inadequate, contradictory and undermined their confidence in their feeding abilities. In particular **the notion that ‘breastfeeding shouldn’t hurt’ was found to be unhelpful** where women were experiencing problems with sore and cracked nipples.
• Staff could give very contradictory messages, promoting breastfeeding on the one hand, but also **quick to resort to alternative feeding methods**.
• Mothers felt that they had to be very determined to achieve their feeding goals in the face of pain and limited support, often relying on their own embodied knowledge that something ‘wasn’t right’.

4. Support from Friends and Family
• Even women who may initially have felt social pressure to breastfeed found that once they reached a certain point in their feeding journey, there was an equal **pressure to ‘move on’ to formula** as part of a ‘normal’ progression, highlighting continued negative conceptions in UK society of women who breastfeed for extended periods of time.
• However even supportive partners and other family members could question mother’s determination to breastfeed where they perceived the mother as not coping well or were concerned about her welfare. Feeding decisions are not individual one-off choices but situated within mothers personal social and cultural situations, with various ‘significant others’ playing an important role in decisions about breastfeeding initiation and continuation. Therefore it is important to continue to work to change wider cultural perceptions of breastfeeding and offer ‘family-centred’ support that **works within women’s own social networks to support them at pivotal points within their feeding journeys**.

Treatments for painful nipples
Secondary Research

While the reasons for early discontinuation are variable and complex, it is clear that many women discontinue breastfeeding due to difficulties encountered rather than maternal choice. One common difficulty that many women experience is painful nipples.

‘Interventions for treating painful nipples among breastfeeding women’

We included four trials of good methodological quality involving 656 women in the review. The four included trials evaluated five different interventions including glycerine pads, lanolin with breast shells, lanolin alone, expressed breast milk, and an all-purpose nipple ointment. A**ll studies included education to position the infant at the breast correctly as part of routine postpartum care to both treatment and control groups.** Pooled data existed only for the comparison of lanolin versus usual care. We did not pool data for other outcomes due to either heterogeneity in outcome measures or differing interventions.

Overall, there was **insufficient evidence to recommend any intervention for the treatment of nipple pain**. However, one important finding was that regardless of the treatment used, for most women nipple pain reduced to mild levels after approximately seven to 10 days’ postpartum. The provision of anticipatory guidance regarding usual time to pain reduction may be a useful strategy in assisting women to continue to breastfeed and to do so exclusively.

The reported incidence of nipple pain and trauma varies between 34% and 96% of breastfeeding women. Characteristics associated with nipple pain include cracked, sore, bleeding, blistered nipples that may have fissures and abrasions present. **For many women, nipple pain appears to have the greatest intensity between the third and seventh day postpartum**, with a **peak in severity on the third day** postpartum.

Unfortunately, healing damaged nipples in breastfeeding women is complicated due to **repeated trauma from infant sucking and exposure to maternal skin and infant oral flora** predisposing the nipple to infection (Brent 1998). In particular, any break in the skin surface may lead to a predisposition to secondary bacterial and fungal infection.

As such, damaged nipples have been associated with an increased presence of infection with Candida, most commonly Candida albicans, and Staphylococcus aureus. Clinically, it is believed that **most cases of persistent nipple pain with minimal trauma can be resolved by altering the positioning and latch of the infant** to the breast, whereas women **with visible nipple trauma may benefit from being treated with antibacterial or antifungal medication**. As such, when considering treatment it is important to note clinically that painful nipples may be a symptom of a problem, a problem in and of itself, and it can be a risk factor for bacterial of fungal infection (for which painful nipples is a symptom). **Unfortunately, nipple pain and trauma have been associated with decreased breastfeeding duration, introduction of artificial infant milks, and increased levels of stress**.

Nipple pain can also decrease breastfeeding self efficacy, a variable that has been demonstrated internationally to influence breastfeeding duration and exclusivity rates. It is also known that pain has an inhibitory effect on the release of oxytocin, a hormone that causes the small muscles around the milk ducts to contract and release milk. Despite documentation of the many detrimental outcomes associated with nipple pain, there is very little information describing the characteristics and effect of pain experienced by breastfeeding women.

Summary of key findings

Education, support networks, and post-partum healthcare are the key factors influencing breastfeeding uptake, and nipple pain and trauma are associated with breastfeeding cessation. Nipple pain is frequently caused by poor positioning, which can be prevented or resolved thanks to education, support from friends, family and healthcare professionals. Other than correct positioning and latch, there is little evidence of a universal solution to relieve nipple pain.

Relationship between delivery method and breastfeeding
Secondary Research

'The impact of caesarean section on breastfeeding initiation, duration and difficulties in the first four months postpartum'

The majority of the sample, regardless of delivery mode, intended to breastfeed (96 %, n = 2846) and initiated breastfeeding (98 %, n = 2954). Mode of birth was significantly associated with both planning to breastfeed, and breastfeeding initiation. **Women who had a planned c-section, had a higher percentage of those who did not plan to or initiate breastfeeding** (7.4 % and 4.3 %, respectively).

Eighty-three percent (n = 2391) of women were still breastfeeding at >12 weeks postpartum. Women who had an emergency or planned c-section were more likely to have stopped breastfeeding at 12 weeks (p = 0.02). A multivariable logistic regression model (Table 3) was created to assess breastfeeding duration up to 12 completed weeks postpartum **adjusting for income, education, parity, preterm birth, postpartum maternal physical and mental health, ethnicity and number of breastfeeding difficulties.**

Using vaginal delivery as the reference group, **mode of birth remained a significant independent predictor for breastfeeding cessation** at or prior to 12 weeks postpartum .

In the adjusted multivariable logistic regression model, **women who had a planned c-section were more likely to have early cessation of breastfeeding (≤12 weeks) (Odds Ratio=1.61) when compared to those who delivered vaginally**. There was no significant difference in breastfeeding cessation between women who had an emergency c-section and women who delivered vaginally in the adjusted analysis.

Our findings demonstrate that **planned c-sections are associated with reduced breastfeeding success in the first 4 postpartum months, when compared to vaginal births.** In particular, we have successfully **added to the growing evidence that planned c-sections negatively affect breastfeeding initiation and duration.**

In our study, **women who had an emergency c-section were more likely to have had an unsuccessful first breastfeeding** attempt, were unable to breastfed their baby within the first 24 h, and were unable to breastfeed upon leaving the hospital. Zanardo et al. (2010) found similar results, reporting that women who delivered via emergency c-section were more likely not to have been able to breastfeed their baby at delivery or at discharge. **It has been hypothesized that the maternal and fetal stress response associated with complications during delivery, particularly related to c-sections, may be related to increased difficulty and early cessation in breastfeeding during the early postpartum period**. Lactogenesis may be equally affected by the insult of abdominal surgery in both planned and emergency c-sections, although the notion of an "emergency" may invoke a greater or prolonged maternal stress response.

Lower breastfeeding initiation and increased difficulties with breastfeeding in women with c-section deliveries **may be related to a physiologic influence on lactogenesis**. A study by Evans et al. (2003) found that breast milk transfer among women with c-sections was significantly lower in the first 5 days postpartum, compared to women with vaginal births. Similarly, Scott and Binns (2007) found that delayed onset of lactation was significantly higher in mothers that delivered via c-section compared to those that delivered vaginally. It is postulated that **the hormonal pathway that stimulates lactogenesis is disrupted by c-section delivery, either from maternal stress or decreased oxytocin secretion, and can hinder milk production.** Late preterm infants, those born between 34 and 36 6/7 weeks gestation, **often have a multitude of issues including disorganized sucking skills, lower birth weight and low level of alertness, all of which can adversely affect breastfeeding initiation.** Since planned c-sections are performed prior to the onset of labour and before 40 weeks gestation, it is possible that physiological reasons are responsible for the decreased likelihood or troubled breastfeeding initiation.

The Breastfeeding Network: 'Breastfeeding after a Caesarean Birth'

Generally speaking, a caesarean birth can cause breastfeeding to be a little delayed compared to a vaginal birth because **mum doesn't get the natural surge of oxytocin that can help with her milk supply**. However, that absolutely doesn't mean that you can't breastfeed after a C-section – just that you need to be aware of the issues that may arise, and how to deal with them to help get feeding successfully established.

Planned sections can be better in some respects because mum isn't exhausted from the stresses and strains of labour, and she can plan what she would like to happen such as skin to skin in theatre, immediately after birth. Mums who are planning a section can also think about hand expressing colostrum before the birth (antenatal expressing), which **may help if baby is delayed in going to the breast**, and more importantly helps the mum be secure in her technique in a non-stressful situation (it can be quite stressful learning how to hand express because you HAVE to, because your baby isn't feeding, rather than relaxed "I'm learning a useful skill" antenatal expressing).

Pain can be an issue – many mums worry about baby kicking their scar – and you **may struggle to sit up for a while after surgery**, so there are several feeding positions you can try to work around these issues […] Try out a few positions and see what works for you (see here for some tips). Check out BfN pharmacist Dr Wendy Jones' factsheet for information on your pain relief options while breastfeeding – there are many options which are perfectly safe for you and your baby. Don't be a hero – take that pain relief.

Get some skin to skin contact with your baby as soon as you are able – preferably in theatre immediately after birth. Mention it to the midwives, even in an emergency – it can make a real difference to baby's instinctive behaviour at the breast by getting hormones flowing for both of you and allowing both you and baby time to get to know each other and start your feeding journey.

Summary of key findings

C-sections can make breastfeeding more challenging for a number of reasons. The mother being in pain and having a large scar makes positioning difficult, and can make skin-to-skin contact soon after birth challenging.

Levels of oxytocin, which helps with milk production, are lower following cesarean delivery compared with vaginal delivery.

There may be a correlation between planned c-sections and lower intention to breastfeed, which translates to shorter breastfeeding duration compared to vaginal deliveries.

New Focus Areas
Brainstorming

	Addressing concerns over whether baby's getting enough milk	**Supporting breastfeeding after a C-section**	**Supporting breastfeeding mothers' mental health and building confidence**	**Facilitating storage of expressed milk while outside the home**
Current situation	• Strong focus on baby's weight means mothers worry about whether babies are getting enough milk	• C-section is a major abdominal surgery, carried out with a screen divider around the mother's chest height. Recovery can take around 6 weeks and be painful/uncomfortable, particularly around the scar	• Breastfeeding, and difficulties breastfeeding in particular, frequently result in women's confidence being reduced and questioning their ability and value as a mother	• Expressed breastmilk must be stored in containers that have previously been sterilised. It can be stored at room temperature for an hour, after which it must be refrigerated. Refrigerated milk should be consumed or frozen within 3-6 days, and can be frozen for up to 6 months
Problems with the current situation	• Pressure to bottle or formula feed so that milk consumption is measurable • Misconceptions around breastfeeding; according to NHS, if baby is feeding frequently, gaining weight and producing wet and dirty nappies they are getting enough • Concerns about milk volume contributes to breastfeeding cessation	• Milk coming in can be delayed due to lower oxytocin • First breastfeed can be delayed due to lack of space in operating theatre • Pain and reduced mobility • Positioning to avoid hurting scar from the incision	• Perceptions that breastfeeding is 'natural' and should be easy • 'Breast is best' rhetoric and pressure to breastfeed resulting in shame if it doesn't work out • 'All or nothing' mindset; supplementing with formula seen as bad and detrimental to supply • Perception that mother isn't producing enough breastmilk and is failing as a mother	• Getting expressed milk into a fridge in time poses challenges, while at work and in particular if travelling • Labelling and dating breastmilk is recommended to keep track of it
Existing products/ solutions	• CoroFlo - a concept for a smart nipple shield that measures milk flow • Apps for logging feeds, e.g. Huckleberry • Scales to weigh babies before and after feeds	• Nursing pillows, some are adjustable to allow for optimum positioning •Abdominal binders to support mobility after c-section	• Communities, e.g. breastfeeding cafes, NCT groups • Online communities, e.g. Mumsnet	• Portable coolers/insulated lunch boxes with ice packs • Storage bags (usually disposable) • Portable breast pump (manual or electric)
Potential solutions	• Improving awareness/education around breastfeeding • Catching letdown/expressing on alternate breast to allow milk flow to be measured	• A versatile breastfeeding pillow that can be used in different stages of c-section recovery and breastfeeding journey • Monitoring wound recovery to offer personalised positioning advice	• App that uses positive affirmations to help improve a mother's confidence and reassure her	• A universally fitting container that cools the milk • Monitoring the temperature of breast milk when in a communal fridge/while travelling • Making cleaning and sterilising of containers easier when access to proper facilities is unavailable.
Reflection	• Issue mostly lies in education and training of healthcare professionals • There is potential for a product but would need to clearly define its function - would it be measuring milk flow or focusing on mother's confidence?	• Not really a PDT brief	• Quite a challenging issue to solve, the solution mostly lies in societal change and better funding for the NHS	• Most promising brief as the problem isn't caused by systemic underfunding in the NHS or deep-rooted societal views

Conversation with a Mother
Secondary Research

Breastfeeding first child

Did a 3-hour antenatal breastfeeding workshop together with partner when pregnant. Struggled to feed at first, baby would latch on but not suck. No tongue/lip tie nor similar issues

Discharged from hospital shortly after healthy vaginal birth and signed off for breastfeeding as latch was good. Went to St Mary's Birth Centre for help, spent 6 days there. Staffed by midwife assistants as cheaper for the NHS. They got daughter to feed by keeping her alert, when she stopped sucking they'd take her off the breast and take off her babygrow before putting her back.

Tried nipple shields, they made it harder to get milk out and didn't help baby's issues with sucking. Didn't work for her.

Mother can express 2-3oz each expressing session but baby was drinking 6-7oz per feed at 6 months, feeds were supplemented with milk donated from a friend (friend's baby had a dairy allergy but didn't realise until after she'd expressed and frozen a lot of milk). Was expressing until baby was 9 months old, would supplement with formula during the day and breastfeed in the mornings/evenings/weekends.

Child went to nursery near mother's workplace, but mother didn't have time to nurse baby during the day, and also didn't want to confuse her child by coming in, feeding and then leaving. Childcare settings are used to using formula rather than breastmilk, which have different storage guidelines (formula can only be left out of the fridge for one hour, breastmilk can be out for 6 hours). Had to be careful to make sure the nursery wouldn't dispose of expressed breastmilk due to confusion over safe storage.

Breastfeeding second child

Son took to breastfeeding right away without any issues, mother also thinks this is because it was her second time. Has had more milk blebs this time around

Expressing at work/on the go

Has her own office with a fridge in it (provided by workplace). Stores breastmilk there when in the office but has also used communal fridges when in other buildings, feels confident doing this and has never received comments on it.

Design school offices don't have locks, and most have glass walls too. Can sit in one corner of her office that can't be seen from outside, with a do not disturb sign and a chair blocking the door, and has also used a colleague on maternity leave's office who doesn't have a glass wall.

Travels a lot to work, e.g. to Loughborough London campus. Will usually express in a toilet when on the go as this is the easiest private place to use, sometimes uses disabled toilet. Has had to throw away expressed milk as can't keep it cool while travelling.

Hired a Medela pump with first child, this had to be plugged in. Has a usb-rechargeable Tommee Tippee pump now which allows for more flexibility. Pump is quite noisy, is conscious of this when expressing in public toilets.

Issues encountered

Had milk blebs with first child, was recommended nursing cups by Charnwood Bras, helpful as allow a drier environment for nipples than breast pads.

Wears them all the time when not feeding. Has also used Lansinoh heat pads for milk blebs, couldn't get them to work with a pump but wearing them in bra was helpful. Never tried any cooling pads nor cabbage leaves. Found cheaper (single use) breast pads to cause irritation.

Had a nipple split once when expressing. 6 minutes has been found to be her limit for how long she can express for, but got distracted and left the pump on for 8-9 mins which caused a split nipple. She treated this with lanolin and avoided feeding from the affected breast for some time, and also used the sterling silver nursing cups.

Support received/classes taken

Antenatal and back to work workshops taken with Charnwood Bras. St Mary's Birth Centre helped establish breastfeeding. In her experience health visitors are 'pretty useless', has heard from others that Angie Bell is the best local health visitor.

- Shame/stigma
- Cleaning
- Storage
- Generally noteworthy
- Time/routine
- Facilities

Summary of key findings

Mother expresses for her child using Tommee Tippee pump, this is portable which is appreciated as she travels a lot for work, although it is noisy. She will usually express in a toilet as this is the easiest private place to use. She has had to throw away milk when travelling for work as she can't get it to a fridge fast enough/keep it cool while travelling.

Feels comfortable storing milk in fridges at work, however has had privacy issues with her office having a glass door, has had to work around this.

Understands that childcare settings are used to using formula rather than breastmilk. Storage guidelines for formula are different as it can only be left out of the fridge for one hour, whereas breastmilk can be out for 6 hours. Had to be careful to make sure the nursery wouldn't dispose of expressed breastmilk due to confusion over safe storage. **How can I improve clarity around breast milk storage and safety?**

Once got distracted while pumping and left it on too long, resulting in a split nipple which was incredibly painful. She treated this with Lanolin, silver nursing cups, and avoiding feeding from the affected breast.

Case Study
Secondary Research

- Shame/stigma
- Cleaning
- Storage
- Generally noteworthy
- Time/routine
- Facilities

Interview 27

Age at interview: 32

Brief Outline: Nursing strikes with her son. Daughter required heart surgery after birth. Expressed breastmilk for her and also provided some for the milk bank. Working and breastfeeding.

Background: At the time of interview, this 32 year old, white woman was breastfeeding her 11 month old daughter. She also had a 2 year old son whom she had breastfed. An IT consultant, she was married to a further education teacher in special needs.

Son born by c-section:

I was clued up that it was the only option as far as I was concerned. I was clued up about a lot of the mechanics and I was clued up about some of the things to bully staff about, like my son was born by emergency c-section and when we were going into theatre I said, "I want skin-to-skin straight after delivery" and they said, "There won't be room." I said, "There will be room, I'll make room" they said "Oh no there won't be room behind the curtain" I said "Oh yes there will be, I'm having skin-to-skin straight after the delivery" and I did have skin-to-skin straight after the delivery and he suckled in the Delivery Suite and I think the midwife was quite impressed with how bolshie I was being about it but to me it was just the most important thing in the world.

Yes I went off to work full-time.

How did you manage that?
With difficulty, in fact when I first went out, back to work after having him I went back on shift, an early shift started at half past five in the morning, a late shift finished at ten past ten to midnight, in the evening, and that was hard work, that was really hard work.

Did you set up a routine of any sort?
To a certain extent. I pumped, because I work in a factory, every two hours is a forced break if you like, the bell rings and we all go out to break and so every break I was pumping. And, I was pumping at home as well, there are several things that I wish I'd known when I started and I found doing the same when I went back to work with my daughter much easier because I knew these things, I knew to express in that first morning feed so you feed on one side, you express on the other at once.

Because?
Because each one stimulates the milk production in the other and he had much, much more and I wish I'd done that with my son but I didn't, and I think I would've struggled a lot less. I wish I'd have bought my expensive breast pump earlier, I bought it about half way through my son's feeding during the day when I was back at work.

What advantage does your expensive breast pump have over an inexpensive one?
It's a double. So again you're stimulating both, each side is stimulating the other, my cheap electric one, is great, it works, but it's one, and it's just one side.

So it's more time-consuming?
It's more time-consuming and I was finding it very hard to stimulate let-down, very, very hard to get let-down, in fact I almost always wasn't and I was just getting dribbles all the time and not adding up to what he needed, and as soon as I phoned La Leche League and they said, "I think you need an expensive double breast pump" and I got it, and bingo, let-down.

How did you know?
Because the quantity of milk tripled [laughs] quite simply.

Could you feel the let-down happening?
No I couldn't.

Could you visually see the increase in milk flow?
Yes, yes I could definitely see that. But I didn't feel it, I did the second time around as I say with my daughter then it was, in, in some ways I think I was more aware with her so I was looking out for can I feel let down coming, and so I could.

And what did it feel like?
Tingly, like that tingling down the back of your spine when you, someone you love is giving you a massage.

A frisson?
Yeah, yeah rather nice [laughs].

And a tightening in the chest?
No, no, just a tingling that, I knew what was going on.

So, so I just want to get this, this going back to work routine straight, you fed in the morning on one side, pumped on the other, every two hours at work during the day, or night, depending on which it happened to be each shift? And then?
And then I would feed again when my son needed it at home.

So what was he doing during the day while you were pumping at work?
He was going to a childminder.

What was she feeding him?
My milk. Expressed breast milk from a bottle.

Did he have any problems taking a bottle?
No, he didn't. He took it absolutely fine. As long as it's the same stuff inside Mum, I don't care. Getting him onto cows milk later, that's another story. That was a nightmare. But breast milk from a bottle? Not a problem at all. And but also by that stage we were starting on solids. Of course. He was taking less milk during the day and she would fill him up a bit on solids and then I'd just feed him as soon as I picked him up.

Case Study (cont.)
Secondary Research

On your days off? Yep. Did you feed him more or the same?
More. I'd latch him on every opportunity.

Why?
To get the milk supply back up because I could tell it was dwindling during the week and I would get more expressing on a Monday than I would do on a Friday. And so I'd feed it up again during the weekend. But these are things again that I came to quite late in the day, and I wished I'd been doing it when I first went back to work. I think that's quite a shame really, that. It took a lot of tears, really, to get to that stage.

Tears over?
'I'm running out of milk. He's gonna have to have formula.'

Where did you turn for support when you felt like that?
La Leche League, certainly. But also my friend the evangelical breastfeeder, who had had a daughter six weeks before I had my son. And she lived just up the road, 20 minutes away. And so we were on maternity leave at the same time and actually, bless her, she'd been expressing as well. And she offered me frozen milk to give to my son because she knew how much it meant to me and how much it would mean to her as well.

So you fed your son the milk from another woman?
We didn't need it in the end, I didn't need it.

But you would have if you needed to?
Oh, yes. Absolutely, absolutely. Certainly over formula milk. I mean, yeah, at the end of the day, if she hadn't been there and either run out of milk, yeah, I'd have given him formula. Of course I would. But if I had any other option, I was going for the other option. And I did.

So that must have been incredibly tiring for you, working all week and pumping and then feeding all weekend.
It was, but it was also incredibly fulfilling cause every time he was weighed and every time he grew, I knew it was me and it wasn't whoever else making the rubbish they sell. It was. It was me. I grew that.

How long did you continue that pattern?
Well, I stopped working shifts about 2 1/2 months into going back to work. I had asked to stop shifts when I first went back and they had problems arranging cover, but as soon as they arranged cover. I went on to day shift, so that made life a lot easier straight away.

Did he adapt to the shifts okay?
Ohh yeah ohh yeah not he's never had a problem with that. He was always very good sleeper and actually I never used to feed him first thing in the morning. If I was on early I wouldn't wake him up at 4:00 o'clock in the morning to feed him. And I certainly, I would also wouldn't have fed him at our last midnight when I came home on a late shift either. So actually to him there wasn't that much of a difference which I think helped. Huge difference to me in my social life and my energy levels. Massive difference. And as soon as I knew actually, that I was coming off shifts, we started trying for another, because we always wanted more than one, and we wanted them close together.

How much was he feeding at this stage?
Well, I was still expressing so he must have been on a morning feed, night feed and one bottle during the day of my milk and at the weekend. I mean this is the way it is my daughter. At the moment it's the morning and night and then during the week they'll get she'll get one bottle or although if I'm there she'll probably get 2 feeds. Because we'll structure the day slightly differently. So he must have been on about the same, and fairly quickly I fell pregnant.

How did you cart the milk around?
I have an insulated sandwich bag and I would put a frozen thingy in it, but I'm also much more [inaudible] about it recently because I've read various research papers telling me how little contamination can happen in breast milk because the antibacterial properties are so strong. And so I'm afraid I'm not quite so good these days.

What's your understanding of how long it can be out of the fridge?
I know what the government says. The government says it shouldn't be out of the fridge for longer than an hour. I also know that studies have shown that after 8 hours of breast milk in an open saucer on the side in a standard house, there's less bacterial activity. Rather than more. And so I throw the government regulations out the window, I'm afraid.

On average how long would it be before you would get your milk from expressing to the fridge?
When my children were younger, I would get it to the fridge and with within the hour definitely. Now they're both at the stage of eating carpet fluff it may take a bit. Because I've been known to leave the breast pump in the bedroom after expressing a night by mistake. Find it there in the morning. 'Oh dear. Never mind, it'll be fine.'

And how long do you keep it in the fridge before you freeze it?
Again, the regulations say 24 hours. I'm quite happy up to three or four days personally.

And how long do you keep it in the freezer once it's frozen before you discard?
It... well, that depends if it's going to the milk bank. Less than three months because they need it within three months.

Summary of key findings

Mother developed hacks and routines throughout her breastfeeding journey, wishes she'd known these earlier. She found her supply would be higher on a Monday than a Friday, after having fed her son over the weekend. She therefore began to feed him as much as possible over the weekend to keep her supply up. She also began to express on the alternate breast while nursing her son, as each breast stimulates let down in the other. A double pump has been much more effective for her than a cheaper, single pump.

Expressed with each break at work, which was every two hours. She stores her milk bottles in an insulated sandwich bag with a frozen ice pack in it. She is more relaxed about milk storage now her children are older, and has kept it out of the fridge for longer than the recommended period without any problems.

Case Study (cont.)
Secondary Research

Right, I want to just look at the company's perspective on this for a little bit, the workplace…
Mm-hm.

As the breastfeeding mother, what have you got to say about that?
I'm lucky, I think, I have a female boss, who failed to breastfeed her son and her daughter, but knows how important it is to try and succeed. Also because I work in a large company we have an Occupational Health Department who have rooms, who have fridges, all the rest. So it was kind of, I said I wanted to do it, and you know I'd read up on it, I knew the, I knew my rights [laughs] and I asked them and they just said, "Oo are you allowed to do that?" and I said, "yes I am" they said, "oo okay then", and I taught them, and in fact after I did that one of the nurses, after having a baby and going back after maternity leave also expressed at work and told me that she didn't know, she wouldn't have known she could do that unless I had done it.

Has it spread any further, it's a large company you're talking about?
No, one of my things at the moment is I'm trying to persuade them, they send out, when you say you're pregnant they send you out a letter saying, "These are your rights, this is when you, you have to tell us when you're leaving, this is when you have to tell us if you're coming back, this is how long we hold your job open for" that sort of stuff, and I've asked them, and I'm not sure that it's got through to the right person yet, to put a sentence, just one sentence on that, "If you wish to express breast milk for your child when you return to work please contact Occupational Health" that's all it needs, because that then just triggers the thought in the mothers' minds.

They haven't done it [laughs] but I'm pretty sure it hasn't actually got through to the right person yet, because I think it's been the same standard since about 1973 so you know, it's just getting through to the right person and then I'll try and get that changed because I think that'll be really good, but yeah we've got a fridge, there are rooms where people go to see nurses and they'd let me have one of those rooms,

Expressing at Work
Secondary Research

'I have another ice pack down here so I pump and I put my pump parts back down here so they stay cold so I don't to wash them every time I pump three times a day here at work'

'so washing them would take into my… I'm only allowed to take 20 minutes to pump if I take more than that I have to clock out so I pump for 15 minutes, put all my stuff away and I should be back at my desk in 20 minutes'

'I grab my bottle of breast milk, put it in this cooler, close it…. it stays cold in here so what I do is I lay, so I don't have to wash them until I get home I lay them in here like this and then I put this cooler on top'

'So I grab one of the clean bottles out of the Medela cooler. I unscrew one of these (pump parts) shake off all that extra milk… put that aside, I grab the other bottle, shake it off and then I pour one into the other.'

'Some people don't mix their previous pump with their current pump, I've never had a problem mixing the milks together'

'I grab my bottle of breast milk, put it in this cooler, close it. Then I grab my big cooler…and it stays cold in here. So what I do is I lay, so I don't have to wash them until I get home I leave them in here like this and then I put this cooler on top, then I zip it closed'

'The safety pin is to keep my pumping bra together, I am not buying a new one, I only have three months left'

'While I'm here at work cuz I don't put it in the fridge because people steal stuff in the fridge here so I don't trust them with my breast milk. 'I feel like some people are a little bit iffy about breast milk and they would probably get grossed out knowing that my breast milk was in the fridge so I don't keep my breast milk in the fridge but you can if you want to'

'The pump I don't take home every day. This one actually stays here, I have two because I got one with the insurance so I keep this one here and the one that I got from the insurance I keep at home'

'There is a pumping room downstairs where the daycare is but that would cut into my 20 minutes so they provided me this room so i use it every day three times a day'

'For me pumping/breastfeeding is very important. I don't make enough milk to feed the twins only breast milk, I still have to supplement with formula. People ask why I do it I do it - because I feel that breast milk is important, doesn't matter how much you're giving or for how long there are some can't and that's okay and that's what formula's there for and I'm grateful for formula'

'Per day I get about 24 ounces on average and that equals to two bottles for each baby so their first bottle in the morning and their last bottle at night are breast milk, the ones in between are formula so I basically bring the formula to daycare and the reason I do that is because I feel that since I make so little I feel like it's precious and I feel like daycare aren't going to care about it as much so it's probably wasted so that's why I only feed them the breast milk at home'

'The only time I don't pump is in the middle of the night when I'm sleeping but other than that every three hours. There are days where I don't get around to pumping every three hours and the next day I generally see a decrease in the amount of milk that I get. You know maybe I'll get 17 ounces instead of 24'

- Shame/ stigma
- Cleaning
- Storage
- Generally noteworthy
- Time/routine
- Facilities

Summary of key findings

Mother is very restricted by the breaks she gets at work. She keeps the pump parts in the cooler with her milk to avoid sterilising them after each session as she doesn't have time for this. All the milk is combined in one container after each pumping session.

She doesn't trust the work fridge with her breast milk so keeps it in a cooler with an ice pack instead.

Expressing at Work
Secondary Research

‘The first time that they had asked me to come into the office I was so overwhelmed with all of the things that i needed to plan and bring with me to pump at work so I have a lot of things to share with you’

‘Thankfully my company is super family friendly, we have a quiet room that actually serves as a really great pumping room they have a fridge, a recliner a sink in there so thankfully for me it wasn't a big problem finding a place to pump at work’

‘I actually had a lot of anxiety taking these breaks throughout the day to pump but it wasn't like a break break. You know i actually hated pumping and it's something that you just have to do otherwise your boobs are going to hurt it's also going to hurt your supply’

‘So next of course is preparing what you’re actually going to need to bring with you to pump to work I think this is actually one of the most overwhelming things because there’s a lot there’s like pump parts and ‘how am I gonna clean my pump parts’ and ‘how am i gonna transport the milk’ so i’m gonna share with you everything that i brought with me’

‘So obviously i had to bring my pump and this is the pump that i use this is the spectra s2. It is quite bulky and big but it’s super light i think it’s three pounds so it’s not that bad. I do have the Medela portable pump. That one was okay, it was actually a lot easier to bring around but i feel like this has a stronger pump and i always try to make sure that i get as much milk out for each pumping session so even if i do have that one i still prefer this one because i feel like I always get a lot more milk out with this pump’

‘This is hospital grade and it also is more hygienic because it has like the back flow protection i think is what you call it. It just helps prevent bacteria from going into your breast milk really love this pump so even if it is bulky this is what i bring with me to work so yeah this is the pump that i use.’

- Generally noteworthy
- Time/routine
- Shame/stigma
- Cleaning
- Storage

‘I also bought extra parts from amazon that are actually not the spectra brand i think they're may mom i don't have it here with me right now but they're not the brand name on they're a lot cheaper. I feel like the quality isn't the same but they are just my extra parts so i didn't mind and really why i brought extra parts with me is sometimes i will be rushing and i wouldn't have time to really clean my pump parts.’

‘If that happens then i know that i have extra parts that are clean that i can just use for my next pumping session. I know a lot of people also don't clean their pump parts after every session but i am just super paranoid and that is also what the cdc recommends but i know they're being extra extra careful too. If you are in a pinch and you don't have extra parts and you don't have time to clean your pump parts. I know some people also will rinse their pump parts or just wipe it with a paper towel put it in a ziploc bag and put it in the fridge until the next session and then you just clean your pump parts at the end of the day.’

‘So for storing my milk i actually have these extra storage bottles that i got from Medela and these are the ones that actually hook up to that portable pump that i was talking about and i bought like a pack of six of these because i thought that was a pump that i was gonna be using more but i ended up loving the Spectra more. I do regret not just getting more of these bottles and using this storage that way i didn't have to transfer bottles but this is what i have and honestly it wasn't that big of a hassle to move them here.’

‘I also have these labels for all of Sienna's bottles... I have washed these bottles so many times in the dishwasher and also hand washed and they've held up pretty well.’

‘I know that you can buy work totes that can fit your laptop and also your pump parts but for me i wanted one that’s separate just for all of my pump parts. It’s basically like a big lunchbox but i like that it’s insulated and again it can fit this big spectra pump perfectly and then i have another space in here for the parts and also all of the milk.’

‘I also have another little bag in here this is actually a lunchbox and this is where i would store all of my milk. This lunch box just fits these Medela bottles perfectly and so I would just put them here and then i would leave this in our office fridge so i’m not just leaving my milk out for everyone to see this also fits perfectly in my work tote so i would just put this in my tote when i’m ready to go home’

‘Another thing that i would bring with me is my pumping bra, i have two of these. These ones i just got from Amazon these actually came with straps that i just never put on because i actually really like that it's just something that you can wrap around and wear whenever you need to pump. I would just put this in my pumping bag and then put it on when i pump. That way i can have my hands free and i can either work be on my phone or something while I’m pumping.... If i didn't have a pumping bra can you imagine i would just be holding these things for like 20 minutes or however long i need a pump that's too much like 20 minutes i could be doing something else.

‘Another thing that i bring with me that i highly highly highly highly recommend is this oxo travel brush. I also mentioned this in my newborn essentials video because honestly this is one of the best purchases ever because it's just been so helpful you're probably like ‘why is she so passionate about a travel brush’ but i'm just saying this has been so helpful you open it up and it's actually a drying rack already it has this little brush it's actually super helpful for bottle nipples or all of the little corners of your pump parts and then this big brush and then you just attach this and now you have a full-size brush and then it also has a stand and a drying rack. i mean i think this is pretty genius. Highly recommend this even if you are not planning to clean your pump parts at work just grab this for like portability if you ever needed to travel.’

‘Now pumping four times a day might not seem like a lot but let me tell you that's a lot. Pumping is so tiring especially since again i'm that type of person who likes to clean my pump parts after every session it was exhausting so eventually i started introducing formula to my baby. She would get one bottle of formula a day, that way i only had to pump three times a day.’

‘So i went from pumping four times a day to three times a day and now only two times a day, one in the morning and then one in the afternoon. In the beginning each pumping session also lasted 20 minutes but i also went down to just 15 minutes. Which let me tell you i don't think 20 versus 15 minutes was that big of a difference, I feel like i still got the same amount, which, like i should have just been doing like 15 minutes all this time’

Summary of key findings

Pumped 4x per day for 20mins each time. Sterilises parts after each pumping session which is ‘exhausting’ and contributed to her supplementing with formula.

Amount of equipment needed is ‘overwhelming’ and the better breast pump is bulky. Bottles are designed to fit onto specific breast pumps so milk sometimes needs to be transferred to a different container.

She likes to keep her milk in an opaque bag when keeping it in the work fridge so it’s not ‘out for everyone to see’

Portable brush and drying rack is very useful - ‘one of the best purchases ever’.

Laws and Regulations for Workplaces
Secondary Research

Employers are obliged under the Workplace (Health, Safety and Welfare) Regulations 1992 to provide “suitable facilities” for a breastfeeding employee to “rest”. The Approved Code of Practice states that these facilities should be **conveniently situated in relation to sanitary facilities** and, where necessary, include the facility to lie down. These “rest facilities” are very likely to also be a suitable place for breastfeeding or expressing. Although private, the ladies toilet is never a suitable place in which to breastfeed a baby or collect milk.

The Health and Safety Executive and guidance from the European Commission **recommend** that employers should provide:
• access to a private room where women can breastfeed or express breast milk;
• use of secure, clean refrigerators for storing expressed breast milk while at work, and
• facilities for washing, sterilising and storing receptacles. (Maternity Action, 2023)

“ The law requires an employer to provide somewhere for a breastfeeding employee to rest and this includes being able to lie down*. While it is a legal obligation for employers to regularly review general workplace risks**, there is no legal requirement to conduct a specific, separate risk assessment for an employee returning from maternity leave who has notified her intention to breastfeed. However, it would be good practice for an employer to do so, to help decide if any additional action needs to be taken. Guidance on these aspects of health and safety law can be found on the HSE website at www.hse.gov.uk/mothers/

Remember – A breach of Management of Health and Safety at Work Regulations may in addition be unlawful discrimination under the Equality Act 2010 depending on the circumstances. **The law doesn’t require an employer to grant paid breaks from a job in order to breastfeed or to express milk for storage and later use. Neither does it require an employer to provide facilities to breastfeed or express milk**”. (Advisory, Conciliation and Arbitration Service, 2014)

Handling requests from employees
to accommodate breastfeeding in the workplace

About this Guide

Government asked Acas to use its expertise in employment relations to develop this short guide to help employers and employees better manage requests to breastfeed in the workplace. In most instances, these requests will be for facilities to express and store milk and time away from work to do so.

The guidance sets out what employers are required to do by law and also gives good practice around managing a workplace issue that can support an employee moving back into work after her maternity leave.

Contents

Protecting pregnant workers and new mothers

4. Rest and breastfeeding at work

Pregnant workers and breastfeeding mothers are entitled to more frequent rest breaks. You should talk to them so you can agree the timing and frequency.

You must provide a suitable area where they can rest. It should:

- include somewhere to lie down if necessary
- be hygienic and private so they can express milk if they choose to – toilets are not a suitable place for this
- include somewhere to store their milk, for example a fridge

Summary of key findings:

Working mums might not necessarily have access to washing facilities or a fridge. Although employers are recommended to provide these, they’re not a requirement - the only legal entitlement is a room to ‘rest’.

Cool bag with built-in UV sterilisation?

But still requires parts to have been washed before sterilising. How can I make the process of washing them easier?

Ultrasonic technology to clean parts via vibration?

Make your own cap mould??
Food safe clay that you screw inbetween pump and bottle and moulds to create a seal

Expressing at Work
Secondary Research

- Shame/stigma
- Cleaning
- Storage
- Generally noteworthy
- Time/routine
- Facilities

‘I haven't been back to the office actually working in the office since I pretty much had Leo so it's kind of different. It sucks um at least i go in earlier and get off earlier so i get to be home in the afternoon. But yeah it sucks it's 5:45 i don't start till 6 a.m. so I’m probably just gonna take my pumps off right now um I’m wearing my freemie and yeah I’m gonna take my pumps off put my milk away and then i guess get to work’

‘Hey guys so it's my first pump break it's around like 8:15 right now so I’m trying to do every like three hours on the dot um at the end of the day i get off at 2:30 so my last pump would technically be around two o'clock um but I’m not going to pump because I’m gonna go home and get leo anyways so i will probably just nurse him as soon as i get home. I’m gonna get started pumping and yeah i'll check back in with you guys when I’m done.’

‘Hey guys so I’m back i am doing my third pumping session of the day the first one was at 5 am on the way to work second one was 8 o'clock when i showed you guys the pumping room and everything earlier and then this is my third one right now at 11:30. I’m actually wearing my Elvies right now, um earlier i was using my Medela and to be honest i haven't used my Medela in probably a little bit over a week so it was the first time using my Medela and my output wasn't that good.’

‘Also if you are wondering yes i did bring three pumps with me to work i know it's pretty excessive but it's the first time I’m actually like going back to work to the office so i was like i need to have options even though on a daily basis i pretty much just use either my Medela or my Elvie and the past week it's only been the Elvie like i said but i brought my Freemie, my Medela and Elvie.’

‘While I’m pumping let me show you guys my pump bag... it's honestly pretty spacious i have like the Medela wipes that i used to like clean my stuff down...’

‘Um our pumping room actually has um a fridge that we can use to store our milk in i just don't feel comfortable in it even though there's obviously only milk is allowed to be stored in here. Just anybody can come into this room and use this room um if they needed to pump and stuff which I’m the only one in the building right now who is nursing so it would only be me who's using it but still. Um i actually just have a cooler in there and i keep all of my milk in there. I really like this bag because it has a cooler part and i just keep an ice pack in there in my milk so it stays cold all day long and i don't have to worry about it. I have some storage bottles um my Elvies but yeah that's basically my pump bag it's honestly really spacious it fits a lot a lot a lot of stuff’

‘Since this is my first week back and then i will check in with you guys at the end of the week and let you guys know how the first week was. Waking up this early is so exhausting. I’ve been putting an espresso shot in my coffee’

‘Beaugen cushions, they're honestly the best thing ever for my Elvie. i don't ever use my Elvie without them because honestly it just doesn't really ever work out unless i have them on.’

Working from Home
Secondary Research

‘Usually on the weekends i don't really pump as much. i may pump like two or three times a day just so i can have bottles for monday or just so i'll have a bottle to feed him the next day if i wanted to but during the week is when i pump the most and i actually have a set routine so that is what we're going to be doing today.’

‘I'm pumping, i've got my Elvies on so i usually don't pump this early in the morning because i pump at around 2:30 or 3 a.m... i'm gonna have my coffee i'm gonna finish pumping and i'm probably gonna get to cleaning around the house until leo wakes up and then i have a whole bunch of laundry to fold so that's probably what i'm gonna do before working today... I usually use my Elvie whenever i’m walking around doing things around the house like cleaning up and i just got done doing all these dishes so that’s what I normally use whenever i’m walking around.’

‘I always use Medela bottles to measure out and to store them in the fridge a lot of people use bags to measure them out and store them which you can use them to store but I don't like measuring out in the bags because the bags are never accurate so just a quick tip always measure in your bottle first and then store it’

‘I usually just label everything like the day that i pumped it. i don't like keeping milk in the fridge more than three days at the three day mark i will freeze it a lot of people say that it's either you can go up to three days or four days but i personally just keep it up to three days’

‘I’m just getting all my stuff ready around my desk like i said i normally use my mandela pump while i'm at work so i've got everything all set up for me to start pumping. so i just started working i normally like to pump right when i start work or within a few minutes after i have started working.’

‘Another thing that I quickly wanted to say is that i like storing these bottles in six ounce portions and then i will leave this one in the fridge. That way later on whenever they're the same temperature i'll add the rest that i pump in from the next session to this one. Leo usually eats from five to six ounces every three hours so that's why i like putting it just six ounces that way we can put this in the bottle warmer that's it and he's ready to go for his next feeding.’

‘So it's pretty late it's around 9:45 normally i work until 10 o'clock so i would have recorded it and pumped at around like 8:30 ish or 9 would have been my last pump of the day before i went to bed.’

Expressing at Work
Secondary Research

Repeat 1-2 per day depending on how busy it is at work

Alyssa

Gets up for work at 3am	Brings pumping bag to work, it doubles as a handbag	Puts on bumbag containing Motif Duo pump	Assembles pump parts and puts discreet pumping cups in bra	Connects tubes from pump to the cups	Pumps for ? minutes while working at her desk	Removes cups and places on desk	Pours milk from cups into bottles. Fills one bottle and then pours the rest into a second	Puts pump parts into a ziploc bag and then 'hides' in backpack	Takes the backpack into the back to wash pump parts	Puts milk bottles into Medela cooler with an ice pack	Occasionally pumps on the drive home as well
											

'The pumping bag I have is from Gogoso on Amazon. It's a backpack you can use as a purse and it has two compartments. It has like the main compartment and then it has the insulated compartment that I keep my breast milk in.'

'This is my breast pump and it's in a waist, um a waist carrier because I don't take breaks at work to pump since I work usually morning shifts or evening shifts and I don't usually have anyone working with me to cover the front desk while I'm working. So I just pump and work at the same time and nobody even notices.'

'I have one ice pack here in this net and I have another ice pack here for the bottles. I usually just switch out ice packs, I don't keep the same one the whole time that I have my pump parts. In this ziplock baggie because I was in a rush this morning so I didn't have time I didn't have a chance to dry them they were just sterilized.'

'I'm going to assemble it real quick and show you how I pump and run at the scene'

'You see me putting my Freemie cups in a Ziploc bag because I take them to the back to wash them and I hide them in my bag so I don't freak out the members.'

'During a working day I have a one or two pumping sessions that work depending on how busy it gets i but if I have two sessions it's usually right before I leave work or it'll be like on the drive on my way home and this time I pumped on my way home so I do one at 6:00 a.m. and then another one at 10:00 a.m. which is when I clock out so that's when I start heading out. I usually pump every three hours because I'm trying to build up a stash.'

- Shame/stigma
- Cleaning
- Storage
- Generally noteworthy
- Time/routine
- Facilities

Summary of key findings:

A lot of the mothers in the videos I've watched have very early starts and are getting up before 6am. Expressing on the drive to work seems quite common. This routine is likely quite complex and must take some getting used to.

Milk is frequently transferred from the bottles that are compatible with the mother's preferred pump to bottles from another brand that are easier to store, and/or have compatible coolers, like the Medela bottles.

Would be good if the need for this transfer could be eliminated, to save the mother time and energy and additional cleaning.

Expressing at Work - Routines
Secondary Research

Stef

Repeat x2-3 per day

Wakes up at 4:30 for work

Drives to work, pumps while driving

Pours milk from Freemie cups into MayMom bottle

When in office, goes to designated room to pump

Pumps for ? minutes, uses Elvie pump

Pours milk into new MayMom bottle

Keeps milk in insulated section of bag with ice pack

Wipes pump parts with Medela wipes

Puts pump parts back in bag

Takes milk and parts home

Alexa

Repeat x4 per day

Brings pumping bag to work alongside work bag

Receives reminder to pump from Huckleberry app

Goes to quiet room to pump

Pumps for 20 minutes, uses Spectra pump and a pumping bra

Transfers milk from Spectra bottles to Medela ones, put in lunch box

Puts lunch box in the fridge in the office

Cleans pump parts and Spectra bottles

Puts pump parts and Spectra bottles back in pumping bag

Takes milk and parts home

Paula

Repeat x3 per day

Brings a cooler to work containing pump parts, ice packs and clean bottles

Medela pump stays at work, has a separate one at home

Goes to locked office to pump (every 3 hours)

Pumps for 15 minutes, uses Medela pump and a pumping bra fixed with safety pin

Shakes drops from pump part into bottle, pours into other bottle, shakes second pump part into bottle

Puts parts on top of ice pack in cooler

Puts bottle with breastmilk into small cooler

Puts the small cooler into big cooler

Combines milk into one bottle

Takes milk and parts home to sterilise

Existing storage solutions
Secondary Research

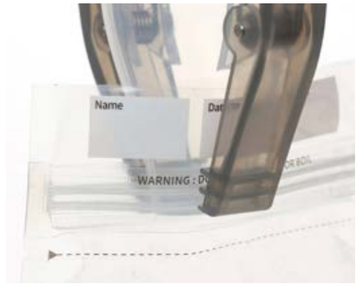
Pump thread adapters: pump flanges and bottles come in a range of diameters and threads, most brands have adapters suitable for their products.

Silicone cap: works with different manual pumps. Versatile, but not leak-proof according to reviews

Breast Pump Brand	Spectra S2
Lifefactory Baby Bottles	Yes, with THIS Spectra adapter.
Born Free Bottles	No
Evenflo Bottles (regular neck)	Yes with THIS Spectra adapter.
Phillips Avent Bottles	Yes
Munchkin Latch Baby Bottles	No
Comotomo Baby Bottles	Yes, with THIS adapter
Medela Baby Bottles	Yes, with THIS adapter.
Tommee Tippee Baby Bottles	Yes, read our post HERE
NUK Baby bottles and Storage Bags	Yes, with THIS NUK adapter.
MAM Baby Bottles	No
Lansinoh Baby Bottles and Milk Storage Bags	No
Breastflow Baby Bottles	No
Joovy Boob Bottles	No
Kiinde Baby Bottles and Feeding System	Yes, with THIS adapter

Breast Pump Brand	Lansinoh Signature Double Electric Pump
Lifefactory Baby Bottles	Yes, with this Hygeia adapter (has the same threading as Lansinoh)
Born Free Bottles	No
Evenflo Bottles (regular neck)	Yes, with this Hygeia adapter (has the same threading as Lansinoh)
Phillips Avent Bottles	No
Munchkin Latch Baby Bottles	No
Comotomo Baby Bottles	No
Medela Baby Bottles	Yes, with this Hygeia adapter (has the same threading as Lansinoh)
Tommee Tippee Baby Bottles	No
NUK Baby bottles and Storage Bags	Yes, with THESE NUK storage bags
MAM Baby Bottles	Not sure
Lansinoh Baby Bottles and Milk Storage Bags	Yes
Breastflow Baby Bottles	No
Joovy Boob Bottles	Yes, with THIS Joovy Boob adapter
Kiinde Baby Bottles and Feeding System	Yes, with THIS adapter set

Storage bag adapters: clip onto bags commonly used for storing/freezing breast milk. Work with a range of pumps but not all as the diameters and threads differ

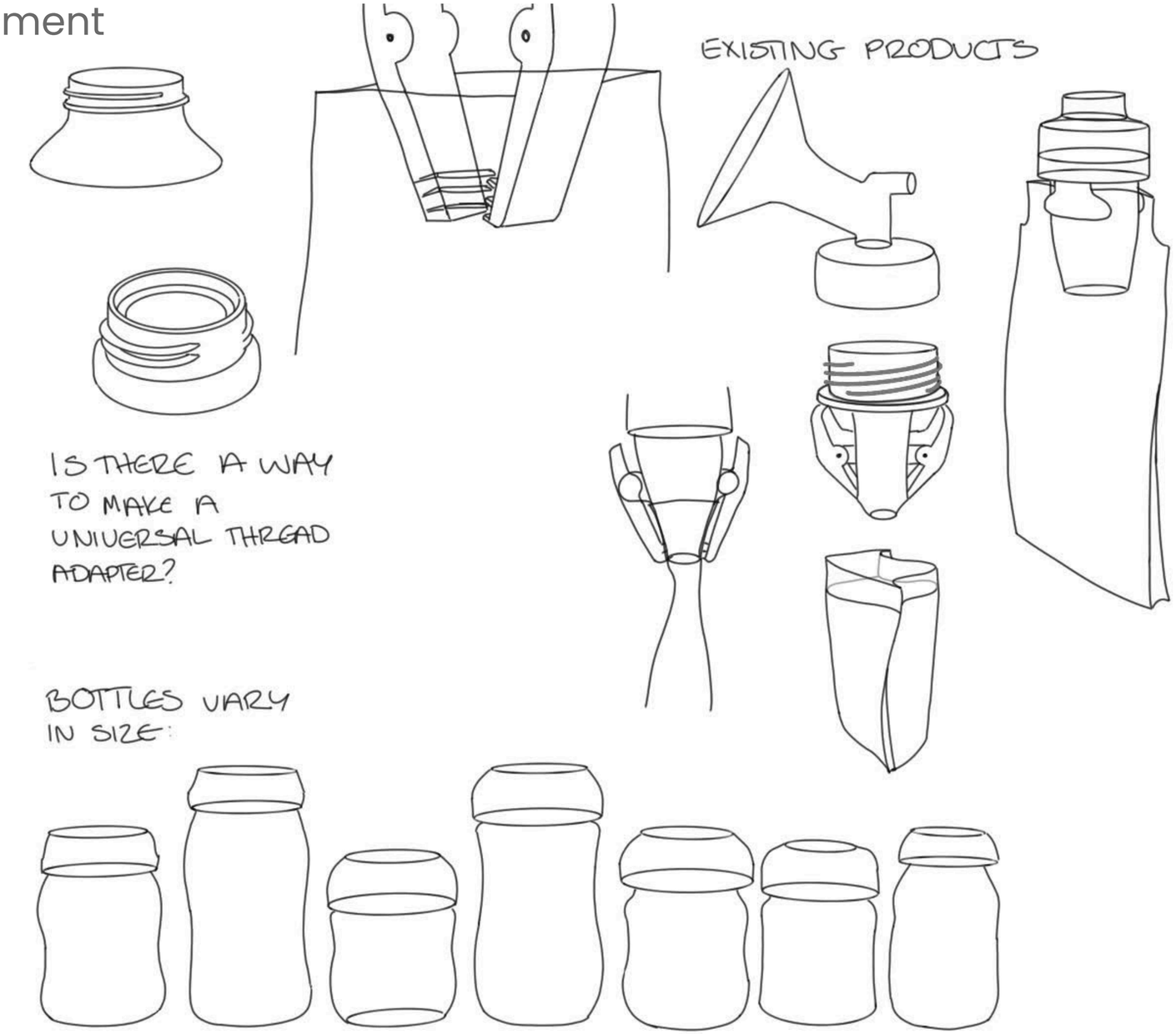


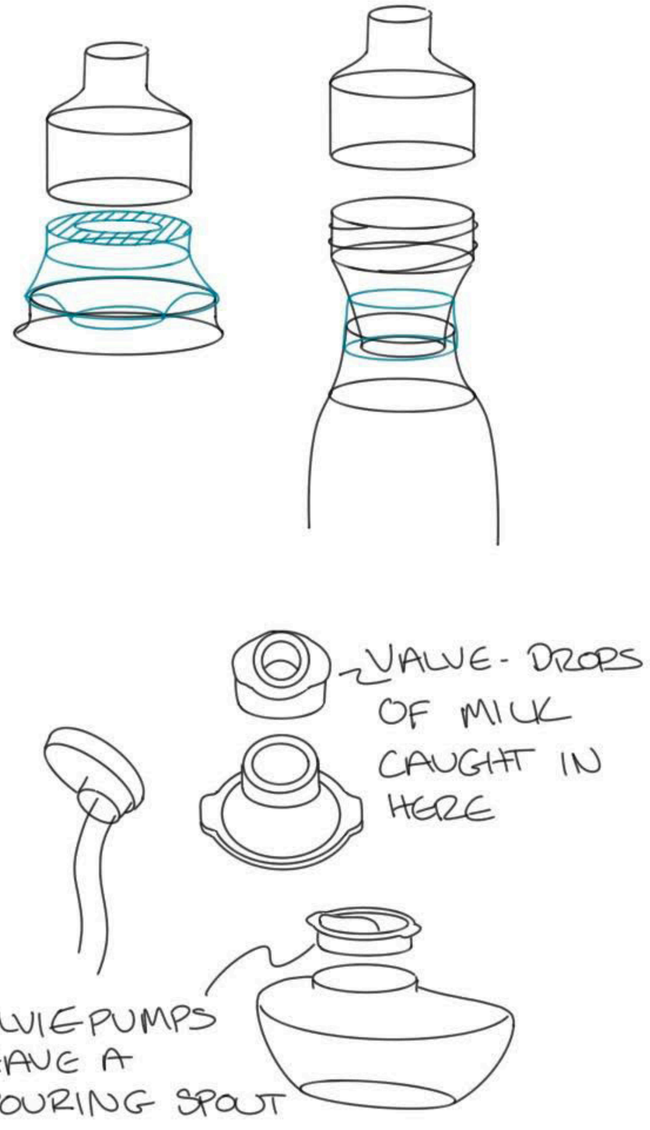
Summary of key findings

There are issues with compatibility of breast pumps and milk storage options, driven by brands trying to lock customers in to buying their products for convenience. There are adapters available to purchase however these are another thing to remember, and another thing to sterilise.

This lack of compatibility sometimes results in women transferring milk between receptacles for storage.

Storage solutions
Development





Existing cooling solutions
Secondary Research

NHS Guidance: Breast milk that's been cooled in the fridge can be carried in a cool bag with ice packs for up to 24 hours. (NHS, 2023)

Nuby Rapid Cool: used to cool formula from boiling to body temperature in 2 minutes

Could this technology be used to cool breast milk to be safely stored?

william

★★★☆☆ **Works but lid is rubish**

Reviewed in the United Kingdom GB on 12 April 2022

Verified Purchase

The flask works but the lid is rubbish. Put water straight from the kettle and it shows orange. Water from a thermos flask that is at least 85'c shows green.
Other than the digital lid, the product is great. Works as it says. We put hot water and powder and set a timer and it cools down the feed brilliant. Good product just a shame the lid doesn't work as it should.

Helpful | Report abuse

Myles Grima

★★★★★ **Game changer**

Reviewed in the United Kingdom GB on 23 March 2022

Verified Purchase

Would not be without the product. Absolute game changer for formula feeds. If my little one was exclusively formula fed I'd need more than 1 but we only use formula here and there. I've found that you need to leave the water in the flask a minute or too longer once the indicator goes green as otherwise the water is still too hot and you end up having to run the bottle under cold water to cook further. We use it with a cold water steriliser and not had any issues. Impossible to see the volume indicator on the inside so we have to measure the water out separately before putting in here with formula which is a pain.

Insulated bag and ice pack: existing solution used by most mothers who express at work and don't have access to a fridge/have a long commute after storing milk in the fridge. Stays cold for 8-12 hours

Freezable ice bags: Alternative solution whereby the whole bag, with a built in ice pack, is put in the freezer. Simpler process but doesn't stay cool as long.

Ceres Chill: flask solution developed specifically for breast milk. Insulated bottle with two chambers, giving the user flexibility. Stays cold for 20+hours

Summary of key findings

Most products are designed to warm breast milk rather than cool, to heat up refrigerated breast milk or formula to 36 degrees for baby to feed. Most are used in the home, sometimes at night.

Most storage solutions for expressed breast milk consist of an insulated bag, used in combination with an ice pack (the ice pack has to be frozen in advance, this is another thing for the mother to remember).

The Ceres Chill is one of the only custom-designed products for breast milk, and can be used with ice which requires slightly less preparation as a mum doesn't need to remember to put an ice pack in the freezer with sufficient time and then take it out again. Ice can be obtained relatively easily from cafés or supermarkets.

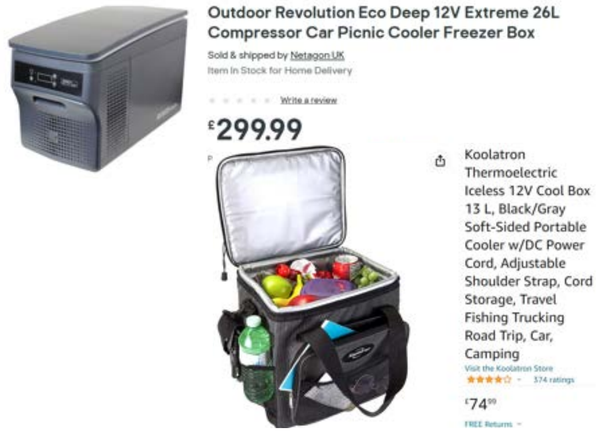
Cold Storage Drugs
Secondary Research

Battery-powered cooling methods:

Thermoelectric cooling: Thermoelectric cooling uses the Peltier effect to create a temperature difference between two materials. When an electric current is passed through a thermoelectric material, heat is transferred from one side to the other, causing one side to cool and the other to heat up. This technology can be used to cool small volumes of liquid using a battery-powered thermoelectric cooler.

Compressor-based refrigeration: Compressor-based refrigeration is commonly used in refrigerators and air conditioners. It works by compressing and expanding a refrigerant gas to transfer heat from one area to another. This technology requires more power than thermoelectric cooling, but it is more efficient and can cool larger volumes of liquid.

Phase Change Cooling: This technology involves using a material that undergoes a phase change, such as from a solid to a liquid, to absorb heat and cool the inside of the cooler. This technology is commonly used in passive cooling systems.



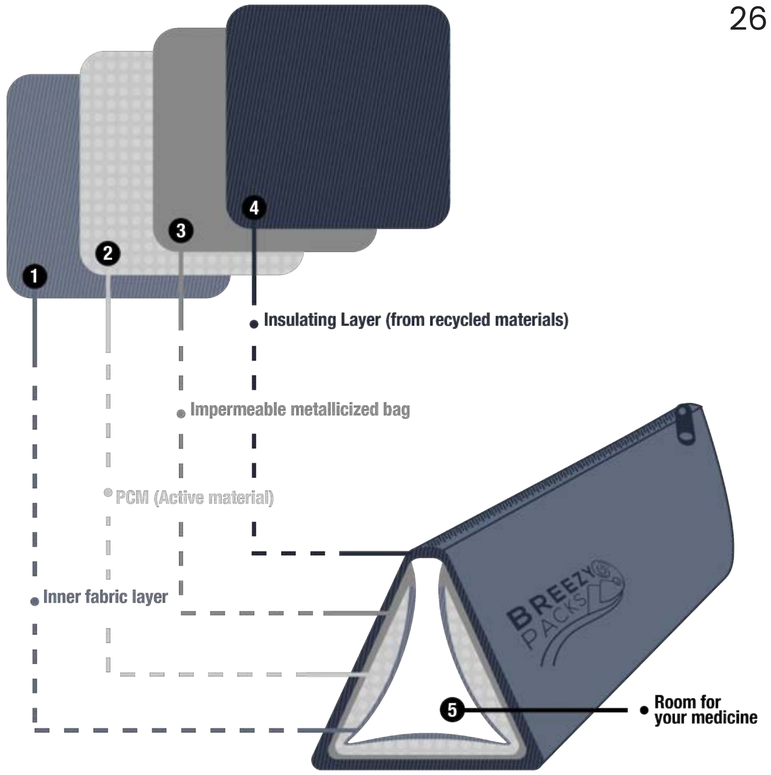
BreezyPacks: storage pouches for insulin and other heat-sensitive medications. Keep medicines cool without any action required from the user.

At the heart of BreezyPacks are materials called phase change materials, or PCMs.

The PCM absorbs and releases energy as it changes phase – this might sound complicated, but that's exactly what ice does: It requires energy to melt, which it takes from the environment, cooling it in the process. It then gets rid of this excess energy when it freezes – which starts happening the moment it goes under 0°C / 32°F.

Recharges by itself overnight (when temperatures are below 24°C/75°F) or in 1 hour in a fridge

Our PCM has some practical differences compared to ice:
- It freezes at 27°C / 80°F.
- This means that there's no need for a freezer – it can freeze at room temperature.
- It also means that it's perfectly suited to keep your medication below 30°C.
- It lasts much longer than ice.
- Ice melts much faster at a hot environment than, say, in the fridge – that's because the rate of melting is related to how far it is from it's melting point. Since our PCM's freezing point is much significantly higher than that of ice, it lasts much longer than ice in a hot environment. But, just like ice can turn into water and back an infinite number of times, so does our PCM – it does not degrade in the transition and can theoretically last forever.



Frío: cooling pouches for insulin and other heat-sensitive medications. User must place the pouch in water for a number of minutes so the crystals inside can become saturated and keep the contents a consistent temperature. Works on evaporation so the pouch must be stored in a breathable place.

The FRÍO® is an evaporative cooling pouch that keeps insulin and other temperature sensitive medications cool within safe temperatures of 18-26°C (64.4-78.8°F) for 45 hours minimum, even in a constant environmental temperature of 37.8°C (100°F).

To activate the FRÍO® wallet immerse it in cold water for as little as 5 minutes. Crystals contained in the panels of the pouch absorb water and expand into a gel which remains cool for an incredible 45 hours – using evaporation for cooling. Then just towel dry and it's ready to go!

Insulin must be at the manufacturer's recommended temperature before being placed in the FRÍO®

Summary of key findings

There are existing products used to keep insulin and other cold storage drugs at the right temperature (below 30°C). These use evaporative crystals and phase-change materials. Insulin pens, however, are very small - would the same technology be feasible for a larger volume?

There are other cooling technologies available, e.g. thermoelectric and compressor cooling, that can be powered by a 12V supply. Is this feasible for a working/commuting mum?

Need to do more research into heat exchange mechanisms.

Sterilisation of pump parts
Secondary Research

NHS Guidance:

It's important to sterilise all your baby's feeding equipment, including bottles and teats, until they are at least 12 months old.

This will protect your baby against infections, in particular diarrhoea and vomiting.

Before sterilising, you need to:

- Clean bottles, teats and other feeding equipment in hot, soapy water as soon as possible after feeds.
- Use a clean bottle brush to clean bottles (only use this brush for cleaning bottles), and a small teat brush to clean the inside of teats. You can also turn teats inside out then wash them in hot soapy water. Do not use salt to clean teats, as this can be dangerous for your baby.
- You can put your baby's feeding equipment in the dishwasher to clean it if you prefer. Putting feeding equipment through the dishwasher will clean it but it does not sterilise it. Make sure bottles, lids and teats are facing downwards. You may prefer to wash teats separately by hand to make sure they are completely clean.
- Rinse all your equipment in clean, cold running water before sterilising.

How to sterilise baby feeding equipment

There are several ways you can sterilise your baby's feeding equipment. These include:

- cold water sterilising solution
- steam sterilising
- boiling

UV sterilising

UV light kills the majority of bacteria and viruses (including coronavirus) by destroying their genetic material and cell structure. UV sterilising units have UV light bulbs and reflective inner surfaces so the light bounces around and kills any microorganisms it touches.

UV sterilising units can be used to sterilise any baby equipment except latex rubber teats. As with other sterilisers, all items must be washed thoroughly first because even very small particles left on surfaces can deflect UV rays. Some units have a drying cycle so items can be put in straight after washing.

The advantages of UV sterilisation are that bottles can be used straight out of the machine without rinsing or cooling. They are also safer for the user because they don't use hot water, steam or chemicals and they are effective against a wider range of micro-organisms. They're long lasting, too – bulbs can last for over 2000 hours.

On the other hand, UV light doesn't pass through objects so everything must be completely dis-assembled and not touching. This might make UV sterilisers unsuitable for some things, e.g. the narrow tubing of some breast pumps. Also, the sterilisation cycle can take longer with these sterilisers.

(NCT, 2022)

Types of Sterilising Products

Cold water sterilisers - e.g. Milton Steriliser - £18
• Sterilises in 15 minutes

Steam sterilisers

e.g. Tommee Tippee microwave steriliser - £20
• Sterilises in 4 minutes

e.g. Tommee Tippee electric steriliser - £40
• Sterilises in 5 minutes

Cleaning BEFORE sterilising:

When surgical tools and instruments are difficult to clean and sterilize with traditional methods, ultrasonic cleaners can deliver excellent cleaning and sterilizing performance. Some instruments, such as laparoscopes used in minimally invasive surgery, may have heat-sensitive components and can't be sterilized in an autoclave. Instruments may have complex shapes with areas impossible to reach with manual cleaning. Using ultrasonic cleaners also reduces the risk to medical personnel of handling sharp tools.

As a result, the use of ultrasonic cleaners in medical facilities is growing. Ultrasonic technology cleans quickly and completely. While the ultrasonic cleaning process does not itself sterilize, adding a suitable amount of disinfectant to the cleaning solution results in sterile instruments.

(Kaijo, 2021)

Summary of key findings

My product could incorporate UV sterilisation into a cooler to allow parts to be sterilised before expressing, and then keep bottles of milk cool afterwards.

However all the recommended sterilisation methods require parts to be cleaned thoroughly beforehand, particularly UV sterilisation, as any particles on surfaces can deflect UV rays. Thoroughly cleaning parts can be time consuming for mums, and requires access to a sink, soap, and likely a brush and a drying rack.

Could ultrasonic cleaning be used as an easier alternative to allow working mums to clean their bottles and breast pump parts before sterilisation?

Could cold water sterilisation be incorporated into the ultrasonic cleaning process?

Existing Portable Sterilisers
Secondary Research

UV Sterilisers:

Nuby Portable UV Steriliser - £106
- Sterilises in 3 minutes
- Works via battery that lasts 'up to 17 cycles'
- One sterilising compartment and one for storage

Nuby Limited Edition Portable UV Steriliser - £80
- Sterilises in 3 minutes
- Rechargeable battery lasts 'up to 80 cycles'
- Digital battery display to indicate battery level
- One sterilising compartment (but could also just be used for storage?)
- Claims to fit two bottles

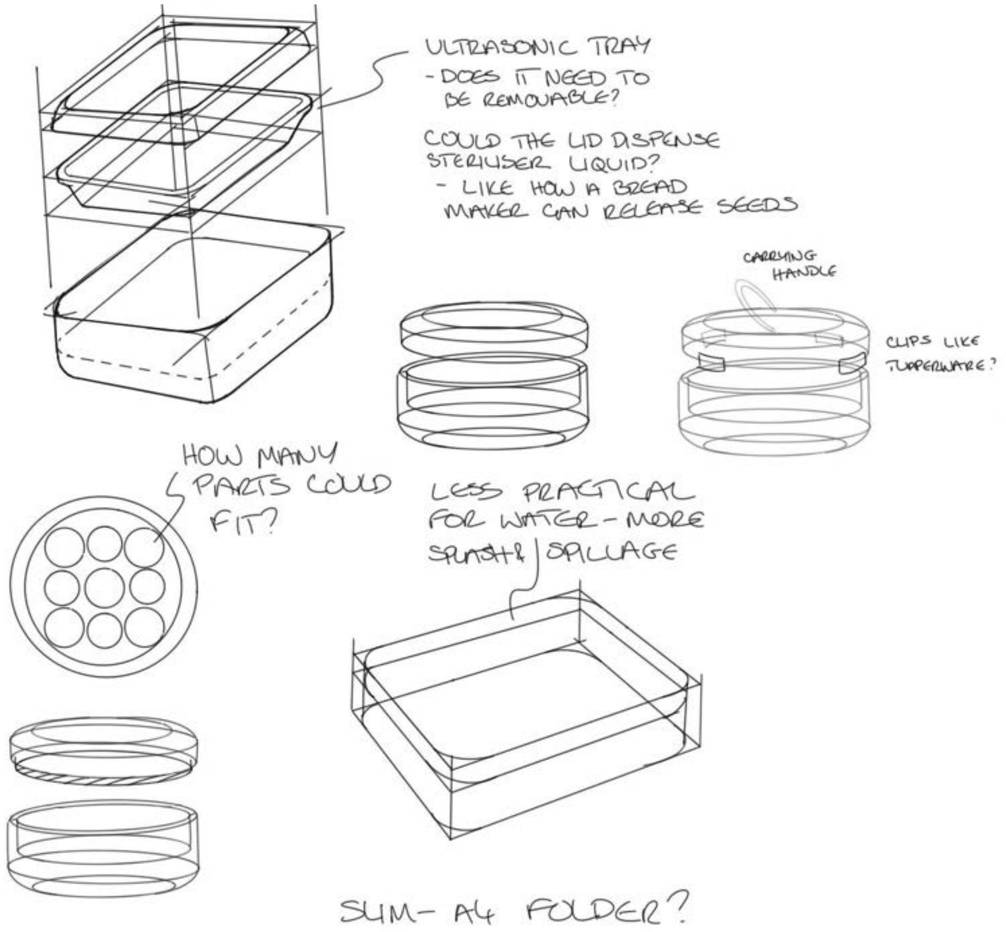
Travel Microwave Sterilisers:

Milton Microwave Steriliser - £13
- Holds one bottle, or a few teats/ dummies
- Can be microwaved or used for cold water sterilising

Disposable sterilising bags - £5
- Sterilises in 3 minutes
- Can be reused 20-30 times before being thrown away

Nuby UV Dummy Steriliser - £25
- Sterilises in 1 minute
- Works via 3x AA battery, or can be plugged into mains
- One sterilising compartment and one for storage

Cleaning & Sterilising
Development



Summary of key findings

A lot of steps to consider if I were to automate the cleaning and sterilising process - bringing water into the mix could be challenging, especially as I'd need to clean the parts with detergent, rinse them, and then sterilise.

There are quite a lot of products designed specifically for this purpose at a range of price points. These do all require the items to be washed beforehand.

Week 4 Tutorial
Meeting Notes

'on the wave' instead of at work.
NUBY Heat conducted away

'Heat exchange
2 key phrase

Passive v. active

Peltiers come in different sizes
- Need a lot of current ⇒ battery constraints.

Heat generated - needs to be regulated/ managed/

Peltier + heat sink

Look at heat exchange mechanisms

Stills & copper spirals?

PCMs:
sucks heat away via latent heat

Physics textbook

Journal: HardwareX

2 Science/DIY guides
- Look for heat exchange tech.

Ultrasonic: how would the product look?

When would it be needed

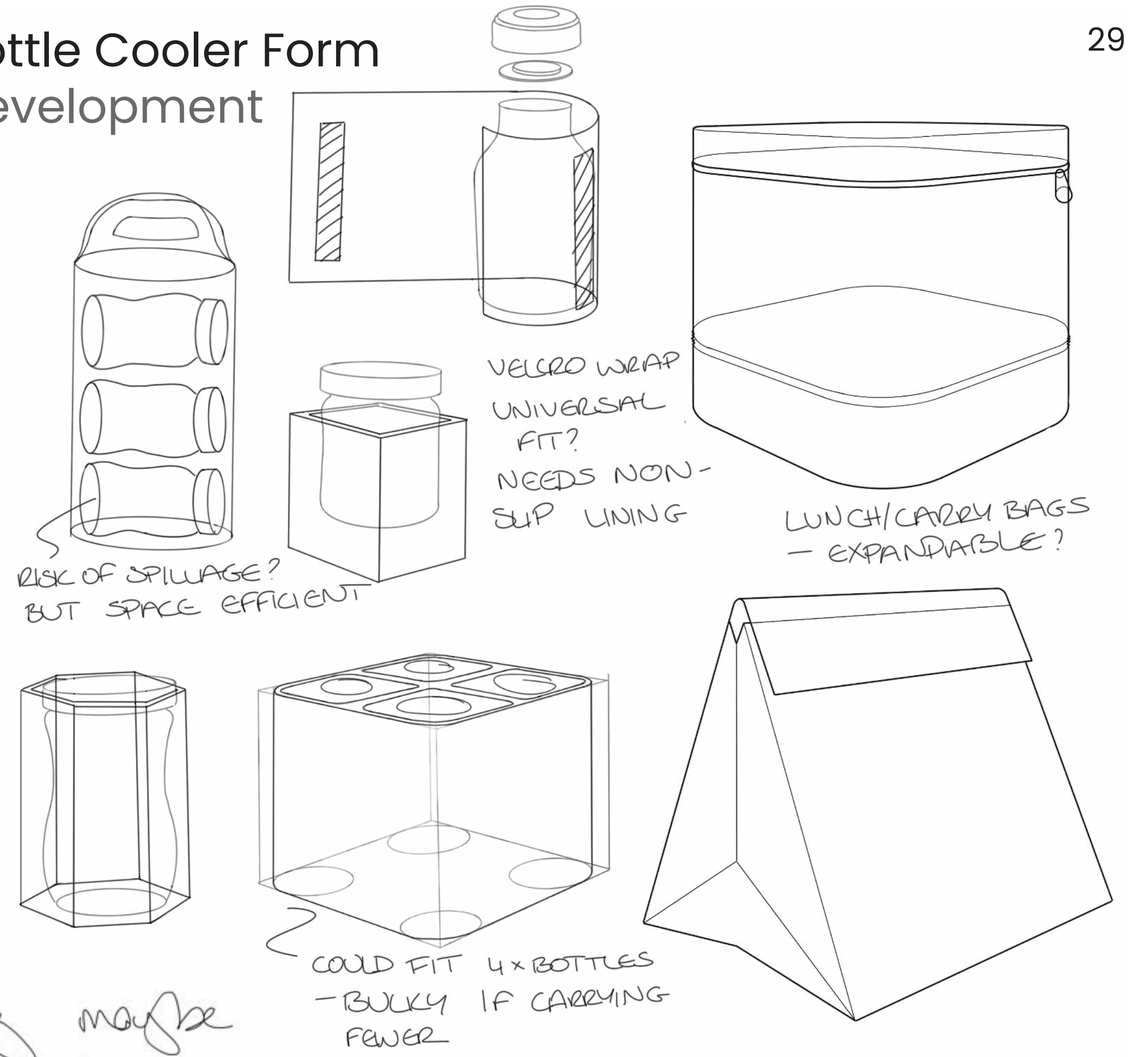
Designing a bag is fine if there's justification.

U important to dial in on brief

Commit to one or the other

Sterilising maybe more work
- Consider steps washing up liquid & scrubbing

Bottle Cooler Form
Development



Summary of key findings

I'm going to focus on cooling, storage and transport. **KEY DECISION.**
It's hard to ensure universality in the compatibility with existing bottles, will need to explore this further.

The size and shape of the cooling container are also important as it should be easy and enjoyable to use, without being bulky and requiring additional effort from the mother to fit it in her bag/carry it around.

Heat Exchange in a Closed System
Secondary Research

The measure of how much heat it takes to raise the temperature of an object of a given mass a given number of degrees is called its specific heat.

The following equation relates the amount of heat needed to raise an object's temperature to the change in temperature and the amount of mass involved:

$Q = mc\Delta T$

- Q is the amount of heat energy transferred into the object (measured in joules if using SI units)
- m is the mass of the object
- ΔT is the change in temperature (measured in degrees Celsius or kelvin)
- c is a constant called the specific heat, which is measured in joules per kilogram-degree Celsius

You can use the heat equation to find out how temperature changes when you mix liquids of different temperatures. The following equation represents the heat lost by the new mass of liquid, m_1:

$\Delta Q_1 = cm_1(T-T_1)$

And here's the heat gained by the existing liquid, mass m_2:

$\Delta Q_2 = cm_2(T-T_2)$

Energy cannot be created or destroyed, energy is conserved within a closed system; therefore, the heat lost by the new liquid is the heat that the existing liquid gains, so:

$\Delta Q_1 = \Delta Q_2$

Therefore;

$cm_1(T - T_1) = -cm_2(T - T_2)$

(Holzner, 2016)

The properties of many objects change with temperature;

Length: $\Delta L = \alpha L_0 \Delta T$

Volume: $\Delta V = \beta V_0 \Delta T$

When we add heat to an object, we can change:

its temperature: $Q=mc\Delta T$

and/or its phase: $Q=\pm mL_f$

There are three mechanisms of heat transfer:

- Conduction: heat transfer within a body or between two bodies in contact. Heat transfer by means of molecular agitation within a material without any motion of the material as a whole. Higher speed particles will collide with the slower ones, with a net transfer of energy to the slower ones.

The rate of heat transfer (heat current) depends on the temperature difference, the cross-sectional area, and the inverse of the length

- Convection: heat transfer by mass motion of a fluid such as air or water when the heated fluid is caused to move away from the source of heat, carrying energy with it.

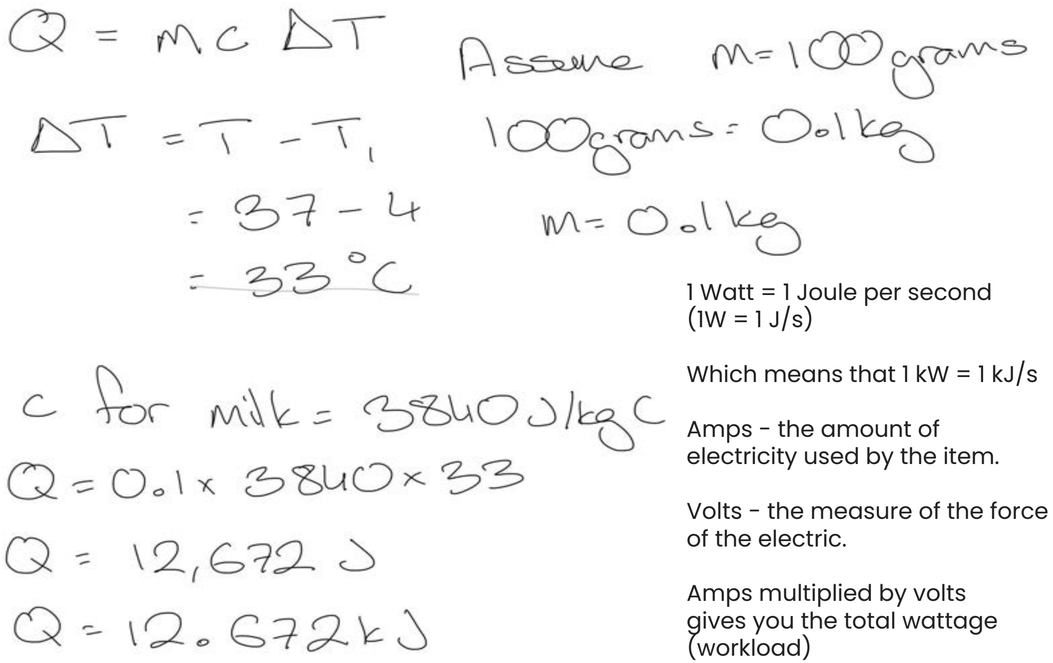
- Radiation: heat transfer by electromagnetic waves such as visible light, UV and infrared radiation. Depends on the area of the surface and the fourth power of the temperature.

http://www.physics.usyd.edu.au/~helenj/Thermal/PDF/thermal4.pdf

Can't find the specific heat value for breastmilk so approximating using cow's milk:

Mature human milk contains 3%-5% fat (Jenness, 1979)

Specific heat of milk: 3.93 kJ/(kg K) = 3840 J/kg C



1 Watt = 1 Joule per second (1W = 1 J/s)

Which means that 1 kW = 1 kJ/s

Amps - the amount of electricity used by the item.

Volts - the measure of the force of the electric.

Amps multiplied by volts gives you the total wattage (workload)

Summary of key findings

Using the equation for temperature change of a liquid, 12.672kJ are required to cool 100 grams of breast milk to 4°C. Next steps are to work out how long this would take, what cooling method is most appropriate, and how to power this in a portable manner (i.e. not requiring mains power supply).

How do I know how long the value I've obtained for Q must act?

If I need 12.7 kJ for one second, that's 12.7 kW.

If using 12V power supply, that means my current is 1,058 A. Is this feasible???

1,058 A = 1,058,000 mA

Temperature-Control Chamber
Secondary Research

Contents lists available at ScienceDirect

HardwareX

journal homepage: www.elsevier.com/locate/ohx

OpenTCC: An open source low-cost temperature-control chamber

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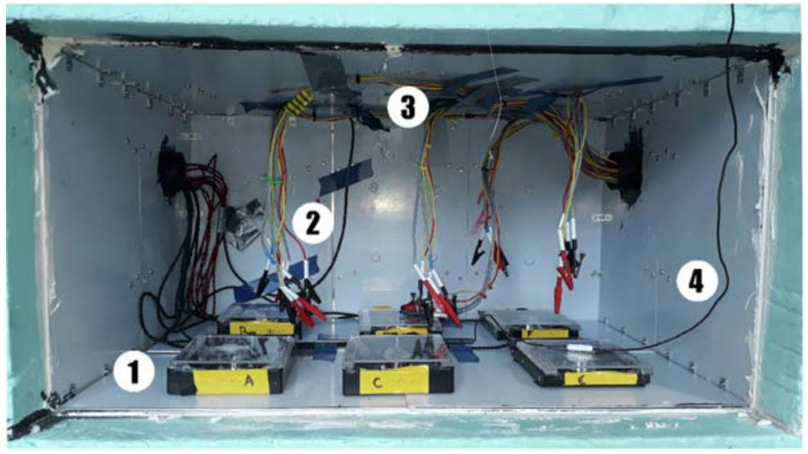
ABSTRACT

Microbial electrochemical technologies (MET) are emerging systems for environmental applications such as renewable energy production or pollution remediation. MET research often requires stable temperatures and low levels of electromagnetic interference. Due to the presence of electrical wires and sensors, heating MET using water jacket recirculation can raise safety issues, whereas heating coils may affect the results of electrochemical analyses. The proposed open-source temperature-control chamber (OpenTCC) aims to provide a low-cost solution for controlling temperature (in the range 20–55 °C) while simultaneously reducing the electromagnetic interferences caused by switching mode power supplies. OpenTCC consists of a light and cheap structure, incorporating eight heating pads and two Peltier-cooling modules powered by open-source electronic circuits. Its hardware is controlled by an Arduino microcontroller and a Python interface which provides data-logging and serve as a basis for programable temperature cycles. The system has a modular design to allow stacking several independent modules. OpenTCC provides a reliable and tunable temperature control at lower costs than currently available commercial temperature controllers and provides a platform for field-specific upgrades. Though optimized for MET, Open-TCC can be adapted to other laboratory applications due to its flexible design.



Here, we present an open source temperature-controlled chamber (OpenTCC), designed to reduce costs and open new possibilities for temperature-controlled experiments in microbiology (e.g.,constant temperature, simulate temperature cycles, e.g. day-night or seasonal temperature conditions).

OpenTCC includes an Arduino microcontroller and a Python interface to obtain a flexible and programmable temperature control and data logging, capable of heating or cooling a volume of 72L in short time. To the authors knowledge, OpenTCC is the only open-source incubator capable of cooling.

OpenTCC can be used in laboratories with limited financial resources, being cheaper than commercially available devices [Table 2]. Although commercial temperature-control chambers such as the Memmert Peltier can set a wider range of temperatures (between 0 and 70C), OpenTCC provides temperature control in the range used in most biological experiments (20–55C) at 10-time slower cost and offers fully open-source design [Table 3]. Furthermore, OpenTCC facilitates a modular installation with stacked units that can be controlled at different temperatures.

In summary, OpenTCC was designed to meet the following requirements:

1. Temperature control in the range of most biological experiments (20–55C)
2. Low cost (less than €400)
3. Portability and stackability (less than 20kg)
4. Dampening effect on electromagnetic interferences (Faraday cage)
5. Programmable interface

The main purpose of OpenTCC is an accurate temperature control inside the chamber, to avoid thermal variations affecting the experimental results. A set of eight heating pad resistors (Table 4: Pad) were installed at the base of the chamber as heating devices, and two thermoelectric Peltier (Table 5: Pelt) modules were installed on the back side of the chamber for cooling. The compact heating pad resistors are covered with aluminium sheets to increase heat distribution and homogenize the temperature inside the chamber. The thermoelectric Peltier cooling modules are characterized by lower maintenance cost and lower weight compared to the commonly applied compressor-type cooling systems [11,12]. Both heating pads and Peltier modules are DC devices with limited EMI generation.

In OpenTCC, heating and cooling elements are powered by a 12 V power supply. The eight heat pads (8 X resistance each) can conduct up to 1.5 A per unit at 12 V if an appropriate heatsink (an aluminium sheet in this case) is supplied to transfer the generated heat. Each thermoelectric (Peltier) unit has a limit of 6 A, therefore 24 A are necessary to power at full potential all the eight heating and two cooling elements installed. However, since the modules never work all simultaneously, any power supply that supplies at least 10 A, such as a typical computer ATX power supply or the one specified in Table 4 (Designator: Pow) can be used.

In this work, the power supply was recovered from an old computer to power OpenTCC. A more efficient and nowadays popular power supply is the switching-mode power supply (SMPS), which regulate its output to supply a constant voltage. However, SMPS is characterized by a high level of EMI radiation, and thus, should be placed outside and distant from the chamber (Supplementary material: EMI).

In OpenTCC, the heating and cooling modules are controlled by an Arduino microcontroller (Table 5: Ardu) which opens or closes the energy supply to the heating or cooling elements depending on the temperature measured in comparison to the set temperature, using logic-level N-channel power MOSFETs (Table 5: Mosf).

OpenTCC incorporates two different temperature sensors: a Pt-100 resistance temperature detector (RTD) as the external temperature sensor and an AD22100 integrated circuit (IC) as the internal temperature sensor. The Pt-100 circuit (Table 5: RTD) comprises a Wheatstone bridge and a differential/instrumental amplifier built from simple op-amps (Table 5: Opa). The voltage difference is then measured by the Arduino analog-to-digital converter (ADC). The AD22100 consists of a low-cost proprietary-RTD IC (Table 5: Therm) measuring the temperature inside OpenTCC using the Arduino as a power source and an ADC without any additional circuit requirements. Other types of sensors can be installed based on the user's needs and possibilities.

Summary of key findings

This open-source project could form the basis for the functionality of my design.

This project, however, is designed to create an ambient temperature of 20-55°C. My product would require a temperature of 0-4°C, and will need to cool a volume of liquid to this temperature too.

Further research is needed to determine whether using the same components as this project would allow me to achieve this.

Peltier Research
Development

To create a practical thermoelectric cooling unit, the Peltier module is built into a system that usually comprises a metal block of high thermal conductivity, such as an aluminum alloy, and a finned heat sink (Figure 2).

The metal block is used to attach the device to be cooled – such as the laser diode or image sensor – to the cold side of the cooling element. The thickness of the block is selected to maintain flatness and so ensure consistent thermal connection with the cold plate of the Peltier element, noting that excessive thickness will introduce unwanted thermal inertia. The heat sink is attached to the opposite side, or hot plate, of the Peltier element, to dissipate the extracted heat into the ambient environment. A thin layer of thermal grease, or other thermal interface material (TIM), is applied to each surface.

Module and controller selection:

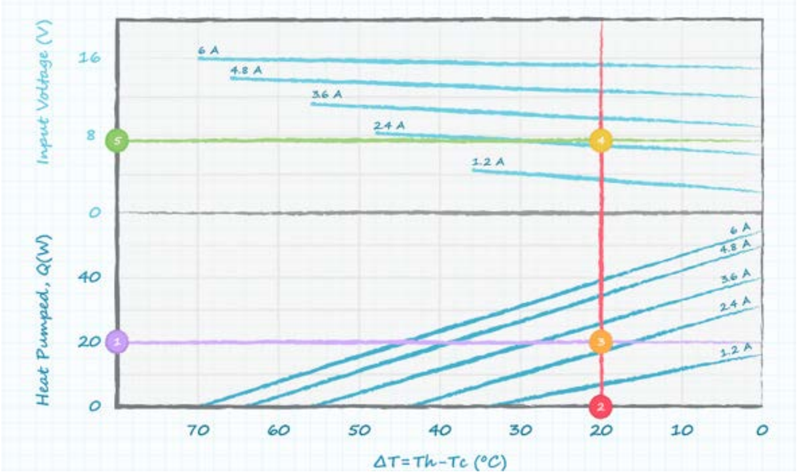
A complete thermoelectric cooling system comprises the Peltier element and heat sink assembly, temperature sensors to monitor the hot and cold plates and a controller unit to ensure the correct current is supplied to maintain the desired temperature difference across the module.

The controller and Peltier module are chosen to ensure the heat from the cooled component combined with the joule-heating effect of the supplied current can be dissipated without exceeding the maximum thermal capacity (Qmax) or maximum temperature difference (ΔTmax) indicated in the Peltier module datasheet. The maximum temperature difference and maximum current should also be considered, to ensure the chosen Peltier module can maintain the desired temperature difference when operating at a suitable current. This should typically be less than 70% of the maximum rated current, to ensure that joule heating remains within manageable limits and the system can respond to short-term increases in the cold plate temperature without encountering thermal runaway. (Smoot, 2018)

Calculating current and thermal absorption - example

Relationships between current, voltage, temperature difference, and heat absorption are all illustrated by datasheet function diagrams

- Draw horizontal line at 20 W on lower vertical axis which represents the power transferred through the Peltier module.
- Draw vertical line at 20°C on lower horizontal axis which represents the temperature difference maintained across the Peltier module.
- Operating current of 2.7 A is interpolated from where horizontal line (1) and vertical line (2) intersect. This is the current required to operate the Peltier module.
- In the upper half of the graph mark where vertical line (2) intersects 2.7A.
- Operating voltage of 7.5 V is interpolated from drawing a horizontal line from the intersection in step 4 to the upper vertical axis. This is the required voltage compliance of the current source. (Rose, n.d.)

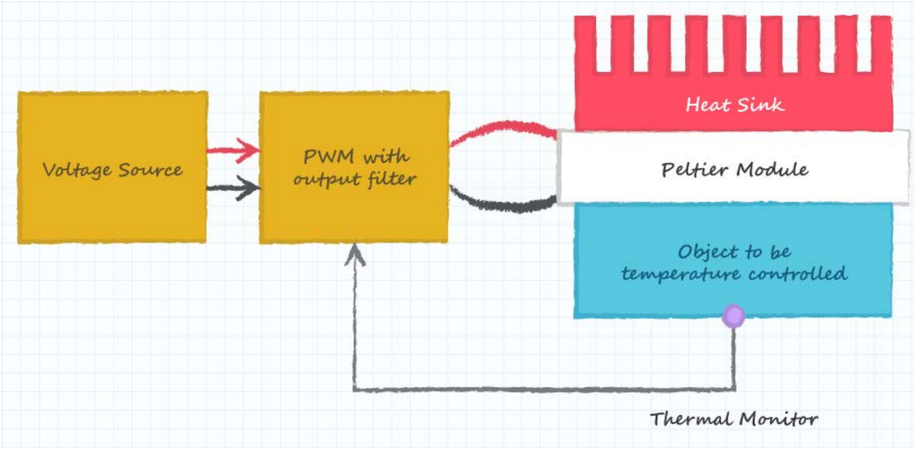


Using Peltier modules to maintain an object at a controlled temperature

These designs utilize a thermal sensor, such as a thermocouple, a solid-state temperature sensor, or an infrared sensor to monitor the temperature of the object.

The temperature data is fed back to the power source via a thermal control loop to adjust the voltage (or current) applied to the Peltier module. A common method to control the voltage applied to the thermoelectric module is to include a Pulse Width Modulation (PWM) stage on the output of a standard power supply. The external PWM stage is necessary because many power supplies do not have the ability to easily adjust the output voltage over a wide range.

The output voltage of the PWM stage should also be filtered so it exhibits less than about 5% ripple. Higher ripple voltages will not damage the Peltier module, but it will reduce its Coefficient of Performance (COP) and may cause electrical noise issues in the object being cooled. The design of the thermal control loop can be implemented in many forms due to the low loop bandwidth required. In addition, polarity of the controlled voltage or current will need to be reversible if the temperature control system will be required to both cool and heat the object.



Summary of key findings

Different Peltiers have different properties, which can be found in a graph in the datasheet. Will need to do some further research and calculations to work out how I could use peltiers in my design. Peltiers should definitely be feasible, just a question of how to power it.

Insulation Research
Development

Insulated thermal bags work by blocking the passage of heat into and out of itself. They have a reflective layer that reflects infrared heat back to its source, as well as a layer of flexible non-conductive material such as foam, plastic or paper as insulation from conduction. They also seal at the top using a zipper, ziplock, magnets or velcro stopping hot air getting in.

Insulated bags are basically compact cooler boxes that are made from softer and lighter materials. They are much lighter than regular coolers which have rigid walls filled with dense foam, making them far more convenient for short trips and also easy to store because you can just fold them up.

While you cannot expect these foldable alternatives to provide anywhere close to the thermal insulation as a proper yeti cooler, they do work remarkably well given how thin and light they can be.

As you can read here, there are three ways heat can transfer into your food warming it up. These are the forces insulated bags fight off when it comes to keeping one the inside insulated from the outside.

1. Radiation
Anything with a temperature will be radiating its stored heat out into the environment in the form of infrared radiation. This is the type of heat we receive from the sun and can feel on our skins on a hot summers day. To counteract this loss of heat, a reflective insulation is used to reflect the infrared heat back to the source – your hot food.

Reflective insulation is the crinkled metallic looking material lining the inside of these insulated bags. The shiny linings are often made using aluminum or some other reflective substance which is able to reflect the invisible infrared radiation.

While this foil looks to be facing inwards it actually works in both directions. It'll reflect AWAY heat and keep heat out when you're trying to keep things cool or if you're using your lunch bag to keep things warm then it'll reflect heat inwards trapping it inside and keeping your food warm.

The reflective layer is very thin and while it does a good job at reflecting the infrared heat, it doesn't do anything to prevent heat loss through conduction. This is why aluminum foil is a good insulator in one aspect, but a bad insulator in another and this is why insulated bags also have a layer of foam, plastic or paper to stop heat transferring through conduction.

2. Conduction
To prevent heat from moving into or out of your bag through conduction, insulated bags will incorporate a layer of non-conductive material that is usually made from foam, plastic or even paper depending on the specific type of insulated bag.

3. Convection
Convection is the process by which heat is transferred by movement of a heated fluid such as air or water.

In your insulated bags this is basically hot air getting into or escaping the bag and most insulated bags seal at the top to stop air movement into or out of the bag keeping the items at a stable temperature for longer. (McLean, 2022)

Materials:
Understanding how insulation works can be confusing. There are many different types of insulation products (cellulose, fiberglass, rock wool, expanded polystyrene/EPS board, extruded polystyrene/XPS board, polyurethanes, etc.) and several methods to measure a product's insulating power. Many of the testing methods lack objectivity, and too much of the information is misleading and biased. Although not well known, polyurethanes have proven to be the best insulating products.

One objective method for comparing insulation materials is to measure a material's thermal conductivity. Thermal conductivity (also known as lambda value) is the rate at which heat passes through a material. Thermal conductivity/lambda is measured in watts per square meter of surface area for a temperature gradient of one Kelvin per one meter of thickness; expressed as W/m-K. Thermal conductivity is independent of product thickness. The lower the conductivity, the more thermally efficient a material is. (Hoffman, 2021)

Which? Cooler bag comparison and reviews

Tested by putting a chilled bottle of water and an ice pack into each bag. Temperature probes were inserted into each bottle and left for the day, taking temperature readings every hour. To replicate typical use, we opened and closed the bags four hours in, and then every 30 minutes.

Key findings:
Great insulation can be nullified by poor design. The bag that came out top in the insulation test was also the only bag to leak.

A good zipper can make a world of difference. An easy-to-use zip means you can get in and out quickly, avoiding hot air getting in and cold air getting out. We found that two bags had stiff zips. One was so tough, it became a chore to open, while another caught on the inner lining, eventually ripping it off. (Morris, 2023)

Summary of key findings

Useful to find out how insulated bags mitigate the three types of heat transfer.

The way to prevent this heat transfer is: reflective material to keep heat out, an airtight design to prevent air movement, and use of a non-conductive material such as plastic or foam to prevent conduction. Polyurethanes are supposed to be the best insulating material.

Another important factor identified by Which? was the choice and design of zip, to allow a cool bag to be opened quickly and efficiently.

Study Investigation of airflow and heat transfer
Development

2.2.1 Experimental setup

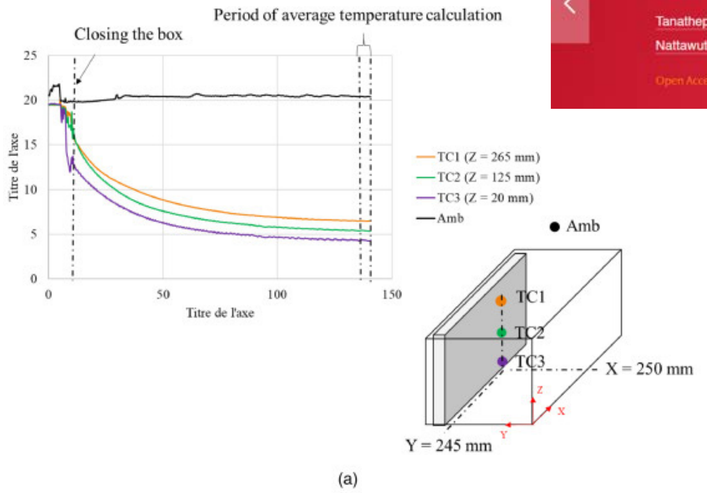
The temperature was measured by T-type thermocouples linked to the Agilent 34972A data acquisition unit (Agilent Technologies, CA, USA). These thermocouples were calibrated at -10°C, 0°C, 10°C, 20°C and 30°C with a precision of ±0.2°C. PCM slab was placed horizontally in a freezer set at -2°C for at least 48 h before each experiment.

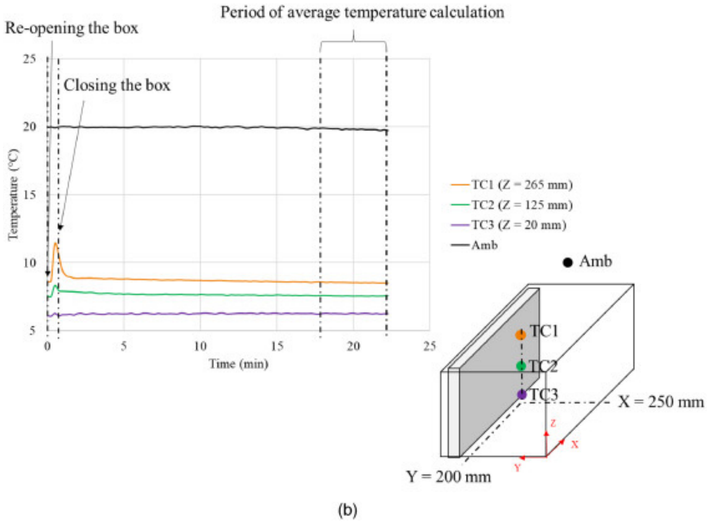
Sixteen packs of test product were put in a polystyrene box and stored in a domestic refrigerator set at 4°C or 10°C for at least 24 h before each experiment to assure the homogeneous product's initial temperature.

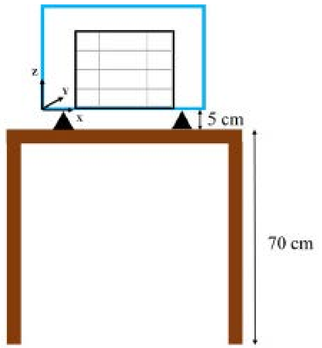
2.2.2 Temperature measurement in an unloaded box

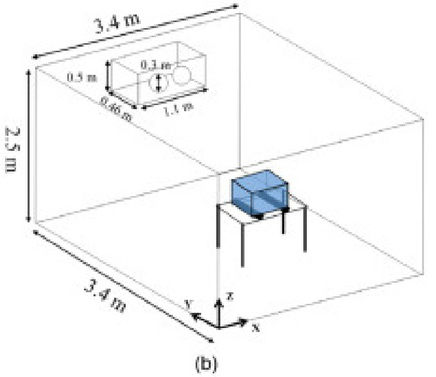
Firstly, all thermocouples were placed in the box. Air temperature distribution was measured at the middle plane of the YZ plane (X = 250 mm) with various y and z positions and around half of the XZ plane (Y = 145 mm for the box with PCM on the side and Y = 165 mm for that with PCM at the top). Two stands, each equipped with 12 thermocouples spreading over the height (z-axis), were displaced inside the box in x and y direction to obtain the air temperature field. Thermocouples were also put inside the PCM (at half thickness), on the surface of the PCM container, and the box's internal walls. The diagram showing thermocouples positions is in Fig. 2a of Leungtongkum et al. [[1]].
Ninety minutes after the box was closed (when the steady state was reached), temperatures were recorded for at least 5 min. (acquisition interval 15 s). Then, the box was opened in order to move the stands prior to closing the box again. This process took less than 1 min. to avoid disturbances caused by external air to the greatest possible extent. Fifteen minutes later (when the steady state was reached again), temperatures were recorded over 5 min. before re-opening the box. Then, the position of the stands was changed in y direction (18 to 21 positions), allowing 200 measurement points in total. A temperature contour map was plotted by MATLAB with interpolation from these measurements.

Fig. 16 illustrates the temperature evolution of some locations in an unloaded horizontal box with PCM on a side under 20°C ambient during the first measurement (Fig. 16a) and the following measurement (Fig. 16b). These figures show the period during which the average temperature was calculated: 135 min. to 140 min. after box closing for the first measurement and 17 min. to 22 min. for the following measurement. Then, these average temperatures were used to present the temperature field in stable condition in the following figures (Figs. 1, 2, 4, and 5).










(c)


(d)


(e)

Summary of key findings

This was useful to see how successful other projects have been at using insulated containers and phase change materials to cool and monitor temperatures.

This project, however, used a fairly large container and focused on the temperature distribution within the container, which is not very relevant to my project.

Mumsnet Research - UK Based
Secondary Research

dizzykitty · 01/03/2013 13:15

I returned to work at 6 months and expressed initially 3 times per day and reduced to twice a day at about 10 months, and continued until 12 months. I was fortunate to have had the general support from managers and colleagues. I was also fortunate that I am incredibly organised so that this daily military operation could continue!

I would take sterilised bottles to work in a cool bag. On arrival I could transfer a freezer pack to the freezer ready to keep my haul cool on the way home. I had a plastic box the bottles fitted into which was labelled 'breast milk please do not use' so that the bottles were identifiable but secured, a small plastic bowl and a mini bottle brush for washing up (in case anyone objected to me using the washing up bowl) and my trusty medela swing pump. Oh and of course lots of baby pics on my phone to help with let down. I was able to use meeting rooms not in use (these generally have locks on the doors) for the 10-15 minutes it took me, which was great although did sometimes require some trecking around to find one.

After pumping I would put the bottle(s) of milk in the box in the fridge. Wash up in my small bowl, and then use the bags you can use to sterilise in the microwave to sterilise the relevant bits of the pump ready for the next time.

At the end of the day I'd get my freezer pack out, and put my bottles with in a cool bag to keep it cool till I got home. On getting home it was either decanted into sterilised feeding bottles for the following day, or to bags for the freezer for storage.

It's a bit of a mission, but if you have the will, you will find a way. I was so chuffed that by the end of my DDs first 12 months I had managed to provide all the milk she needed (and even some spare for the milk bank). I still breast feed her now, but only need to express for my comfort when she stays over at Nanny and Grandad's!

cinnamongreyhound · 28/02/2013 21:27

I expressed with ds1, took my cup of tea with me and expressed at tea break and then just before I left work as these were the times he fed when I was home. I had milk storage bags and a insulated bottle bag to keep it foolish on way home. Kept in the fridge we used for lunch food. I expressed in the first aid room. I managed to express enough for one feed in two pumping sessions. I just rinsed pump and bottle under a very hot tap/just boiled kettle. Didn't sterilise as he was over 6 months. I did this for 3 months until he dropped to only having milk first thing and last thing so I was with him then.

leedy · 28/02/2013 15:41

I stopped expressing at about 14 months, largely because DS1 was showing less and less interest in the bottle and I wasn't going to go through all the faff of producing the stuff if he wasn't going to drink it! Boobs adjusted after a day or two and he still had that feed at weekends for a couple more months.

I got a really good mini cold bag with freezer pack thing with my Medela pump as part of a set. Also Pacapod-brand changing bags come with a mini cold bag (though not the freezer yoke), I think you can probably buy them separately too.

CMOTDibbler · 28/02/2013 15:52

I expressed 3 feeds a day for a few months, then 2 for a few more, then 1, using the first aid room and the canteen fridge.

I travelled for work, and pumped in the back of the car under a shawl, in loos, hotel rooms, on planes and all sorts!

Don't buy a special cool bag - take your lunch in a nice one, then take your milk home in it 😁

I expressed for a year at work, and until ds was 23 months when I was away overnight for work, so it can really work out

leedy · 26/02/2013 22:57

I expressed one feed a day for DS1 when I went back to work (he was 10 months) - I think if I'd gone back much earlier I might have needed to do more but at that stage he'd really ramped up his solids intake and was pretty much only feeding once during the time I'd be away at work.

I pumped once a day, took about 10 minutes while I read stuff on my phone, got about 5oz which was all he'd take in a bottle. I was very lucky in that my office had a provided mothers' room which was basically ALL FOR ME (and any visiting mums) as I was the only woman with a new baby in the entire building at the time (I work in IT, it is a blokey office) so I had a comfy chair and a lock and a nice HR lady to show it to me. Kept the milk in a cool bag in the office kitchen fridge with a freezable ice pack thing for the way home, nobody ever objected to it, or to me taking the extra break. As I only did one pump a day I didn't need to sterilize anything in work, just took the sterilizable bits home with me. HTH.

Loislane78 · 27/02/2013 07:17

Wouldn't it be nice if office's did little parents rooms, like John Lewis! :). Comfy chair, water dispenser, little fridge etc. :)

At my work ladies use the first aid room. I'm not back yet but lots of others do/have so it's no biggie. I don't think colleagues mind or even notice tbh, you could just be in a mtg, loo break....

HorryDrelincourt · 27/02/2013 07:38

It was all very hard, actually. They obeyed the letter of the law but what was *reasonable* was not *desirable* and vice versa.

I expressed in the disabled toilet 😳 which was the only room in the building with a proper door, dumped the result, and washed as thoroughly as possible in the little sink.

Storage was an issue, although I *could* have used the client fridge that usually only held bottles of water and (cows') milk. My main problem was a 90-min commute mainly on public transport.

In any case he was 11mo when I went back to work and only missing one feed if that, so he had ff in my absence for a bit, and by 18m my supply had regulated and he wasn't bothering with milk at nursery. 🤣 at the memory of reverse cycling though.

I was their first ever still-bf mother.

MinnesotaNice · 27/02/2013 17:58

I generally only expressed once a day, usually right before lunch. However, I started pumping at home shortly after the birth so I had enough milk. Stored extra in the freezer in the Medela bags that are intended for storing breastmilk.
Where I worked, there was a small room set aside for this specific purpose. It wasn't too bad, had a comfortable chair and outlets. I used a Medela Pump in Style which is a double pump so the whole process was only about 20 mins total. Also invested in a bra to hold the shields so I could pump hands-free which was great. I would take a book and relax (no cell phones allowed where I work).
Stored the milk in a chilled bag that came with the pump. The few times I pumped a second time in one day, I didn't sterilize the shields in between, just rinsed with water. I carried everything in plastic zip-lock bags and sterilized at home. Not sure if they are carried in the UK, but the quart-sized bags work great for a set of shields.
Pumped at work for about 5 months and DS1 was BF until he turned 1.
HTH!

HorryDrelincourt · 27/02/2013 18:05

Yes, reverse cycling is when the little ~~buggers~~ darlings take their missed feeds when normal people are fast asleep 🥶 😁

The disabled toilet was not ideal, but it was better than my next best option, which was locking myself into the library and hanging paper over the glass-panelled door. I was trying to be discreet!

I think the wording is that they must provide somewhere to express/feed which "should not" be a toilet. But it wasn't a big workplace and there weren't a lot of options. And since I wasn't worried about keeping sterile anyway (see earlier post) it didn't matter.

Mumsnet Research - UK Based
Secondary Research

HeyDuggee24

I'm looking for any top tips (and any experience of) returning to work and expressing..

DC will be 8 months. I have access to a private room, with a sink and a fridge. Obvs I need my pump, and I'm assuming a cool bag suitable for bottles..fridge thermometer?

I'm a bit nervous about it as DC still feeds frequently (like every 2hrs..) and I've never known anyone actually return to work and keep expressing..

Namechangeymcnamechange11

I did. Is there anything in particular that you'd like to know? It sounds like you're all set up and ready to go, with a supportive employer!

MrsGrannyWeatherwax

I am but struggling as my meetings regularly extend into time I should be expressing in. Only a few weeks back though.

HeyDuggee24

I guess I'm wondering how doable it is? It seems so few people express at work (or maybe they are super discreet about it!)

Do you express for every feed? Did you manage to match what baby was taking in from missed feeds? Does it cut too much in to your working day?

I'm not too meeting heavy in my job role so hopefully that wont affect me too much! Good luck with it!

CmdrCressidaDuck

I've done it for months with both babies. Never bothered with a thermometer. Just booked the pumping breaks into my diary, went and did it, put them in the fridge or freezer, and carried them home at the end of the day in my mini cool bag. It's an easy enough thing once you're in it. I flexed them sometimes for important meetings

TruthSweet

Just check the mini fridge will get cold enough (if you mean those 6 can sized fridges?) as some only keep XC below room temperature.

Some pumps come with cool bags and ice packs too (or as an optional extra) so have a scout around and read reviews before committing.

I'd get a hand pump to keep in your desk drawer too (or learn how to hand express - ask your MW to show you) in case you forget the pump one day/run out of battery power/blow a fuse.

getagoldtoof

I went back to work when DS was 5 weeks, he is now 12 weeks. I express 3 times a day, it takes 10-15 mins including washing the pump parts. I get in to work for 8.30, express 4-5oz. I then express again at lunchtime, usually 5oz. I try to express again at 3.30, and usually get 4oz. This means I only take one break out of work time, which I can make up (but usually don't...!). DS usually only has around 6-10 oz while I'm at work, and breastfeeds a lot more when I'm home, the remaining milk goes in the freezer. I'm happy with this reverse cycling, as I get to spend lots of time with him, but I don't sleep a lot. Also, has caused a bit of excess supply which is tough, so i block feed too, and we always get covered in milk, forget muslins, just keep a huge towel by the bed!

We got him on the bottle at 2 weeks, he took it straight away, we were very lucky. He now happily takes the bottle from me, and has been known to have it straight from the fridge! He has never had trouble switching although very much gets comfort from breastfeeding (as any baby does).

There is legislation which means your workplace have the duty to provide you with space to express. My pump has a battery pack so wouldn't need a plug socket. I know people recommend against open system, but I got the medela pump in style. It does the trick, and DS doesn't seem to mind a bit of dust in his milk. Maybe you'd need to do more research on this.

We bought the whole medela kit. It cost loads, but my husband was adamant if he were looking after the baby he wanted it all to work together. The steriliser is ok, and bottle warmer fine, but double the price of everything else on the market!

I get home in the evening, put two bottles in the fridge with the date on (masking tape), and one bottle emptied in a freezer bag. I then wash the bottles I bring home and the ones DH has used in the day, sterilise and pack away for the next day. I only bring the pump home at weekends or if I've been/will be out of the office, otherwise it's locked in my desk.

Xenia 31 Oct 2012, 7:13 pm

I had a battery operated hand pump which was quite light and worked fine. I took it home ecah night with the milk and I did sterilise its parts and the bottles for the next day every night.

I certainly remember how nice it was to come home and breastfeed right away, very relaxing.

With numbers 4/5 I was working for myself which was easier so I had our nanny bring them to me to feed in my office here or I went to her unless I was out at a meeting and that was definitely easier as I hardly had to express at all BUT with the older ones there was no other option and it has really paid off - I wanted them to have breast milk and I wanted to work full time.

Like some above we also carried on with some feeds when they were eating more foods. I never voluntarily stopped feeding but the toddlers did which was fine.

getagoldtoof 2 Nov 2012, 10:23 pm

I did the same as above. Bought loads of bottles as all the sterilising can get a bit rough. I hated doing it every night after work, but it had to be done. Reckon a microwave steriliser might be easier? Get the caregiver to wash the bottles after use if they get the chance. It'll make life a bit easier.

I went back to university lectures when my son was a week old, and full time at work when he was a month old, so even with a very tiny baby it can be done.

However, i had a two week break from work when he was 5 months old and he gave up on bottles, just wouldn't take one at all, all day. He breastfed all night long instead (still does.... but thats another story).

If you plan everything carefully, there is no reason for it not to work. Good luck.

Val007 2 Nov 2012, 10:36 pm

I hand expressed at work in one of the toilets. I did not really advertise what I was doing there approx 2-3 times a day. I hid the small Medela bottle in my trousers pocket on my way to and from the toilets. Then once at my desk, I transfered the milk to a bigger glass bottle (luckily I had no colleagues in my office at the time), which I kept in a coolerbag with a few packs of ice, all brought from home each day.

- Shame/stigma
- Cleaning
- Storage
- Generally noteworthy
- Time/routine
- Facilities

Mumsnet Research - UK Based
Secondary Research

ElphabaTheGreen

For those of you who expressed at work with a view to keeping the milk for later use, and not just a pump and dump, how did you sterilise your expressing equipment? Did you do it at work, or sterilise at home and take into work? If the former, what sterilising method did you use? If the latter, how did you keep your stuff sterile (or at least, as sterile as possible) during transport?

Thanks!

Xenia 29 Oct 2012, 7:58 pm

Caveat that the oldest of my babies is now engaged herself! but I did with the first three - bought a good book on it at the time.

I sterlised everything before I left home. I took ice packs to work as did not want to bother asking about fridges or drawing attention to it. I then pumped into the bottle(s) and saved it agains the ice pack. It was always kept cool. Took it home and put it in the fridge when I got home. There would be nothing to sterilise at work really. I did rinse the pump top bit that goes over your breast just under the tap after expressing. I did not sterlise that bit at work before the next pumping and the babies are pretty strong. One ran the London marathon last year and both the oldest are about to do triatholons and they were rarely ill - may be because they only ever had breastmilk.

I breastfed just before I left the house and as soon as I got home.

I had one of those insulted picnic things with the ice packs in which would take the milk too for the journeys home. It all worked fine. In fact I've never fed a baby from a bottle in 28 years as a mother.

The milk I took home was then used whilst I was out the next day on the baby.

CMOTDibbler

I had an Ameda Lactaline, and bought extra pump head sets, and a big locknlock box. Then in the evening everything got a good wash, put a Milton tablet in the box, put the pump stuff in, fill with water, put lid on. Then after it had been in there long enough, I rinsed with boiled water (ie, pour milton out, pour kettle of water in, then pour out), and sealed the box. Then I just took out what I needed during the day. Not a faff at all, and meant I wasn't trying to rinse stuff in the canteen sink or leaving pump parts in the fridge.
I expressed at work for a year

YesILikeItToo

Certainly feasible. I used the KellyMom website for ideas about practicalities - all sorts of questions will spring up in your mind about storage and transport. Two tips from me -1. however understanding your office environment, the first time me you open that fridge you will realise you want a container to put your milk containers in. 2. Looking at pictures of the baby on your phone will speed things up and improve your results.

Aria2015 16 Mar 2017, 9:26 pm

I went back to work when lo was 7 months. I expressed at work until he was about 13 months (he gave me up!). I pumped twice a day, I told my work ahead of going back and mostly I was able to express at the times I wanted. Sometimes I'd have a meeting and would have to pump a bit earlier or later but mostly I could squeeze it in. The only thing I struggled with was that my two pumping break were basically my lunch hour split in two. I found the days very full on not having a break to myself. I had to eat while I pumped and I couldn't meet friends for lunch or shop for bits in my lunch hour (the one bit of returning to work I looking forward to!). But it enabled me to feed him to a year which was my goal and I still think it was worth it. You sound more fortunate than me, I had to pump in the toilets sometimes and keep my milk in the general fridge - no special room or fridge for me! Good luck!

Duskybluebell 15 Mar 2017, 5:36 pm

My first, back when maternity leave was a little more restricted, I expressed at work from 17 weeks until she was a year old. It worked fine so long as I remembered to collect my milk from the fridge on my way out. Continued to breastfeed until she was two I think.
My second, work was happy for me to express in theory but in practice front line NHS staff in an acute setting doesn't lend itself, so he got formula when I was at work and I breastfed at home. He also breastfed until he was two.
It sounds like your work is supportive if they've got a room and a fridge so no reason any it shouldn't work. I used to read office paperwork while expressing. Obviously you don't need to express at the same time every day any more than you need to breastfeed exactly the same time, but it may help your colleagues if you have a routine.

SauvignonBlanche

I used an Avent Isis pump, sterilised everything at home.
Kept milk (hidden) in the fridge during my night shift, took it home then DH took it to the childminders.

NovemberAli 29 Oct 2012, 10:30 pm

I also had an avent isis. Microwaved sterilised pump every night at home and kept pump parts in tupperware box. Took 3 sterilised bottles in with me everyday, had to store my milk in the fridge with everyone's lunch boxes and washed my pump in the coffee room sink 😂. Had cool bag to take milk home in and only a 15 min walk so stayed cold.

ITryToBeZenBut 31 Oct 2012, 2

I express at work like the others. Went back at 4.5 months, he's now 9 and intend to until he can get onto cow's milk at 12 months.

Like the others, with a bit of organisation, not a problem. I commute for 2 hrs each way. Take 2 sterilised bottles with me in a medela cool bag with ice block which I put in the fridge at work with everyone's sandwiches but it's zipped and sealed (although if out and about the cool block from the freezer can easily chill the milk for 12 hours). I have 2 pumps. One at home and one that lives in the office. Expensive - yes - but means less carting stuff about as I need to express at the weekend to build up milk for Monday.

We don't really have many facilities at work so I express in the disabled loo - wipe surfaces and wash hands etc then careful with the pre-sterlised equipment. Wash the pumps bits in boiling water with washing up liquid and put in a clean sterile tuperware in the fridge at work. I also, before I use the bits from the tuperware again, rinse them in boiling water again just in case.

LexiWITCHious

I had the use of a ~~broom cupboard~~ small meeting room, and a fridge in the office. I used a double medela and was forever fascinated by the variation in how much I got out of each side when I pumped!

In the morning I would microwave sterilise the pump head and bits, and six of the storage bottles and caps, take them in to work in a little insulated zip up cool bag, the pump bits in a zip lock sandwich bag. In fact I think the cool bag and some bottles came with the double medela when I bought it. Most days I would then just take the cool bag over to the nursery at pickup time, leave the bottles in their fridge for the following day, and take that day's empties home.

Once you have sterilised a storage bottle and cap, if you put the cap on it stays sterile inside. After each pumping session I unscrewed the boob parts from the bottles and put them back in the sandwich bag, and kept them in the fridge too. You can't pump body temp milk into a cooled bottle of earlier milk, but if you only get them partly full, once they are cooled to the same temp in the fridge you can consolidate them a bit. But bear in mind that when one is warmed up to give to your baby, it has to be all drunk then rather than dipped into. So perhaps having a lot of half bottles is better, certainly in the early days of childcare when baby may just be getting used to taking your milk from a bottle with a carer.

Summary of key findings

Expressing in the first aid room or an unused office is common, although a couple of mothers reported expressing in the toilet. Most sterilised the pumps and parts at home, either in the morning or evening. Some had a private fridge while others used a communal one, before putting the milk in a cool bag to take home.

Existing Products
Secondary Research

BABEYER Breastmilk Cooler Bag with Ice Pack Included, Baby Bottle Cooler Bag for 4 Large Baby Bottles (up to 270ml), Cream

Visit the BABEYER Store

★★★★½ 244 ratings | 10 answered questions

£23.99

Isoliertasche Thermibag Double, rosa

★★★★½ 599 ratings

£13.57

Skip Hop Double Bottle Bag (Chevron)

Visit the Skip Hop Store

★★★★½ 3,486 ratings | 18 answered questions

£19.00

Get £5 extra when you top up £60. *Terms and conditions apply. Learn more

Colour Name: **Chevron**

£21.91 | £19.00

Brand	Skip Hop
Colour	Chevron
Material	Polyester
Style	Chevron
Closure type	Hook and Loop

Baby Bottles Cooler Bag & Travel Pack

In stock

£15.99

Quantity: 1

ADD TO BASKET

Add to Wish List

natural baby shower

Tommee Tippee Closer to Nature Insulated Bottle Bag, Pack of 2

Visit the Tommee Tippee Store

★★★★½ 5,404 ratings | 79 answered questions

Amazon's Choice for "baby bottle bag"

RRP: £12.99 Details

Deal of the Day: £8.99

FREE Returns

Ends in day, earlier if units allocated to the deal sell out.

You Save: £4.00 (31%)

Get £5 extra when you top up £60. *Terms and conditions apply. Learn more

Available at a lower price from other sellers that may not offer free Prime delivery.

Size Name: **2 Count (Pack of 1)**

Lekebaby Double Baby Bottle Cold Bag, Grey

Visit the Lekebaby Store

★★★★½ 661 ratings | 11 answered questions

Currently unavailable.

We don't know when or if this item will be back in stock.

Brand	Lekebaby
Colour	Grey
Material	Polyester,Plastic
Closure type	Zipper
Pattern	Solid

About this item

- Baby bottle cooler bag holds two large breast milk bottles or sippy cups; Bag size: 18 x 10 x 23 cm

UV Light Sterilization Bag

$59.95

★★★★½ 10 reviews

Keep things clean with this UV Light sanitizer bag that kills 99.9% of germs.

- 1 +

Add to Cart

Philips Avent Glass Bottle Jacket for Bottles – for Protection and Insulation

Visit the Philips Store

★★★★☆ 184 ratings

£13.01

Get £5 extra when you top up £60. *Terms and conditions apply. Learn more

Brand	Philips
Item weight	2709.23 Grams
Capacity	125 Millilitres
Age range (description)	Baby
Dishwasher safe	Yes
Unit count	1 count

Summary of key findings

Most of these bags are just insulated, so will keep the milk at the temperature it's already at. Some have space specifically for an ice pack (sometimes has to be bought separately).

The NanoBebe bag has an icepack that comes with it, although some reviews say it doesn't last very long and put in an additional cooler block.

Many existing bags have velcro, poppers or clips on the straps to allow them to be hooked onto a pram or another bag.

Product Requirements
Secondary Research

Bottles come in two sizes, small ones which hold 150mls (5 fl oz) and large ones which hold 250ml (9 fl oz). For the first few weeks, newborns feed little and often because their stomachs are so small. The smaller bottles are more suitable for this period. Babies who feed from larger bottles consume more milk, which may lead to overfeeding.

Parents who bottle feed find that they may need to move onto using larger bottles as their baby grows and milk consumption increases. Every baby is different so there isn't a set age for when this should happen. It's important to follow your baby's feeding cues and signs that they need more milk, such as finishing each feed and seeming to want more.

(NCT, 2021)

Approx. age	Amount per feed - ml	Amount per feed - fluid ounces	Number of feeds per 24 hours
Up to 2 weeks	90ml	3fl. oz	6
2-4 weeks	120ml	4fl. oz	5
4-8 weeks	150ml	5fl. oz	5
8-12 weeks	180ml	6fl. oz	5
3-4 months	180ml	6fl. oz	5
4-5 months	210ml	7fl. oz	5
5-6 months	210ml	7fl. oz	5
7-12 months	210ml	7fl. oz	3
1 year+	150ml	5fl. oz	2

(Cow and Gate, n.d.)

Brand	**Volume**	**Dimensions** (including teat as these are the dimensions available online)
Haakaa	160ml	8x8x14cm
Haakaa	250ml	??
Avent (Philips)	125ml	7x7x13cm
Avent (Philips)	260ml	7x7x17cm
Medela	150ml	9x9x14cm
Medela	250ml	9x9x16cm
Lansinoh	160ml	6x6x13.7cm
Lansinoh	240ml	6x6x17cm
Tommee Tippee	150ml	8x8x13
Tommee Tippee	260ml	8x8x16cm
MAM	160ml	7x7x17cm
MAM	260ml	7x7x19cm

Summary of key findings

Assuming this to be the maximum amount of breast milk consumed by a baby;

Assuming an 8-hour work day, 5/3 (1.67) feeds would be expressed and stored.

Round this up to 2, so 2x210ml = 420ml. Up to this much milk may need to be stored using my product.

Depending on the brand of bottle used this could be stored in two or possibly three bottles.

Is it sensible to restrict my design to being able to hold only two bottles? This would make it much simpler to design. It's reasonable to expect a mother to move onto the larger bottle size at the point when the baby is having 210ml per feed. KEY DECISION

Interview with an expressing
Primary Research

Over Easter: Relisten to recording & double check everything

Interviewer:
I was wondering if you could kind of talk me through what your routine was for expressing.

Interviewee:
Mm-hmm. Umm, so I would express... Let's say uh and on a work day only, so I didn't express when I had him, only on work days. And at somewhere sort of mid morning, lunchtime and mid afternoon, so probably three times a day at work. For like, I don't know, maybe 7 minutes, 8 minutes. I had a double.

Interviewer:
A double pump?

Interviewee:
Yes.

Interviewer:
And then. So I was wondering what you stored milk in after expressing stored?

Interviewee:
I'm, I just stored it in a baby bottle, like a bottle you could drink out of. And I had... I was given a fridge in my office. Yeah, I could put it straight in there.

Interviewer:
Did you get the caps that are just caps or when they the where the teat on as well?

Interviewee:
Yeah, just for the teat on, like literally like a bottle like you would give to a baby to drink from.

Interviewer:
OK, great. And then I was wondering how you clean them? And sterilize them and all that jazz.

Interviewee:
I'm so I didn't do any different than I would do to to sterilize the bottle, so I'm it. I then would take it home and it would live in the fridge. And the next day, he would take it to nursery with a new sterile teat and top on it.

But I didn't transfer it between the bottle, it just went in the bottle that it was.

Going in and then I would bring to work. Uh, sterilized bottle to express into and we'd we used an electric steamer sterilizer. So it's sat in the kitchen.

Interviewer:
Would do that kind of in the evening or in the morning before work?

Interviewee:
Yeah. In the morning before work, you put water in the bottom, bottles on top, takes about 10 minutes.

Interviewer:
OK, great. So then how many bottles did you need to sterilise? Did you combine the milk or did you use separate buttons?

Interviewee:
Uh, so I'd sterilize the pump. Which had two bottle attachments on it and another bottle. So I would pump from two small bottles and then tip it into one for storage in the fridge. So that's three and then he would have a formula bottle and nursery as well. So then I'd do one for that and then once there.

Interviewer:
OK. So then when you after your first pump with the day? Did you put the milk just in the same bottle or?

Interviewee:
Yes. So then the tip in the same bottle, put that in the fridge and then when I pumped later in the day, I'd again just type it in on top of the one that I already had.

Interviewer:
OK, great. And then how did you take it home?

Interviewee:
And I just carried it, you know, I've probably got... I've got the stuff laying around here because I'm not into tidying.

In a carry case. so it's like a thermos.

Both sides and it's the you know or like insulated. Milk in that.

And for that I'm if I pick him up him up, it's got like a... Clip it on the pushchair.
Yeah. So didn't have to hold it.

Interviewer:
Is that a Tommee Tippee? I think I've seen it before. I can't remember whether...

Interviewee:
Yes, it's Tommee Tippee. Yeah.

Interviewer:
Okay great. How long... do you know how long that stays insulated for?

Interviewee:
No. No idea.

- Shame/stigma
- Cleaning
- Storage
- Generally noteworthy
- Time/routine
- Facilities

Interview with an expressi
Primary Research

Over Easter: Relisten to recording & double check everything

Interviewer:
How long is your commute when you're in Loughborough?

Interviewee:
And it is about 20 minutes. I walk, so I'm outside.

And I got that second hand too, who knows if it still has its insulation qualities.

Interviewer:
And that's just insulated and you put it, you put the milk in when it's at which temperature. So there's no coolers or anything?

Interviewee:
No. So chuck it out the fridge, put it in there and supposed to keep it the same temperature.

Interviewer:
Lovely. OK. And then when you when you're on the go, I think last time you mentioned that you've expressed in disabled toilets before. How does your routine change when you're kind of out and about?

Interviewee:
And I would try I I just have to plan it in around the meeting schedule. So rather than when is a good time for me, it's like looking at the agenda and when is the time where I'm not going to be missed... It's a pain in the in a toilet you don't have as much like places to put anything.

I'm, but then I didn't ever express in a toilet and keep the milk, so I wasn't really bothered about being clean. It was more about not tipping it over me. So then I didn't walk into the work meeting with liquid spots all down me. Umm. Yeah, so it's it's you end up carrying a lot of stuff.

Interviewer:
OK. And then how do you store the pump parts in between your expressing sessions?

Interviewee:
In between I was using a uh... It's literally all here.

Interviewer:
So just a Tupperware is it?

Interviewee:
No, it is a Tommee Tippee box. I think it comes with the hand pump I had to start with. And then it's cause it's got the lid that so you can put it in the microwave and sterilise in the microwave. So yeah, so I would keep the bits in there and the pump I would just chuck in my bag.

Um but obviously if you check it at the bottom of the bag, it might turn itself on. So I chuck it near the top of the bag.

And then I would assemble the bits and put it in a. Sandwich bag. If I wasn't. You know, if I if if it was about trying to transport it in a small way and I wasn't gonna keep the milk, then you'd put it together and put it in a sandwich bag.

And then just take the pump bits because I didn't need another bottle to store the milk. So I didn't keep it in the box like to keep it clean or anything like that.

Interviewer:
OK. And then when you were are keeping the milk, when working in Loughborough. How would you do it then?

Interviewee:
And the then I use this box that yeah. Then it's like a bigger sealed unit.

Interviewer:
Yeah. Did you clean the bottles in between?

Interviewee:
I did not no. Um it's not. There's not really facility. I don't think like to just use the key point.

Yeah.
Interviewer:
Fair enough. If you had, if you did have access to a kind of private bathroom, would you in your I don't like. Hypothetically an office with an on suite. Do you think that would affect anything?

Interviewee:
Uh, so they let me express upstairs in ... her office. So you know, upstairs her office.

I'm and I think (colleague's) office on the 1st floor at doesn't have glass windows.

But all of the other rooms in the design school have got glass windows. So that's where I was using. Uh, none of the rooms lock though. It's not actually possible to look any of them from the inside, so somebody could walk in.

Interviewer:
And then I was wondering, so would the Tommee Tippee pump so that ones battery powered USB rechargeable?

Interviewee:
It's a USB rechargeable, yeah.

Interviewer:
How often do you charge it and how long does it last you?

- Shame/stigma
- Cleaning
- Storage
- Generally noteworthy
- Time/routine
- Facilities

Interview with an expressi
Primary Research

Over Easter: Relisten to recording & double check everything

Interviewee:
I probably would say I charged it up every day, but I don't need to. I reckon it probably could have gone 2 days.

But the charger was just next to the sterilizer. So it was just part of the routine to plug it in.

Interviewer:
How long did you charge it for? While sterilizing?

Interviewee:
Overnight.

Interviewer:
Lovely. Thank you. That's really helpful.

Yeah, that's basically all my questions. I was just. OK. Yeah. It's good to know that you got on the 20 everything because I was literally looking at them, the insulated bags, OK. Is there anything else you wish to add that may be relevant?

Interviewee:
I've definitely lost milk due to it leaking in the bag, so storage is definitely an issue.

Interviewer:
OK. So that's the Tommee bottles?

Interviewee:
Yes, yeah. If you don't put the lid on quite right and then it gets tipped over. And then it smells because you've spilt milk in your bag.

And it's really annoying. And like they say, like crying over spilt milk is OK if it's breast milk and all the effort you've been through to get it.

Interviewer:
Yeah, definitely. How do you wash that TommeeTippee bag?

Interviewee:
I do not.

Interviewer:
But I mean, if milk spilled, do you just kind of wipe it or...?

Interviewee:
Yeah. If. Well, if I think I just chucked in the washing machine, when it's spilt everywhere, but I don't routinely wash it.

Umm. And also it's so I had a private fridge, not that I would say not that it would have affected me anyway. I would rather store milk in something that looks obviously like a baby bottle, so everybody knows what it is and they're not gonna mistakenly take it. But some people would rather not do that because they don't want everybody to know that they're expressing at work.

Interviewer:
And yeah, makes sense. When you, I think you said that you've used other fridges on the left for campus when you've expressed is that, do you literally put the bottle or do you put the container in?

Interviewee:
So I just put the bottle in. Yeah, yeah. For me, I would rather it look very obvious.

Interviewer:
Yeah. No, I wasn't sure if they like if it was in a lunch box type thing... okay.

- Shame/stigma
- Cleaning
- Storage
- Generally noteworthy
- Time/routine
- Facilities

Summary of key findings

Lack of facilities to clean bottles and parts between uses when at work.

Sterilising bottles and pump parts is part of the morning routine

Mixes body temp milk with cold milk for ease of storage + avoiding the need for multiple bottles/ containers

‘You end up carrying a lot of stuff’ - could the need for any of these items be eliminated to reduce the amount of stuff?

How could this cooler be used if she didn’t have access to a fridge?

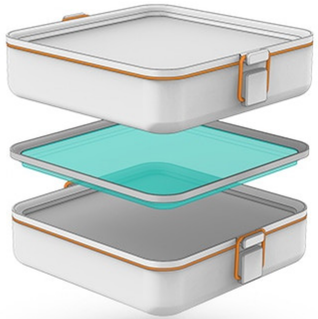
Cooler works well for one bottle, what if there are more?

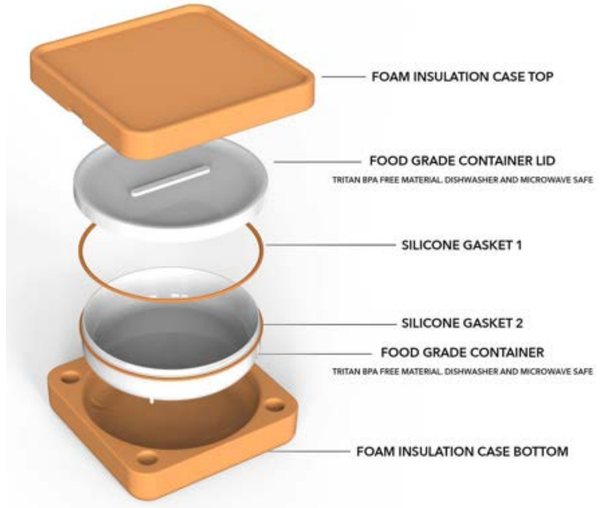
Can an insulated container degrade over time? Need to research this further

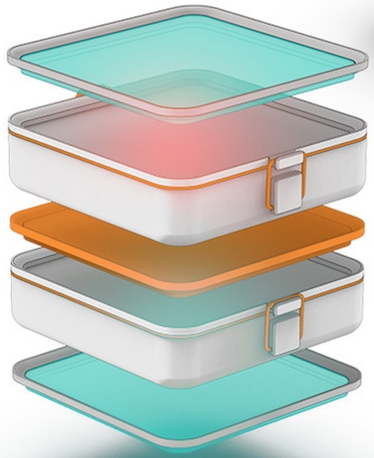
Milk has leaked in the bag in the past if it’s not stored upright, gets smelly and the waste of breast milk that took a lot of time and energy to get is a big shame.

Modular Lunchbox Research
Development

These cover the entire surface and can be placed between compartments when you need maximum efficiency. One placed between compartments would keep a cold/ warm temperature for the top and bottom.







Two packs so you can carry **HOT** & **COLD** containers at the same time

Summary of key findings

Material is insulated - not clear to what extent but gel packs provide additional cooling directly next to the container.

Design uses magnets in the mat to hold the containers in place, this is a good idea, could be applied to my design.

Modular boxes allow user to choose how much food they want and stops them having to carry unnecessarily large containers. Only carry what they need. Roll top design gives users flexibility over how much they want to store in the bag.

The boxes for liquids use a screw top to ensure it's watertight.

Expandable Lunchboxes
Development

INSULATED WIPE CLEAN LINING

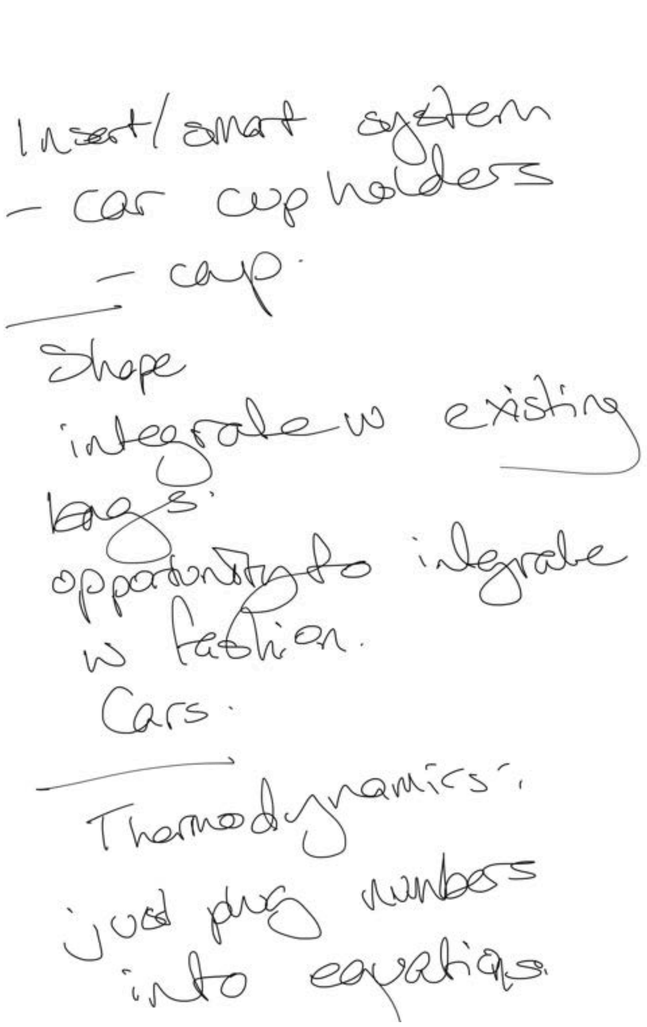
The inner insulating food safe lining will keep the contents of your bag cool (not hot). It is also wipe clean and sealed, so there is no danger of anything from your bag leaking out.

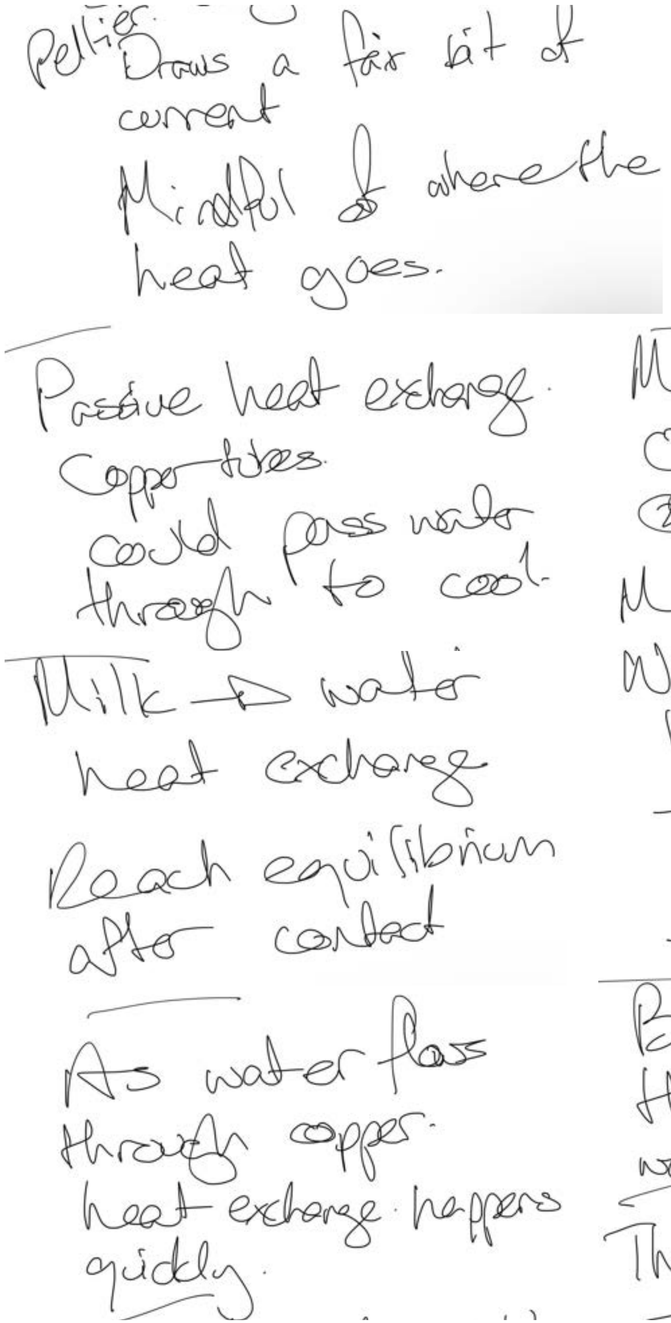
Summary of key findings

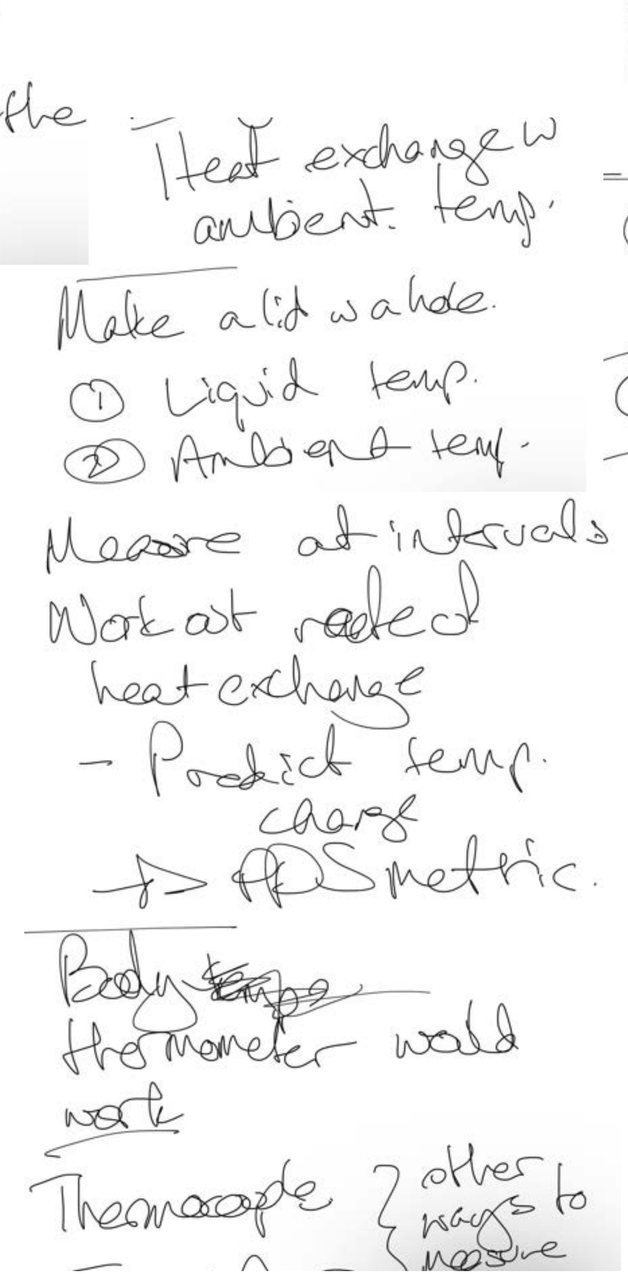
Expandable lunchboxes mostly use additional fabric that can be zipped up, same as an expandable suitcase. **If this additional material is insulated presumably it can be quite bulky when zipped up?**

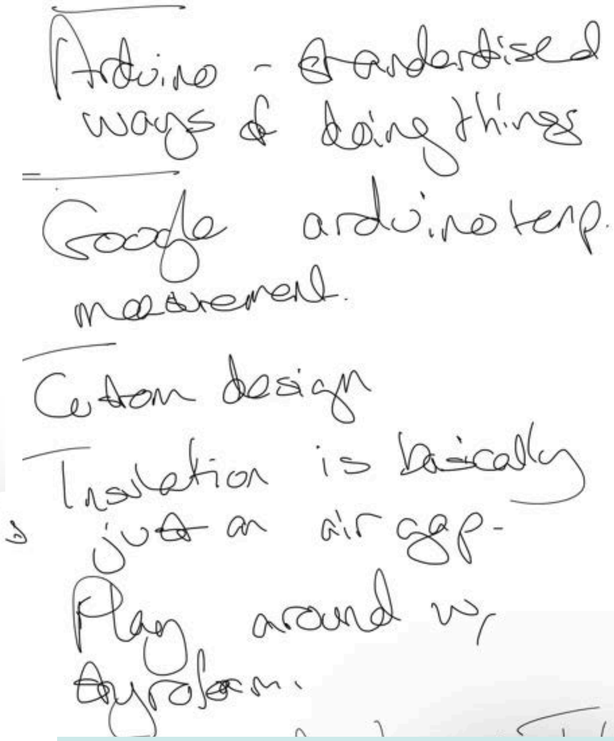
Black + Blum's bag uses a simple roll top - a simpler way to make it expandable maybe? Fewer grooves/folds to collect dirt in too. Clip mechanism is quite satisfying, I like the way it gives users flexibility to carry/clip on to existing bag/ possibly a pram as well?

Week 5 Tutorial
Development









Summary of key findings

I need to do some research to better understand heat exchange and how to enable it to cool the milk down.

There are different ways heat exchange can be achieved, e.g. peltiers or copper stills.

This will also help me understand how to prevent heat exchange once the milk is cooled.

I need to work out reliable and repeatable ways to test the effectiveness of the cooling as well as insulation.

Temperature Sensors
Development

Thermistor

RTD

Thermocouple

Semiconductor

Types of temperature sensor:

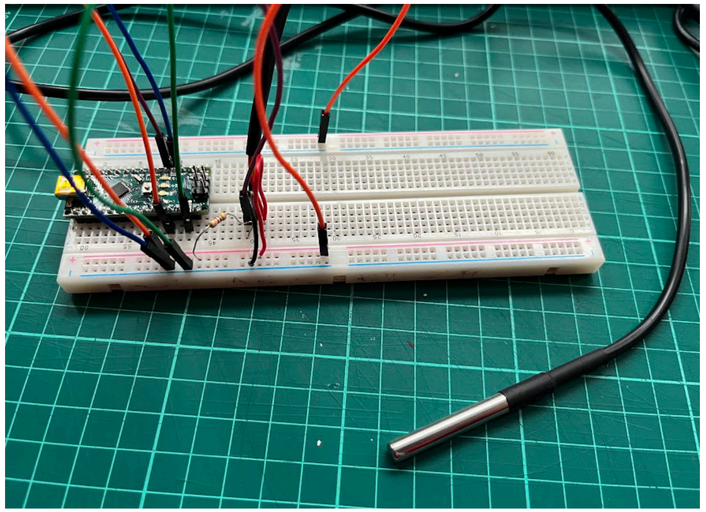
1. Negative Temperature Coefficient (NTC) thermistor
A thermistor is a thermally sensitive resistor that exhibits a continuous, small, incremental change in resistance correlated to variations in temperature. An NTC thermistor provides higher resistance at low temperatures. As temperature increases, the resistance drops incrementally, according to its R-T table. Small changes reflect accurately due to large changes in resistance per °C. The output of an NTC thermistor is non-linear due to its exponential nature; however, it can be linearized based on its application. The effective operating range is -50 to 250 °C for glass encapsulated thermistors or 150°C for standard thermistors.

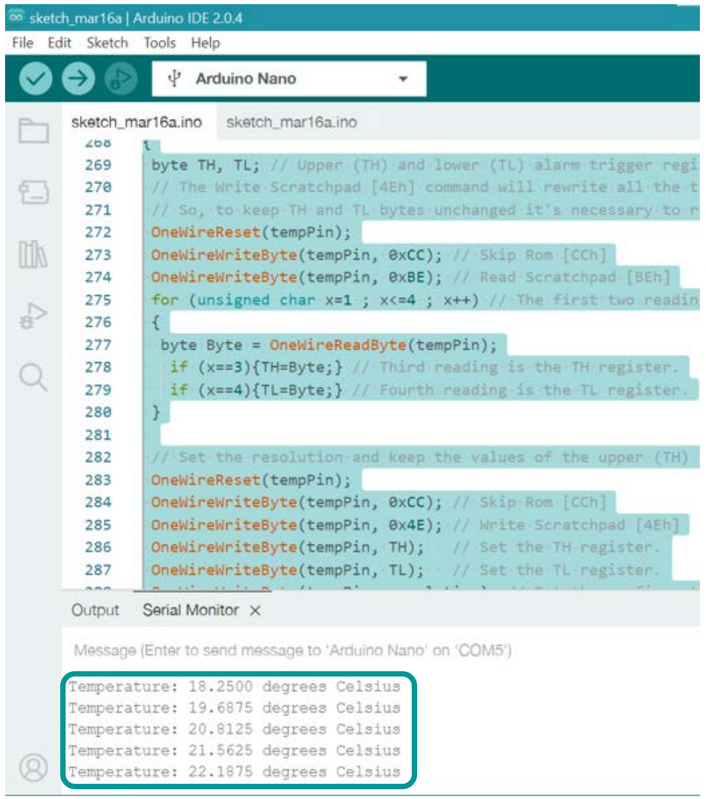
2. Resistance Temperature Detector (RTD)
A resistance temperature detector, or RTD, changes the resistance of the RTD element with temperature. An RTD consists of a film or, for greater accuracy, a wire wrapped around a ceramic or glass core. Platinum makes up the most accurate RTDs while nickel and copper make RTDs that are lower cost; however, nickel and copper are not as stable or repeatable as platinum. Platinum RTDs offer a highly accurate linear output across -200 to 600 °C but are much more expensive than copper or nickel.

3. Thermocouples
A thermocouple consists of two wires of different metals electrically bonded at two points. The varying voltage created between these two dissimilar metals reflects proportional changes in temperature. Thermocouples are nonlinear and require a conversion with a table when used for temperature control and compensation, typically accomplished using a lookup table. Accuracy is low, from 0.5 °C to 5 °C but thermocouples operate across the widest temperature range, from -200 °C to 1750 °C.

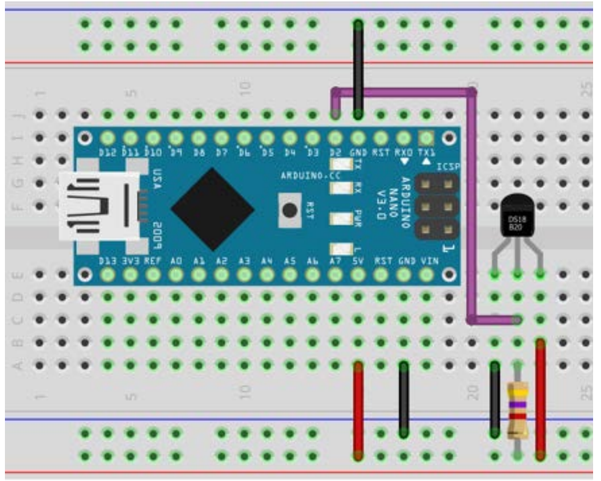
4. Semiconductor-based temperature sensors
A semiconductor-based temperature sensor is usually incorporated into integrated circuits (ICs). These sensors utilize two identical diodes with temperature-sensitive voltage vs current characteristics that are used to monitor changes in temperature. They offer a linear response but have the lowest accuracy of the basic sensor types. These temperature sensors also have the slowest responsiveness across the narrowest temperature range (-70 °C to 150 °C).

https://www.ametherm.com/blog/thermistors/temperature-sensor-types
https://atlas-scientific.com/blog/types-of-temperature-sensors/





Testing a temperature sensor I have from a previous project:



Circuit diagram and code used from Ferraz, n.d.

Summary of key findings

Testing the DS18B20 temperature probe was successful, I was able to successfully measure the temperature and observe changes in the temperature when the probe was at ambient temperature and then when I held it in my hand.

The sensor I use in my actual project will need to be different, however, as using the probe in a container of breast milk would raise significant hygiene issues and risk spillage as the lid then wouldn't be able to shut.

A lot of the temperature sensors available have a huge temperature range, however my product would only need to measure between 0 and 40°C.

Previous Student's Work
Development

Empowering people who rely on refrigerated medications

Many people live with a medical condition requiring treatments that must be kept cold for them to remain effective. Individuals with these conditions are left feeling like prisoners of their own medication as requiring access to a fridge limits their spontaneity, holiday options and other unplanned events.

As a system, the product looks to keep users drugs at the correct temperature wherever they are. (2-8)

Looked into different ways to things cold. Peltiers seemed like the most obvious one from a sort of portable product perspective but they've got a lot of drawbacks; they're power hungry. Issuing them with a certain amount of power is difficult. All the other methods of keeping things cool had drawbacks than peltiers, however.

The user would put medications into a flexible zipped storage pouch in the middle. Allows users to put a different variety of different medications in it rather than a rigid fridge. Also had a bit more sort of tactility behind it to make it nicer to travel around with.

Half of the issue is removing the heat from the internal cavity, using whatever method you use, and then the other challenge is keeping the heat from getting back into it. So you know, looking at different types of insulation. The foil insulation I was trying to use on the inside of it. Because I was quite constrained with a flexible pouch, I ended up using a mixture of Thinsulate, which is a 3M product that's actually used for like, you know, like clothing basically, and a bubble foil insulation.

I think if I was to do it again, I probably would have just gone with a rigid, you know like PU foam or something like that, cause the K value of the insulation is a lot better. And of course like the more insulation you can put into it, the less harder your refrigeration system has to work to keep the heat out. And the longer the batteries last and et cetera, et cetera. But that was the insulation side of things. The peltiers are actually reasonably simple, um in how they work, obviously, and I had stacked them so that you've got two peltiers here.

So the main efficiency improvement that you can make with the Peltier is how quickly you can remove heat from the hot side. So once you apply a current to it. It sucks heat away from the cold side and moves it to the hot side and the more efficiently that you can remove the heat from the hot side with a big heat sink then the better it will perform overall.

And then on top of the peltiers slat this big sort of heat sink. I tried to sort of integrate it into the actual form factor of the product. So you basically had the medications being stored centrally, with the cooling system on the right side of it. Which included most of it of the volume in there was just a big heat sink, which I'd made in the workshop. I think out of bits of aluminum and stuff stacked together.

These little copper washers in between, which sort of transmitted the heat, I did some like thermal imaging testing on it. And you could tell that it really wasn't very good at transferring the heat compared to a normal like a PC CPU cooler, which has instead of having copper washers in between the layer or the fins of the heat sink, it's got heat pipe which is basically like a sealed piece of copper with substrate in the middle of it, which is like it's usually acetone. So what happens is that as one end of the heat pipe heats up. The acetone will evaporate and then move to the other side, so it's a really efficient way of moving the heat from the hot surface of the Peltier up through the fins of the heat sink.

You'll probably be pretty constrained as to what you can find that will fit in the size of your actual thing, which is why I went down the route of this form factor. None of the PC cooling things will ever fit in this, so let's try and make my own one which consisted of, yeah. A bunch of uh sheet aluminium uh which I then stamped out on the guillotine in the workshop and then stacked it up with copper washers in between and thermal paste, and then basically just put bolts through the entire thing and try and squish it all together.

This is my functional, uh, sort of rig here so you can see that the bolts running through the through the heat sink. And the fan mounts either side of it to try and force air through the heat sink, just like you were to cool a PC... They were, uh, centrifugal blowers. And so obviously instead, normally you have like a a standard axial fan which moves air through it. This one sort of sucks in and forces it through sideways, if that makes sense.

What I didn't know and probably would have done if I was gonna optimize this a bit further. Was only actually put one fan on one side. It sort of makes made sense in my mind to put more fans and then it will work better, but actually in fact the air flow path from the two fans were sort of opposing each other and didn't work that well. I think the the other thing that I probably would have done is to actually make the fins of the heat sink thinner. I probably would have tried to do something thinner to to make it to make basically to stop the air flow obstruction through the through the fins.

But I think I managed to get it down to a temperature drop of about 12 degrees or 14 degrees [from ambient temperature] Yeah, so I managed to get it down from 25 ish to about 12 so it sort of worked. But it I suppose it was just a more a proof of principle rig to show that it worked in this slightly weird form factor that I was trying to chase.

Previous Student's Work
Development

And then the power delivery system. I've done quite a few little calculations on what a typical battery life could look like in a in a little portable device, and it didn't look that great. It was, you know, it was like a couple of hours or something at best case scenario, but I sort of tried to enrich that narrative by saying, well, you could like plug in little phone battery charger things (power banks) to try and extend the range.

I tried to get around it by saying if you were on, if you're in a car, then you could plug it into the, you know, into the cigarette lighter thing, or there's often USB power things in a car. If you were in airports and stuff like that, they usually have plug sockets and stuff around that you could boost it before you get on the flight.

And then the other use case that I found when I was talking to people was when they've got to their destination and they wanna keep their drugs cold, then they often have to either book into more expensive hotels that have a fridge in the room or try and organize the hotel to store it in one of their fridges. And this was a proposition that you could turn up to a hotel room, plug it into the socket and have a dedicated space for storing medications at a set temperature.

The screen displayed the temperature, but I think I was shooting for like, the current temperature, the ambient temperature and the battery life remaining. Just some simple stuff I didn't really want it to connect to an app. Just as an extra like thing to faff around with, I just wanted like the a simple readout of 'is my medication cold? Yes/no. How long is it gonna last?'.

Instead of getting the medications out the fridge, putting it into the pouch and then turning it on. It's gonna use quite a lot of energy to get it down to 5 degrees C in the 1st place, but if you could literally just like an oven timer, if you could delay the time by, you know 8 hours or something. It would pre-chill over the entire device when it's still plugged in, and then you could transfer the medication into it and then you know, buck off to your flight or train or whatever. So that was another thing that was like, oh, you could use three buttons to do that. I'm sure you could. So I just saw slap three buttons on it. So yeah, that was that was the sort of reason behind that. But that main side obviously had the screen. Which was a dot matrix LED screen because those were sort of trendy at the time. Uhm, it had the batteries in it, which was largely what that volume on the left hand side was taken up by.

I had decided to go with a PID controller, which will limit the power to the Peltier. In order to achieve that range of between 4 and 8. You can either use, the crude way of saying it is a 'Bang Bang' thermostat. So it literally will either turn on or off it will it will say 'is the temperature within the set range? No' turn on Max Power and then cut off when it does reach that and then when it creeps up above, uh, whatever it was before degrees, It'll turn back on again. The other, slightly more intelligent way of doing it is PID control or potential difference, which is when it will limit the power to the Peltier. To basically like a Max power to reduce it down and then sort of trickle feeder where it's in that nice range of between two and four degrees.

Carried an egg on a flight to do some empathy testing. So it was nothing necessarily about having to keep a medication within the correct temperature is more like the context of. What I was doing and how I was feeling throughout that entire process, so I'd gone away and I've talked to a couple of people who had already struggled to manage their medications. You know, on flights, on long periods of travel. And I'd ask them how they did it. One person said that they got a a vacuum flask and they put the medications in it and they put some ice in it and then they went on a flight. And then another person did something very similar, they got one of those like cool pack lunch box thing. Put a freezer ice pack in it and then you know, went on the train.

And I was like, yeah, I was trying to do some empathy testing and think, how could I put myself in someone else's shoes to see what it's like to carry this, that, you know, on a journey and stuff. So I thought that I'd bring an egg with me because it was something that is reasonably fragile. I used the put it in a lunchbox method and add an ice pack and in the in the bag as well. I had a temperature data logger which is just like a little USB thermometer. Which takes readings every five seconds of the temperature of the ambient temperature. Obviously it was in the bag, so it would track the ambient temperature of the bag.

Yeah, temperature data logger is really useful for any sort of temperature controlled thing.
You just pop it into any. Yeah, I use it on the my final prototype and stuff. He just popped it into the compartment and it. They're not very expensive, they like £20 or something and it gives you a graph reading of temperature over time, which was really useful. Um and yeah, I basically tried that. There was sort of a couple of data outputs from it. One was the temperature data, which basically proved that these existing methods that people were using wasn't at all suitable for keeping things within a four, two to four degree temperature range. So it's sort of able to disprove that pretty quickly.

And then secondly. I was jotting down at every point in the journey what I was doing, how I was feeling and what I was thinking it. But yeah, it ended up being quite pretty useful like. A lot, a lot of the things. That I was trying like targeting online forums, interviewing people. I wasn't really getting a sense for how they were actually feeling, you know, I could, I could take direct quotes and indirect quotes and stuff from them, but it wasn't the most useful thing. And so I decided to, yeah, to, do the egg test.

So yeah, I think my actual device probably ended up being not very easy to clean. I was sort of saying well, you could put, you know, put a cloth for some disinfectant in it and then clean it that way, but going around, it was like, as long as it doesn't get too gross, then that's fine because a lot of the medications come prepackaged in sterile packaging.

Wrapping fabric and soft textiles around any product is always difficult. What I'd basically done is the fabric layers which can like the flexible layers which consisted of the two layers of insulation and then like a topping fabric.

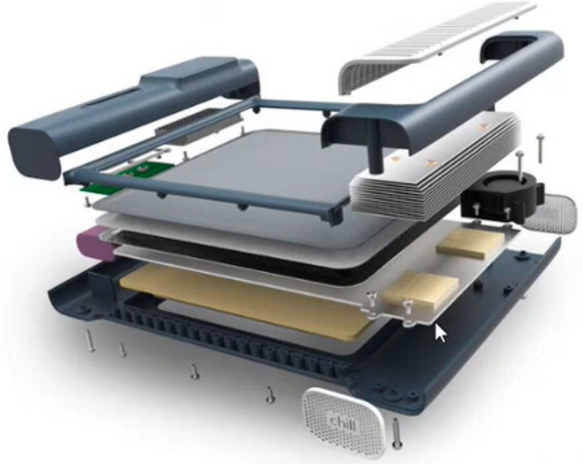
I'd stitch that together right on the edge. So that was one piece. And then the way that I'd done the CAD and split the parts out, it was basically clamped in place. And so this top part had enough screw bosses on it so that it would clamp around the the fabric when you clamp those two parts together. Yeah, that was something that just required a little bit of prototyping beforehand, just like quick laser cut mock ups to be like, oh, I need this many screw bosses around the outside to make sure the fabric doesn't look crap. I ended up making this weird like clamping system thing. Which wasn't really that useful to be honest, but it did give me a sort of this cool, like subside pattern view. Which was based on a Herman Miller chair. I like the way that they're fabric could interfaced with the like solid plastic frame.

Previous Student's Work
Development

The only thing that I maybe would have done differently, especially in maybe a slightly less critical use case was to look at like other forms of pass more passive cooling. Like ice blocks and stuff. There were quite a lot of slightly more low tech versions UM, I mean basically when I finish this project. **I've done the rough BoM costs and stuff and I was like no one is ever gonna be able to buy this thing because it's gonna be so ludicrously expensive.**

I tried to then justify it by saying that a lot of the medications that need to be refrigerated are often like. Incredibly expensive, you know upwards of like £5000 per dose for some of the like really critical genetic biologic drugs. It was more the value that it would provide to a healthcare provider like the NHS or a private healthcare client if they gave this to the customers. Then they would stop, they would stop their drugs from going bad and then they wouldn't have to waste these really expensive drugs.

So that was the way that I basically tried to justify it, but I think If I was going for a more accessible solution, I definitely go down the. You know, put something in the freezer, be it like an ice block. There were quite a few things that I researched that were nice, like gel packs that would release the that would absorb the heat slowly compared to just a block of ice.



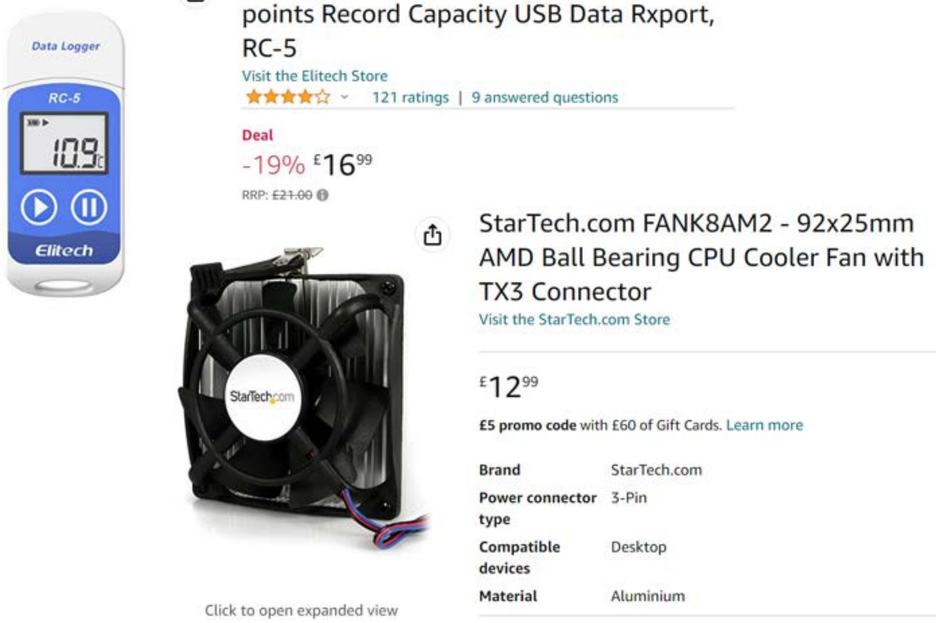
And that you could keep, you know, multiple ones of these in the freezer. And then put it into a compartment inside the device that would then keep it cold for if not a longer period of time than a battery could keep a Peltier cold for. Uh, and then embed some sort of other electronic intelligence that would basically just give you a readout of the temperature or something they like inside there were these really nifty little devices that I came across.

I can't remember what they're called, but they were like it was basically just like a little connected thermometer for your fridge. And the diabetes patients use to keep their insulin levels or, sorry, their insulin storage in check. So it's like this really nice little compact thing that connected to your phone and you put in your fridge and it just told you at what temperature that's specific compartment of your fridge would be so a lot, a lot low tech but actually probably higher value to the people that would need to use it because you know an ice pack and a thermometer.

Inside a device that actually is well insulated and can keep the thing cold is probably gonna be a lot cheaper than something that has batteries and peltiers and PID controllers and all that in it. And again that was, hat actually came from an, that design approach came from an insight during the egg testing.

When I was on the road and I had the ice pack and the temperature data logger and the egg in the cool box, but I didn't know what temperature it was at. And I was like, well, how the **** do I know? What if I am storing it correctly, and what I tend to do is open up and check the thermometer reading and then put it back. And then that lets all the heat in. So you know, actually, if I was able to read that directly through a an outside screen on my phone or something like that, then it probably would have kept a decent temperature so. I think that was a if it was gonna do it again, that would probably be a different approach to go down that I would chase.

It also gives you a bit more freedom with the design as to what you could do, you know cause the more low tech solution can take on a much larger range of form factors compared to something that has Peltiers and batteries and all that stuff in it.



Summary of key findings

Insulation is really key, more rigid materials are more effective at insulating. Fabric allows for more flexibility for the user but restricts insulation material choice and can be awkward to interface with hard plastic parts.

I've ordered a temperature data logger to allow me to do some testing, will look into the fridge thermometer for diabetics mentioned as well.

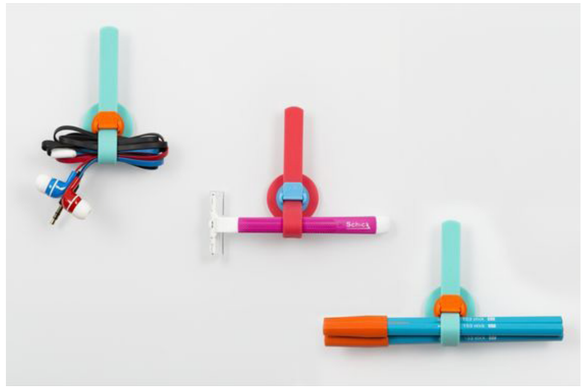
Would be beneficial to use a bought-in cooler fan/heatsink combination and design the form around this to ensure the heat is dissipated away as efficiently as possible

Ensuring transparency and providing clarity to the user is important to prevent them worrying and feeling a need to open the container and check the milk's temperature (and consequently let heat in)

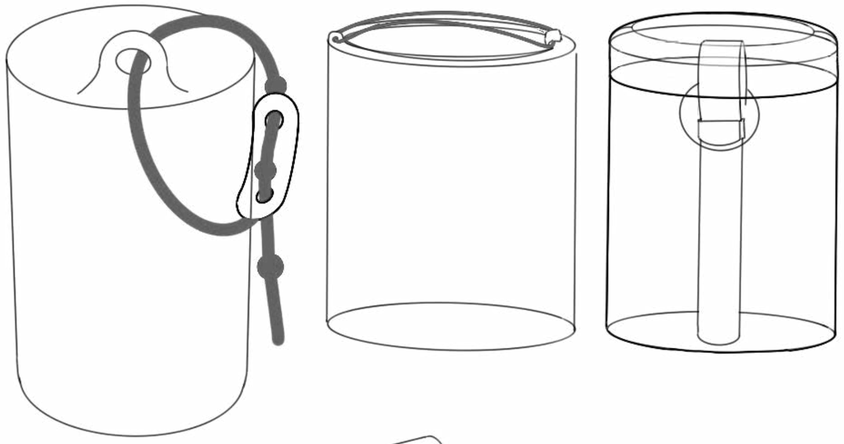
I'll need to think carefully about the cost of the technology used to ensure the design isn't so expensive it's inaccessible for most people.

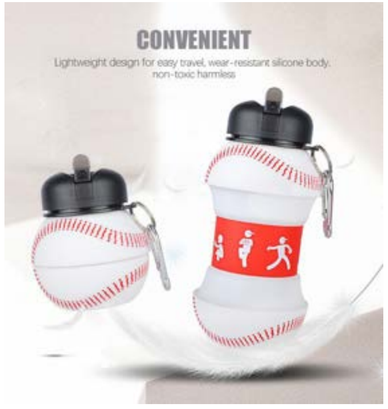
I need to make sure my design can be cleaned, need to work out how to do this - could I have two parts, one soft fabric one that can be washed, and one hard one containing the tech that can be wiped clean?

Clips and Loops
Development



Straps and carabiners
Development



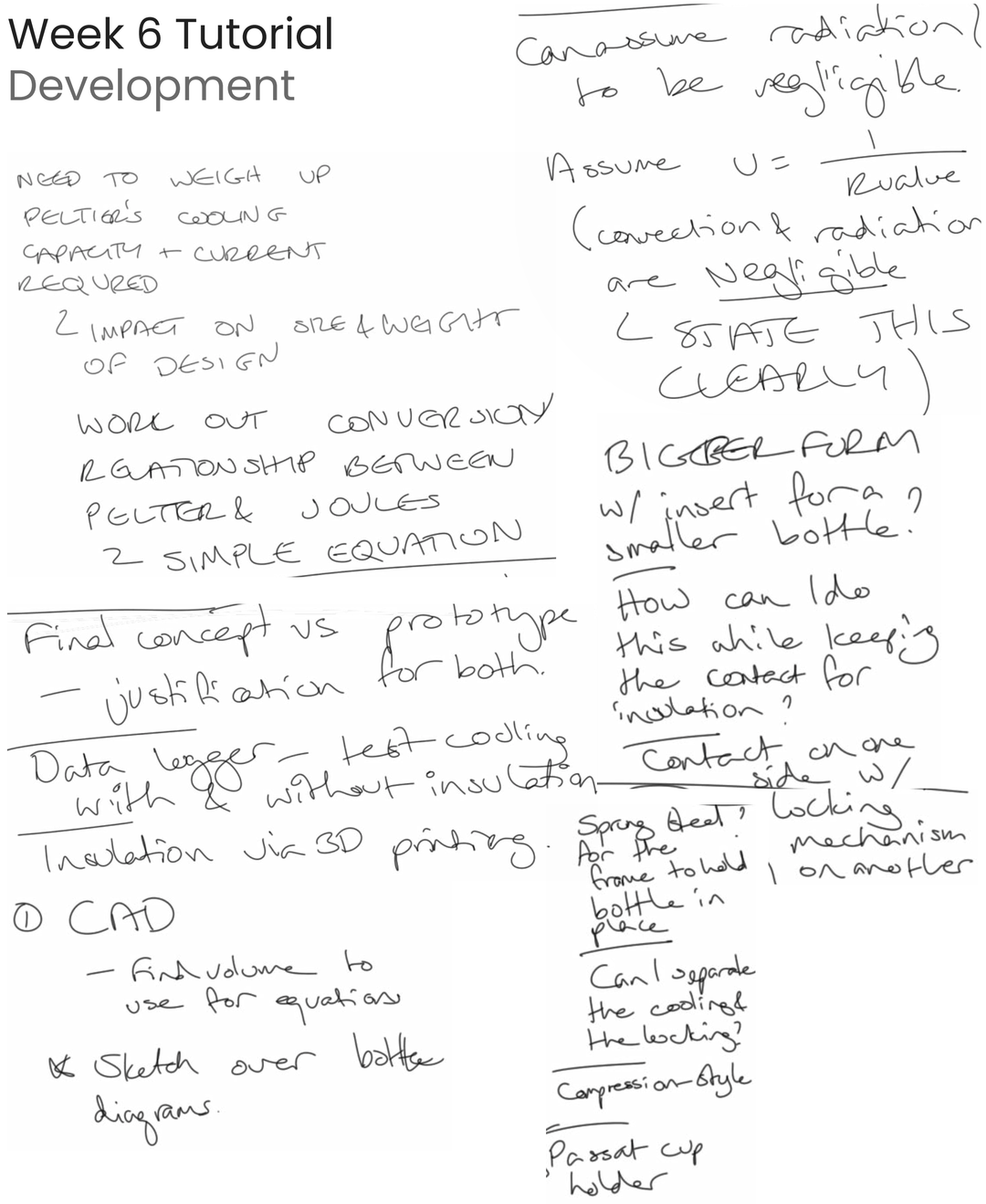


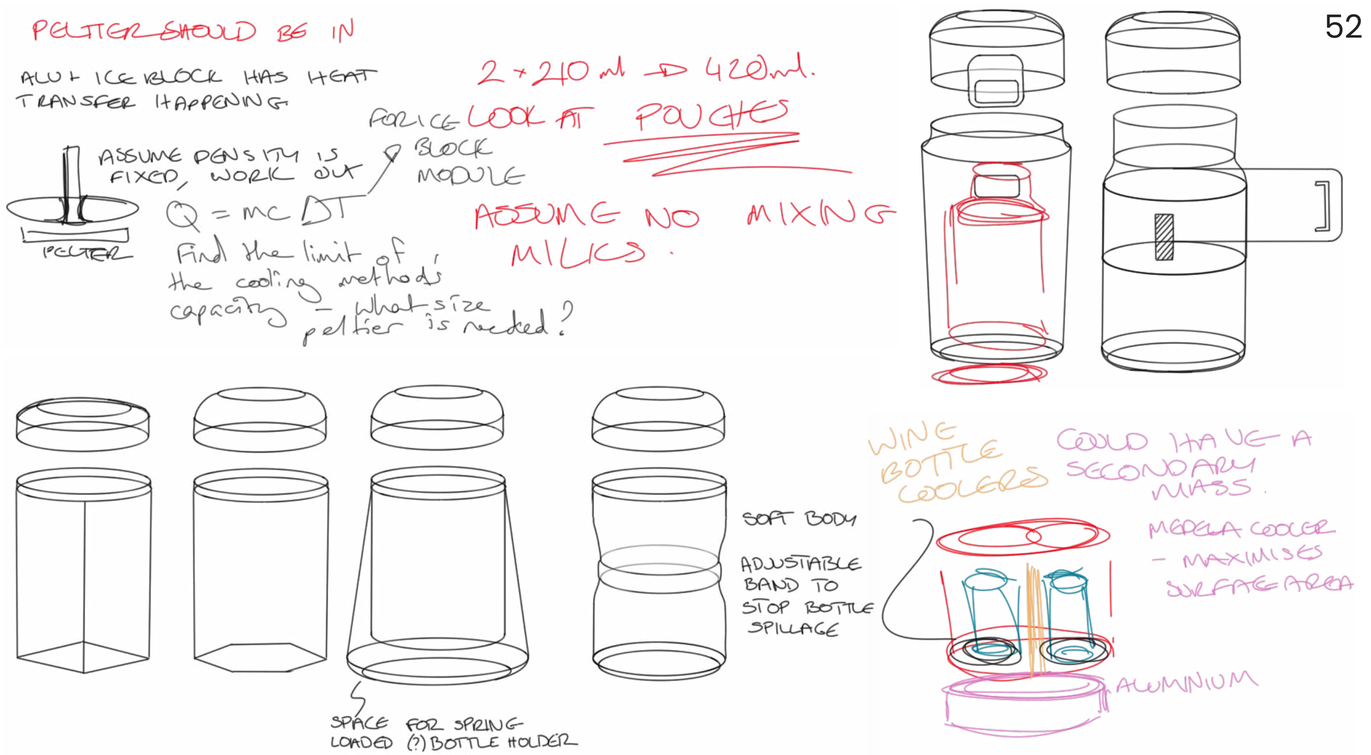
Summary of key findings

It was helpful to look at the types of loops, straps and fixings used on similar products, as well as products with different applications. I want my strap to be universal and let the user use it in different ways and at different lengths.

It also shouldn't get in the way, or have excessive nooks and crannies that could collect dirt and require additional effort from the user to clean.

Week 6 Tutorial
Development





Summary of key findings

Need to maximise contact between bottles and the peltier/ice pack/conductive material. Peltier would be best placed at the base to guarantee contact (as opposed to having the peltier in the lid) to maximise conduction. Will need to work out air flow to remove heat from the warm side of the peltier though to allow the product to be placed on a surface yet still get air flow.

I'll likely need another body, made of a conductive material or ice block, to sit inbetween bottles to maximise the surface area in contact with the bottles to allow for heat transfer.

I had initially wanted to avoid the use of an ice pack as this is something else for a busy mum to remember, however this may be a more effective way to keep things cool based on the power requirements of peltiers, which increase with the peltier's size.

I'll assume up to 420ml of milk will be cooled/carried in this device (based on the requirements shown on p.118 - a baby will have 210ml 5x per day, two of those feeds would be during an 8-hour work day), which could require it to hold 2-3 bottles, depending on bottle capacity.

Need to explore ways of keeping the bottle(s) upright and in place that has a universal fit, exploring cup holders in cars could be helpful.

Testing Tommee Tippee Bottle Bag
Development

Test conducted by placing a Tommee Tippee bottle containing 150ml of water in the fridge overnight (after which the temperature measured at 8.1°C) and then in the cooler alongside the temperature data logger.

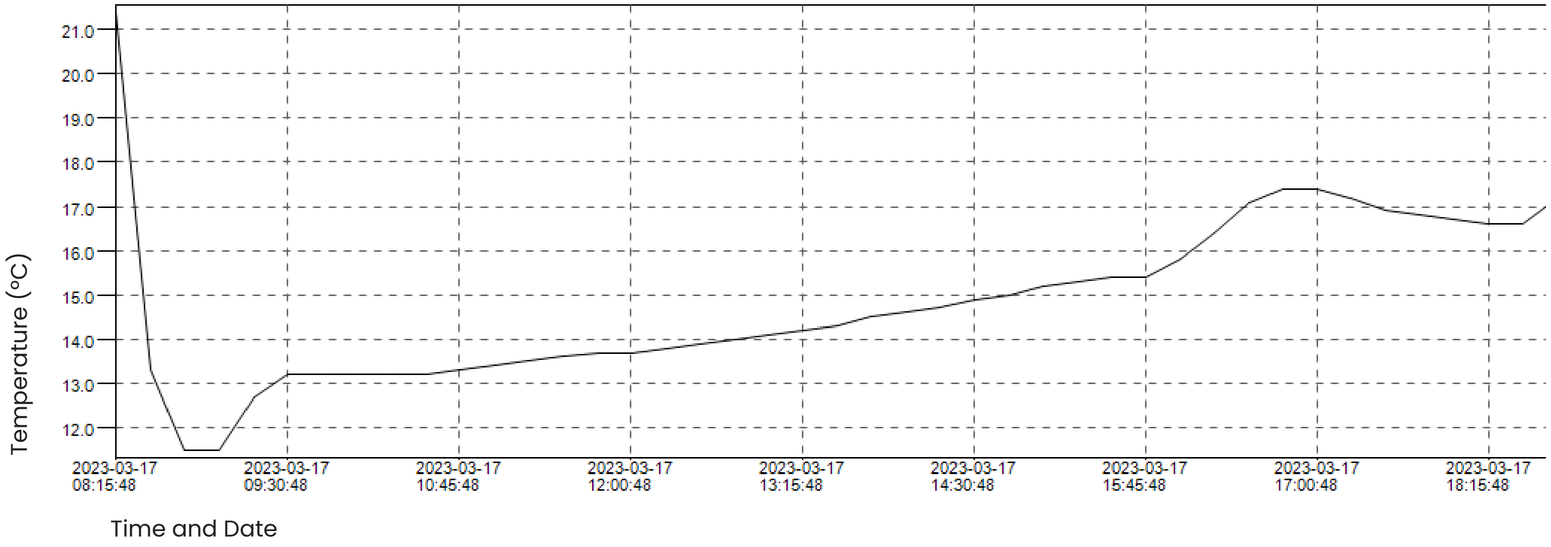
The logger was placed at the bottom of the bag to ensure constant contact with the bottle. The graph of the results is shown below.

A borrowed Tommee Tippee insulated bottle bag. Has had milk spilt on it which has soaked into the neoprene outer.

The insulated/water resistant inner lining has a few folds where milk can gather too, this is awkward to clean and could get smelly if milk leaks in it. This was also mentioned as a downside in reviews I read of the product.

The label states the bag is hand wash only, which makes it even more of a faff for a mother.

Temperature of a bottle of chilled water inside the insulated bag over a period of 10 hours:



Summary of key findings

The data logger took a temperature reading every 15 minutes, which doesn't allow for very fair analysis. It appears to have only kept the bottle cold for around 45 minutes before the temperature started slowly creeping up. This matches what was mentioned in reviews of the product.

It would probably be good to repeat the experiment, with the bottle at a colder starting temperature (perhaps 2-4°C), and readings taken at more regular intervals.

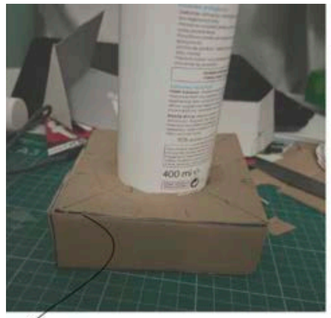
The bag is not designed with mess/cleaning in mind, as the black neoprene makes spilt milk very obvious and the interior is difficult to clean due to the creases in the silver fabric. However the bag is still popular amongst mothers due to its portability and the velcro strap, according to online reviews.

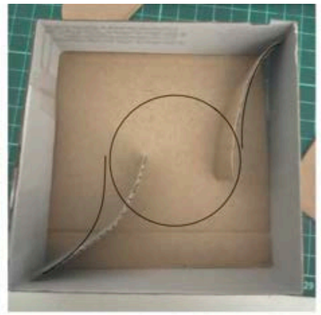
My product needs to ensure more effective insulating, without sacrificing too much of the portability of this Tommee Tippee bag. As my product offers the additional function of cooling milk without a fridge, a bigger size can be justified.

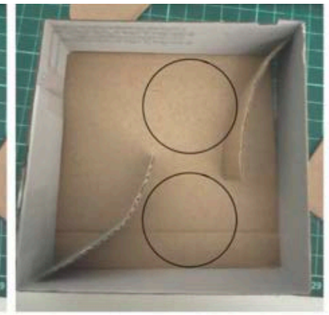
Prototyping Plan
Development

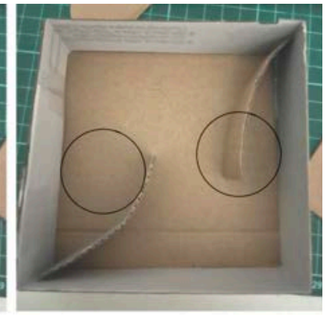
Week	What's being tested?	Key question/learning point	How will it be tested/evaluated?	What do I need?	Who will it be evaluated by?	Are there any risks?
6	Insulating materials	What materials provide the best insulation? How long are existing insulating containers effective for?	Placing a container of fridge temperature water/milk in an insulated bag and measuring the temperature over a period of X hours	Cool bags Thermometer/temperature data logger Container of water (need to research how the c-value compares to milk, may need to use milk for testing)	Me	No
	Tommee Tippee insulated bag	How effective is the bag at insulating?	Placing a bottle of fridge temperature water in the bag alongside a data logger.	Tommee Tippee bag, bottle of water, temperature data logger	Me	No
	Peltier functionality	How long does it take to cool milk from body temperature to fridge temperature using a Peltier?	Placing a peltier phone cooler on a bottle of body temperature water and measuring the temperature change.	Peltier phone cooler Insulated bag?	Me	No
	Peltier functionality	What battery capacity is required to power a peltier to cool milk to fridge temperature?	Maths and physics calculations	To know the quantity of water, power of the peltier, how long it would take to cool the water	Me	No
7	Circuitry	How can I use arduino to measure the temperature of a liquid?	Building a circuit with an arduino and a temperature probe	Arduino Temperature sensor	Me	No
	Control loop mechanism	Can I use a PID to make an effective control loop mechanism?	Online research and speaking to technicians	N/A	Me	No
	Sizing & universality	How can I make the product fit multiple bottles without risk of spillage?	Cardboard models	Cardboard	Me	No
	Expandability	Can I make the product expandable while ensuring it's not unnecessarily large if only carrying one bottle?	Sketching and cardboard models	Cardboard	Me	No

Cup Holder Research
Development

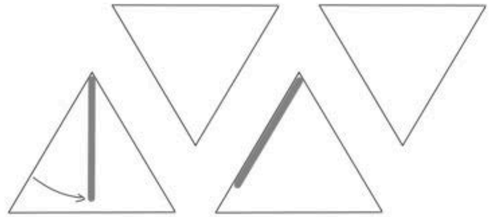








FLEXIBLE SILICONE



Summary of key findings

Cup holders ensure a (more or less) universal fit using flexible plastics that are smaller than the cup space and flex to accommodate a cup, while still providing enough resistance to hold it in place.

The cup holder style that would work with the largest range of bottle sizes is the kind that has a flexible/ spring loaded flap.

Incorporating something like this in a contained cylindrical shape might make it difficult to use though, as depending on the shape of the bottle used, the user would have to pry it open to be able to put a bottle in.

An option that's easier to use is a silicone skirt with cutouts to allow it to flex, however this could be more difficult to clean.

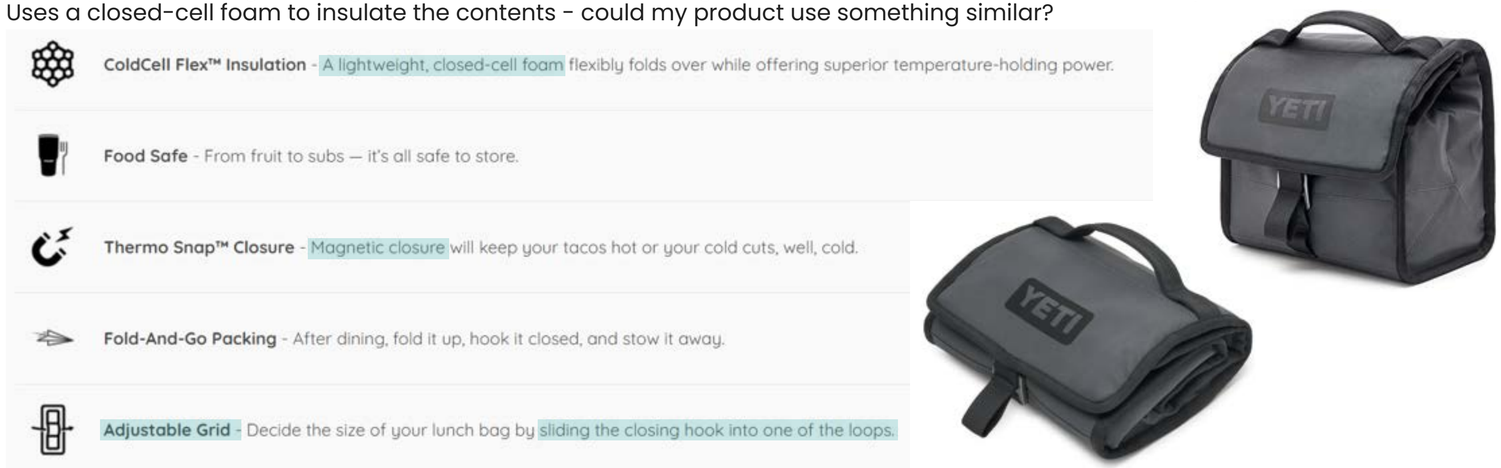
Insulation Materials Development

The higher the R-value, the more thermal resistance the material has and therefore the **better its insulating properties**.

The lower the U-value is, the **better the material is as a heat insulator**.

Material	Thickness	Insulation Properties	Cost	Cost per m^2	Supplier	Lead Time
Yuzet Triplex Laminate bubble insulation foil	5mm	R-value: 0.88 m^2K/W U-value: 1.136 W/m^2K	£9.99 for 1.2x1m	£8.33	EBay	4 days
3M™ Thinsulate™ CS150	11mm	R-value: 1.7 m^2K/W U-value: 0.29 W/m^2K	£12.60 for 1x1.5m	£8.40	profabrics.co.uk	3 days
Nomex Thermal Insulating Sheet	0.13mm	U-value: 0.139 W/m^2K	£26.43 for 304mm x 200mm	£434.7	RS Components	7 days
General Purpose ThermaWrap Insulation	3.5mm	R-value: 1.47 m^2K/W U-value: 0.68 W/m^2K	£19.99 for 600mmx7.5m	£4.44	Tool Station	2 days
Insul-Shine	3mm	Not provided	£5.25 for 0.55x1m	£9.55	Amazon	5 days
K-Flex Closed-cell foam	6mm	λ=0.033-0.035, therefore U=5.67 W/m^2K	Waiting on quote		Encon	
K-Flex nitrile rubber Closed-cell foam	10mm	U-value: 3.4 W/m^2K	£26.27 for 1x1m (+shipping)	£26.27	Buy Insulation Online	
ArmaGel DT aerogel insulation blanket	5mm	λ=0.02, therefore R=0.25 and U=4	Waiting on quote		Encon	

YETI Daytrip lunch bag - the highest rated insulated lunch bag, keeps ice frozen for 24 hours and is waterproof and leakproof. Uses a closed-cell foam to insulate the contents - could my product use something similar?



The R-value is a measure of resistance to heat flow through a given thickness of material. So the higher the R-value, the more thermal resistance the material has and therefore the better its insulating properties.

The R-value is calculated by using the formula: $R=l/\lambda$

Where:

- l is the thickness of the material in metres
- λ is the thermal conductivity in W/mK.

The R-value is measured in metres squared Kelvin per Watt (m^2K/W)

Heat transfer occurs in several different ways and an R-value only takes into account conduction. It does not include either convection or radiation.

The U value is the inverse of the total thermal resistance of that element. The U-value is the most accurate way to judge a material's insulating ability. It is a measure of how much heat is lost through a given thickness of a particular material, but includes the three major ways in which heat loss occurs – conduction, convection and radiation. The lower the U-value is, the better the material is as a heat insulator.

This is calculated by taking the reciprocal of the R-Value and then adding convection and radiation heat losses, as follows:

U = 1/(R+ convection heat losses + radiation heat losses)

Units are in Watts per metre squared Kelvin (W/m^2K). (The Green Age, n.d.)

Summary of key findings

Different units are used to indicate insulation. Two main ones are R- and U-values. In order to allow me to compare ratings, I've assumed convection and radiation to be negligible, and therefore a material's U-value to be the inverse of its R-value.

Not many of the materials meant to be used as fabrics for sewing have actual ratings or metrics for their insulating properties, making it hard to compare. The majority of insulating materials are meant for home insulation so come in large quantities which would be very expensive for my application.

Using two layers of insulation for my product could be a safe bet, e.g. through one later of Thinsulate and one layer of Thermawrap, as these two can be obtained relatively easily and affordably and have good insulation properties. This would allow me to double up on the insulation and take advantage of the properties of both in terms of preventing all three methods of heat exchange.

Foldable products
Development

Summary of key findings

I collected images of various products I could think of that folded up flat to see if I could take inspiration from their folding mechanisms.

The IKEA boxes and glasses case in particular were helpful to consider as they both have flaps/panels that hold the product's shape when it's opened up.

This helped me think about how my product could fold, either for storage or to reduce the size to hold smaller or fewer bottles.

Cooling Methods
Testing

Cooling 150ml water from 37°C in a household fridge (tested using a thermometer probe in the bottle): Cooled by 30° in 2 hours 20 minutes

Cooling 150ml water from 37°C using a Peltier phone cooler at room temperature: Cooled by 21.5° in 4 hours 24 minutes.

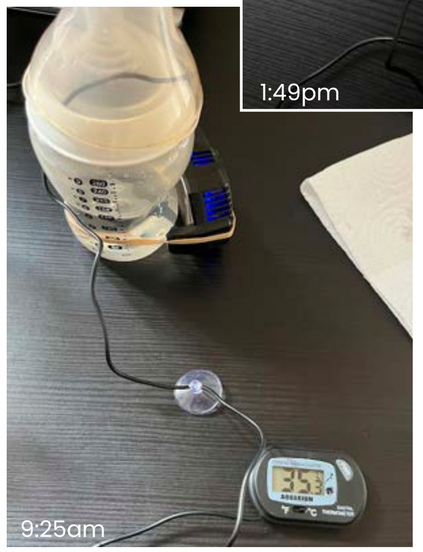
(I had to leave before it cooled to fridge temperature)

Limitations of the peltier experiment:

• Due to the shape of the Timmee Tippee bottle it was impossible to ensure a good amount of contact between the peltier and the bottle

• Experiment was completed in a room of around 16°C, should ideally have been conduced in an insulated environment but this would have been difficult without shoving the peltier module into the bag and cutting off its air supply

• Would need to measure how long a bottle takes to cool from 37°C to room temperature if left out without any intervention - use these findings to allow for a fair comparison



Product used by diabetics who need a reliable fridge temperature to store insulin:

Keep your appliances at the perfect temperature at all times with the Hygiplas alarmed fridge freezer thermometer. Designed with flashing LEDs that alert when the temperature falls outside of a set range, the thermometer ensures your appliances are storing your food safely and hygienically. Made with a one metre probe cable, the thermometer unit can be stored outside of any appliance, allowing you to ascertain the internal temperature quickly and easily. Boasting a large, easy-to-read display, the thermometer is also incredibly simple to use, making it easy for you to keep your kitchen running hygienically. This thermometer features a temperature range from -50°C to +70°C.

Product features:
• Dimensions: 5 1/3(W)x 1(L)"/ 135 x 26mm
• Power Type: 1 x AAA
• Temperature Range: -50°C to +70°C
• Weight: 80g
• High and low temperature alarm, pre-set refrigerator or freezer alarm ranges
• Easily mounted outside freezers, fridges or display cabinets
• Probe cable: 1m
• Flashing LEDs give visual alarm

Summary of key findings

Could I put the bottle in the Tommee Tippee bag upside down and then place it on top of the peltier? This might be a good way to keep the bottle insulated and in contact with the peltier but keep the air flow to the peltier to allow it to cool the hot side?

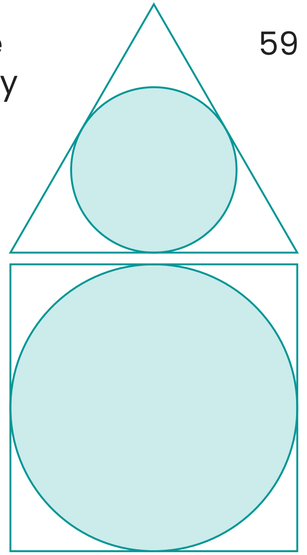
Or would this prevent evaporation/heat transfer??

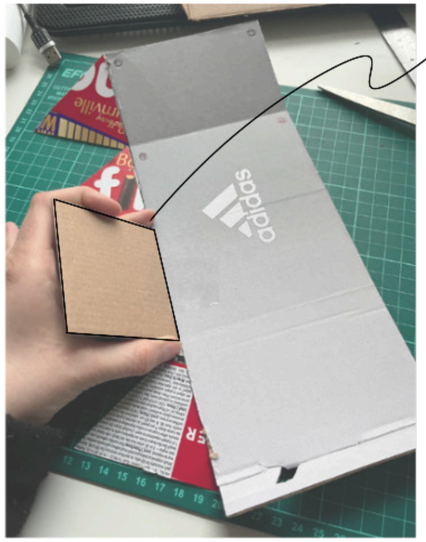
The peltier phone cooler is powered by a USB cable - USB 2.0 delivers 5V at 500 mA, for a total power output of 2.5 watts, while USB 3.0can provide up to 900mA or 0.9A, which translates into 4.5 watts. Could my product have its cooling ability 'topped up' by plugging it into a laptop?

Could my product utilise some features of the diabetic fridge thermometer/alarm to monitor the temperature and alert user when required?

Card modeling
Testing

Square base can fit a bottle of a diameter approximately 73% larger than a triangle with the same side length:

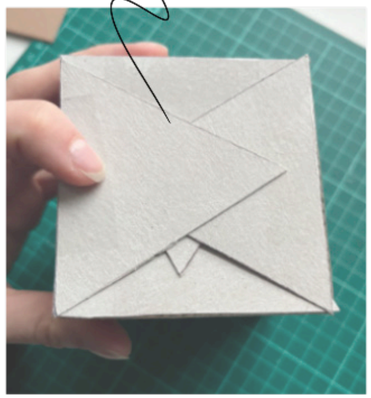


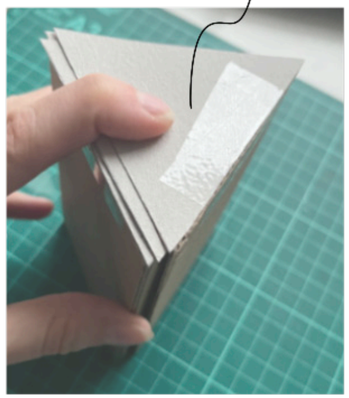


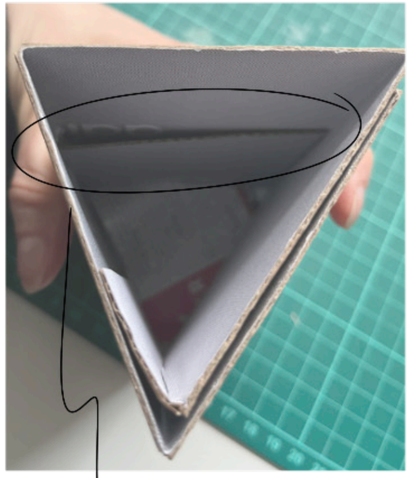
SOLID BASE/FLAP FLAPS DOWN & FORMS A BASE - LIKE IN IKEA BOXES

MAGNETIC SNAP FIT ON TRIANGULAR FLAPS

SLIGHTLY AWKWARD TO FOLD IN - BUT MAGNETS WOULD AID THIS

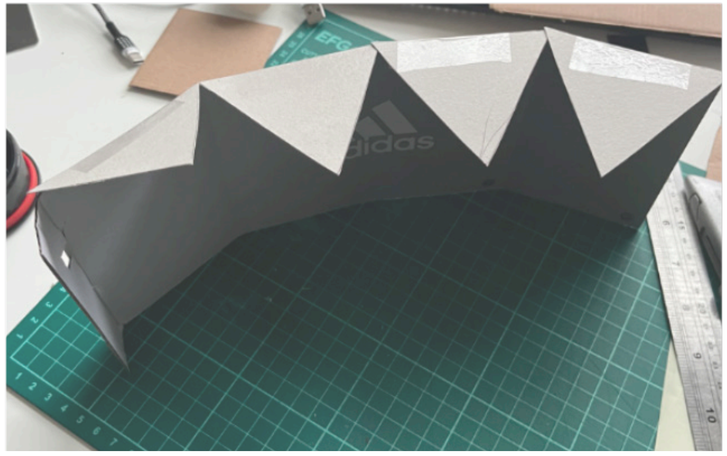


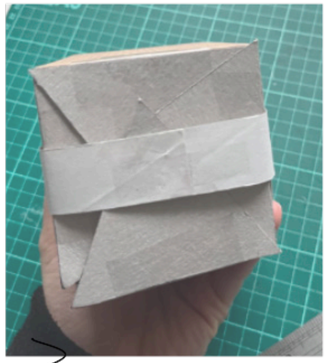




CLIPS TO SIDE IN TRIANGLE MODE

FOLDS DOWN IN SQUARE MODE





STRAP TO HOLD EVERYTHING TOGETHER

Summary of key findings

The option to switch between a triangular and square form gives the user flexibility to use bottles of different diameters and therefore brands. Ensures a snug fit to prevent bottles tipping over inside the bag (potential for milk to leak if the whole bag is turned is still there however...).

Is it worth the faff for the user to switch between the two forms when any bottle size could fit in the larger/more capacious configuration?

What if they want to carry multiple bottles?

Could the product be designed to fit multiple bottles, with the option for an extra bottle not being used for breast milk be filled with ice and also placed in the bag to facilitate cooling? Would this add value or just unnecessary weight?

Week 7 Tutorial
Development

Bespoke insulating solution is best
- potential + innovation

New solutions/ new applications of new existing solutions.

Balancing insulation with other properties??

Air is free
3D printing samples
2 Gyroid infill could use others.

3D printable test structures.

Universal jig for different ϕ materials

Sandwiched materials
Container w/ multiple

Layers to test materials
2 boxes, one inside another.

Test my own solutions rather than existing products

IKEA containers.

Distinguish between insulation & cooling.
2 should be tested separately.

Currently Peltier is only form of cooling

Higher mass = LONGER to cool

Why and how
- Eg. using metal plate to conduct cooling.

Material doesn't have to be all-or-nothing

Why and how
- Eg. using metal plate to conduct cooling.

Material doesn't have to be all-or-nothing

Bag + external form
- how it could clip

What is the advantage of modular folding?

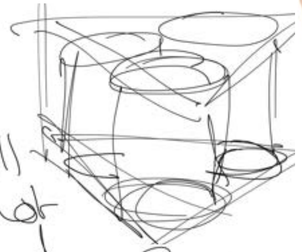
Doubled up insulation?

Cylindrical?

Snap shut?

Like bracelets/ children's rings

Box that collapses in



Reused bottle full of ice not very good.

Picnic bags w/ sections?
elastic straps.

Heat sink used in fridge to speed up cooling.

Summary of key findings

Looking at existing products isn't overly helpful, I should be focusing on my product and how I can make it innovative, through using a bespoke insulating solution or using existing technologies in a new way.

I'll need to make sure to distinguish between the insulation and the cooling aspects of my design, and test them independently.

I also need to take care not to neglect the aesthetics of the design in favour of its functionality, need to work on these concurrently.

Having an expandable form by which the material is 'doubled-up' when in the un-expanded configuration could work, as the insulation properties would be increased through a double layer of material.

Insulated Bag Development
Development of Functionality

Medela Cooler Bag

4.6 (62)

Medela's Cooler Bag is perfect for safely transporting breast milk to and from work and day care while keeping it cool.

£26.99
VAT included
Item in stock

Add to basket

★★★★★ · 3 years ago
Perfect pumping cooler

[This review was collected as part of a promotion.] This was a great addition to my pumping kit. Great to transport breast milk when out and about as well as for storing milk that is expressed on the go. The curved ice block keeps bottles colder for longer. Can fit four 150ml bottles but loses half a point as it dies not fit the 250ml size.

★★★★☆ · 7 years ago
Good value product

Great product for storing expressed milk and keeping it cool. Just wish it was big enough to fit the bottles in with calma teats already attached rather than having to carry them separately

★★★★★ · 2 years ago
Best cooler bag

[This review was collected as part of a promotion.] This is the best cooler bag around, the ice pack hugs the bottles and they remain cool all day. Since they are all snug, the items inside don't slide and move as you lug it around all day. You can also just use 2 bottles, and use the empty space to put in your pump parts so they remain cool as well and save you trips to the office fridge.

★★★★★ · 6 years ago
Love medela!

[This review was collected as part of a promotion.] This is perfect for keeping breast milk cool on the go! I love that it has a ice pack and holds 4 bottles perfectly for upto eight hours. Medela products are by far the best and never fail to deliver brilliant designs with great quality every time. A little overpriced but you get what you pay for. Definitely recommend this cooler bag!

★★★★★ · 7 years ago
Fabulous product. Ideal for working moms who do not have access to a fridge to store expressed milk.

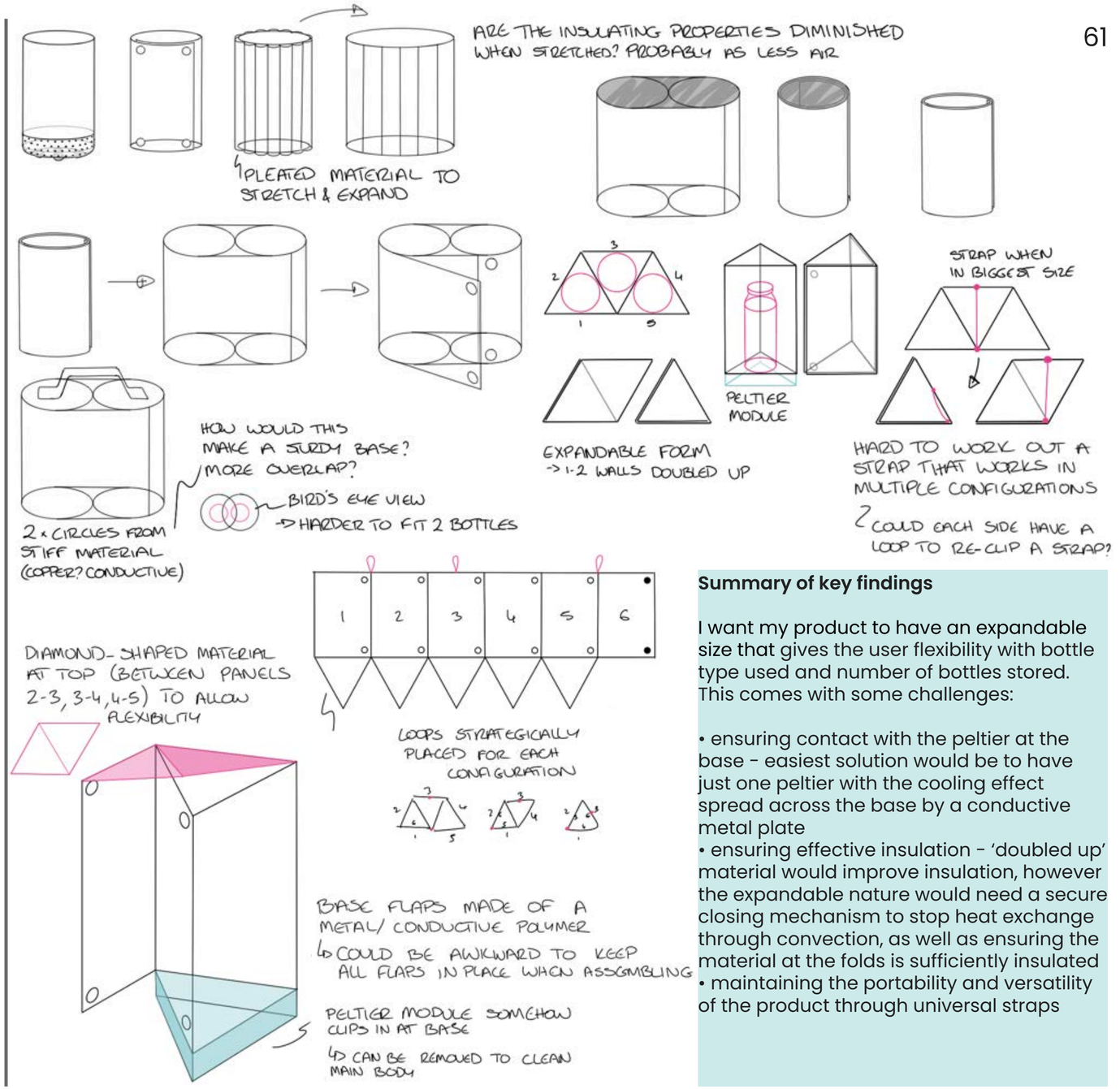
I purchased this before my return to work as a method of keeping expressed milk cool until I got home. It works a treat. I leave the house at 7am and do not return to 5:30 and my milk is still refrigerator cool when I get in. The ice pack itself is curved to fit around the bottles. You could fit four 5oz bottles in. Would highly recommend to moms who do not have refrigerator access or just want to store their milk with their own things for hygiene/ safety purposes.

Summary of key findings

This is one of the most popular and highest-rated coolers available and is specifically designed for breast milk and for use with Medela bottles (which it comes with).

Reviewers report 8-11 hours reliable cooling.

A commonly reported downside was the lack of flexibility to store bottles with teats on or larger bottles (i.e. height restriction). One user mentioned only storing two bottles in it and using the other half to keep pump parts cold and therefore sterile. It would be good if my design could give users this flexibility.



Summary of key findings

I want my product to have an expandable size that gives the user flexibility with bottle type used and number of bottles stored. This comes with some challenges:

- ensuring contact with the peltier at the base - easiest solution would be to have just one peltier with the cooling effect spread across the base by a conductive metal plate
- ensuring effective insulation - 'doubled up' material would improve insulation, however the expandable nature would need a secure closing mechanism to stop heat exchange through convection, as well as ensuring the material at the folds is sufficiently insulated
- maintaining the portability and versatility of the product through universal straps

Prototyping Plan
Development

Week	What's being tested?	Key question/learning point	How will it be tested/evaluated?	What do I need?	Who will it be evaluated by?	Are there any risks?
Easter 1	Insulating materials	How can I set up a rig to test the insulating properties of materials?	Using two plastic IKEA containers with an insulating material sandwiched inbetween. Ice placed in the inner container and the time it stays cold for measured using a data logger.	Plastic containers, insulating material, temperature data logger	Me	No
	Product form and fit	What are the minimum dimensions I can make my product to ensure universal fit?	Cardboard modelling		Me	No
Easter 2	Component and material dimensions and fit	How thick can I make the walls of my material while making sure the design works?	CAD		Me	No
		How can I fit the peltier, heat sink and fan in the available space?	CAD		Me	No
	Expandable mechanism		Sketching and cardboard modelling		Me	No
					Me	No
Easter 3						
Easter 4						

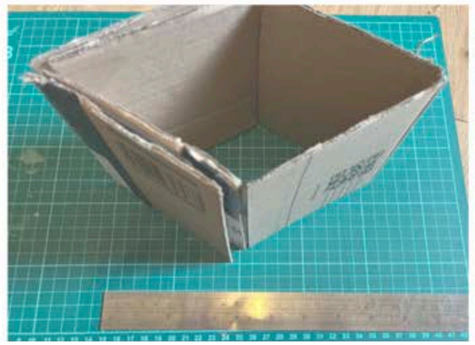
Cardboard Modelling Development

5x EQUAL PANELS MAKE EITHER A SQUARE OR EQUILATERAL TRIANGLE

TWO BOTTLES COULD ONLY FIT VIA THIS 'DIAMOND' CONFIGURATION

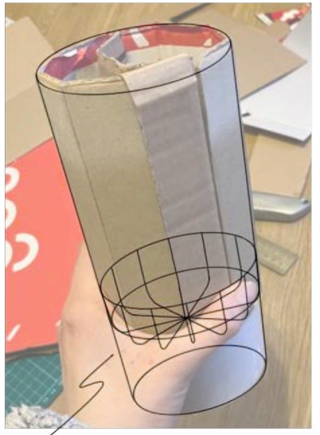
→ A BIT AWKWARD IN REALITY

LARGER BOTTLE ONLY JUST FITS - WOULD NEED TO BE BIGGER



YETI BAG USES AN ADJUSTABLE HOOK & LOOP SYSTEM - COULD I DO SOMETHING SIMILAR?

WHAT ADVANTAGES WOULD THIS HAVE OVER VELCRO?

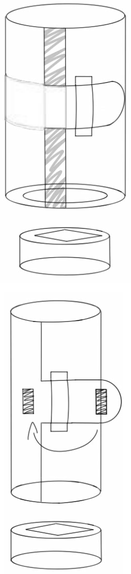


ROLL OF TAPE REPRESENTS PELTIER MODULE

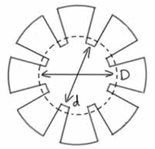
FLAPS FOLD UP AT LARGER DIAMETER - BUT STILL WORK IN SMALLER DIAMETER

SMALLER DIAMETER FIXED TO PELTIER BASE

ALUMINIUM/COPPER BASE CONDUCTS COLD



WOULD NEED TO FIND A WAY TO DEAL WITH EXCESS LENGTH – VELCRO?

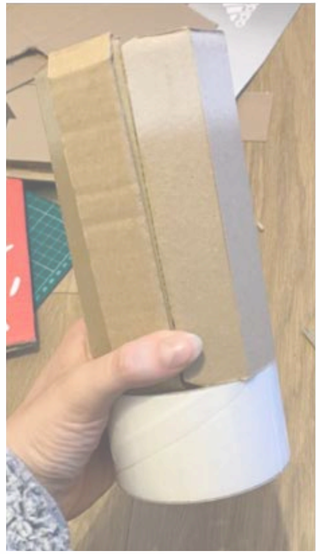


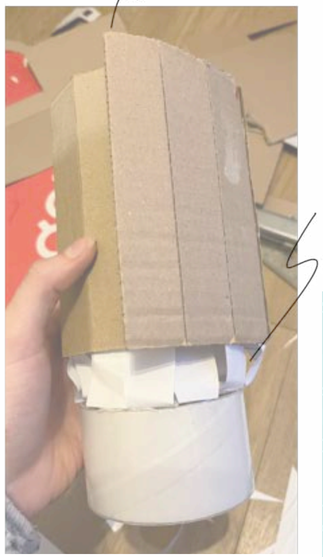
STRAP AFFIXED DIFFERENTLY MEANS WIDTH ISN'T COMPROMISED

IF STRAP IS FIXED HERE, SOME OF THE BODY HAS TO BE NARROWER → NOT PRACTICAL

CARRYING STRAP DOUBLES AS A LOOP TO ADJUST SIZE?

ADJUSTABLE SIZE
→ BUT NEED TO WORK OUT HOW TO INSULATE TOP & BOTTOM





DOESN'T REALLY WORK - GETS MESSY & CREATES GAPS WHEN EXPANDED

Summary of key findings

KEY DECISION: My product will work with one singular bottle, as more than this is not feasible. If larger bottles are used, this can contain around 260ml of breast milk.

After cooling, the bottle could then be moved to another insulated container to allow a second bottle to be cooled.

Need to work out how to keep the top and bottom insulated while keeping the form expandable.

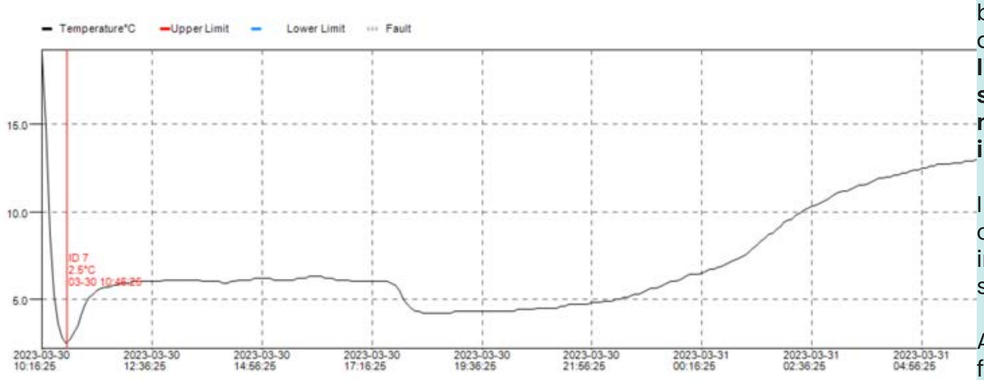
Insulation Testing
Development of Functionality

Setup: 2x IKEA tupperware containers were used in two different sizes. The larger was lined with material from an insulated shopping bag, while the inner had 150ml of water poured into it and frozen.

The experiment was conducted at an ambient temperature of 15.1°C.

Temperature data logger wrapped in a ziploc bag as it's not waterproof - **Would this have added additional insulation, skewing the temperature readings?**

A plastic lid was placed on the smaller inner container, with a layer of the insulating material placed over the top and secured with a rubber band.



Summary of key findings

Need to measure gap between both boxes

The contents of the container remained at an appropriate temperature for over 13 hours which meets my requirements.

The thick air gap between the boxes, however, likely won't be feasible in my design as it would be bulky and limit the design's flexibility - **Could my design be inflatable? Possibly like inflatable protective sleeves placed on bottles during shipping. This would allow the design to be less bulky when not in use and could easily be inflated, using air as an insulator.**

I was using ice as a starting point based on tests I read of coolers on the market, however a more accurate test may involve liquid at fridge temperature and seeing how long it stays at that temperature.

Ambient temperature when conducting this experiment was fairly low at 15°C, temperature would generally be higher than this at 18-21°C.

Peltier Exploration
Development of Functionality

Pre-assembled Peltier & heatsink assembly:

The Peltier Module is 40mm x 40mm

The aluminum plate is 40mm x 60mm

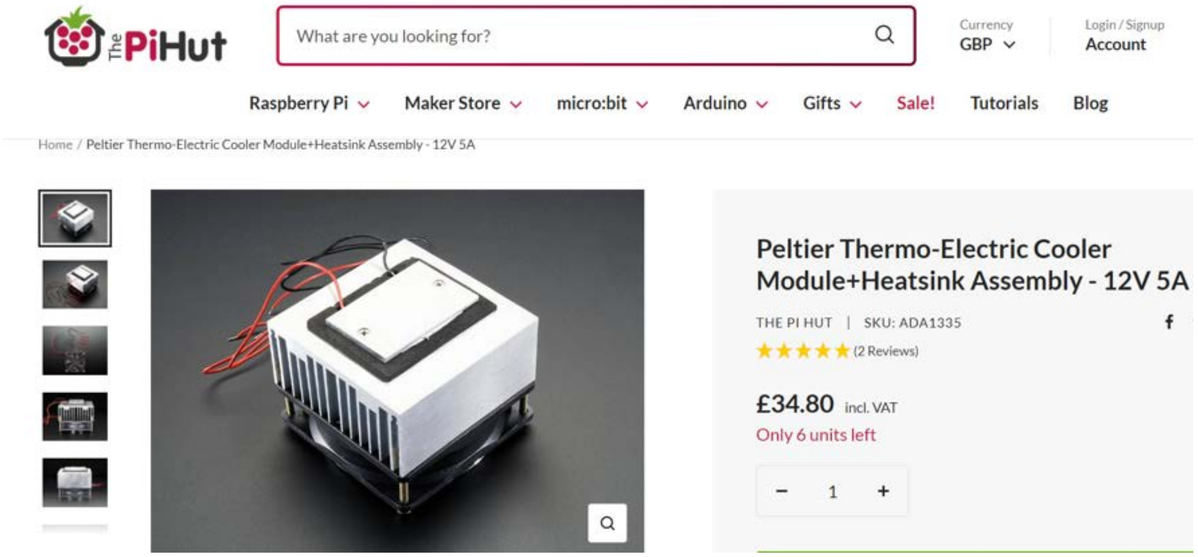
The heat-sink is 90mm x 90mm

The whole assembly is approximately 78mm

Wire Length: 280mm

Weight: 455g

Wattage: 60W nominal (12V * 5A), 72W max



Cooling 420ml from 37°C to 4°C:

Q = mcΔT

$\Delta T = T-T_1$

ΔT = 37-4

ΔT = 33°C

'The density of human milk is approximately 1.03 g/ml' (Neville et al., 1988; Woolridge et al., 1985). This matches up when compared with the density of cow's milk, which fluctuates between 1.025 to 1.035 g/cm^3 (Parmar et al, 2020).

Therefore 420ml of breast milk would weigh 432.6 grams.

m=432.6 grams

m=0.4326 kg

Using c=3840J/kgC;

Q= 0.4326*3840*33

Q= 54819.072J

Q=54.819kJ

~~If transferring this much heat energy to the milk for an hour (1W = 1 J/s):~~

~~W=54,819*3,600~~

~~W= 197348659.2~~

~~W= 197.3 MW~~

~~If using 12V power supply, this requires a current of 16,441,666.67A~~

~~16,441,666.67A=16.442MA~~

If transferring this much heat energy to the milk for an hour (1W = 1 J/s):

W=54,819/3,600

W= 15.2275

Watts = Amps x Volts

If using 12V power supply, this requires a current of 1.27A

Summary of key findings

Getting confused by the physics - I know the energy required to change the temperature in Joules. If the cooling time is extended does this mean the wattage is reduced??

'A joule of energy is defined as the energy expended by one ampere at one volt, moving in one second. Electric current results from the movement of electric charge (electrons) around a circuit, but to move charge from one node to another, voltage is required to create the work to move the charge.' (Electronics Tutorials)

Need to work out how to actually relate my calculations to the requirements of the Peltier modules.

Using this Peltier assembly would add significant cost to the product and also weighs quite a lot - an additional 500g could make a big difference to the desirability and ease of use of the product.

Conversation with my Mum
Development

Looking at products with a rounded form (particularly at the base) to reduce corners/grooves that would collect dirt and be hard to access for cleaning




Insights from the conversation:

There's so much to clean when you have a new baby, she'd be really thankful for something that can be chucked in the dishwasher (or washing machine).

Expressing at work means they could wash the product in the evening when the milk has been moved to the fridge at home.

Seams and zips inevitably lead to creases. Could I use a closing method like zip-loc bags? E.g. reusable silicone bags with a plastic zip.
Could the lid be removable? Look at coats with removable hoods that zip on.

Could it have a silicone lining that could be removed and put in the dishwasher? Silicone is quite floppy, not ideal in the dishwasher as it doesn't always clean reliably. A material similar to outdoor gardening bucket could work. Look at menstrual cup sterilising containers.

Egg-shape wouldn't have any creases, a cylinder shape is a close second.

If the Medela cooler bag had a curved top you'd have more flexibility with bottle sizes/types stored/ type of cap used (e.g. teat or flat lid).





Summary of key findings

A rounded form with a removable lid could be the optimal design in terms of the product getting dirty and cleaning.

The Peltier section would have to be removable to allow for cleaning without any electronics components getting wet (or could it be waterproof?? Even if splash-proof it wouldn't survive a washing machine/dishwasher cycle).

A removable section would be optimal for access to the electronics for repairs/ maintenance/end of life.

Up until this point I'd been imagining the main body as made of a flexible material/fabric to allow for an expandable size. A rigid material, however, is probably more feasible and easier to clean. Could I have a rigid outer body with a removable silicone lining?

Lining Development

Development of Functionality + Interaction

TOO MANY GROOVES & DON'T REALLY HAVE ANY ADVANTAGE

IS THERE ANY ADVANTAGE TO DRAFT ANGLE? PROBS NOT

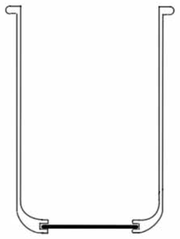
LIP OVER THE TOP MIGHT BE BEST FOR CONTAINING POTENTIAL SPILLAGE

↳ CLAMPED BETWEEN BODY & LID - ACT AS A SEAL GASKET TO MAKE WATERTIGHT

PELTIER & COOLING BITS

COLLAPSIBLE? WOULD ONLY BE USEFUL IF THE WHOLE PRODUCT WERE COLLAPSIBLE

SIMPLE SHAPE WOULD PROBABLY BE BEST FOR CLEANING & MANUFACTURE



SILICONE LINING WOULD INSULATE FROM PELTIER - HOW CAN I AVOID THIS? EMBEDDED CONDUCTIVE PLATE? COPPER MAYBE (DISHWASHER SAFE?? NEED TO LOOK INTO THIS)

CROSS-SECTION OF LINING

BOTTLES ALL HAVE A SLIGHTLY CONCAVE BOTTOM (FOR STRENGTH?)

THIS WOULD REDUCE CONTACT SURFACE W/ PELTIER

COULD THE PLATE AT THE BOTTOM HAVE A LITTLE 'NIPPLE' FOR SURFACE AREA + BOTTLE STABILITY?

Summary of key findings

A removable silicone lining could be a good way to make the product easy to clean as it can simply be taken out and placed in the dishwasher. Also if the product came with a few linings, they could be swapped out and washed e.g. at the end of the week rather than needing to be washed immediately.

This does pose challenges with the Peltier, however, as silicone would act as an insulating layer between the peltier and the milk.

I also realised bottles have a concave base with a dimple in it that means contact with a surface they're on is reduced. One way to work with this is to put a little 'bump' on the base plate.

Need to research into thermal conductive polymers.

Next Steps & Questions to Answer
Development

Area	Questions to answer	Next Steps
Electronics	Is a Peltier (which would work without forward planning, as opposed to an ice pack) worth the added weight, expense, size and power requirements? What exactly are the power requirements? If a temperature monitor is being used, how would I convey the information to users? Is an LCD display enough/would I want a traffic light colour system/alerts sent to a mobile phone?	Speaking to potential users - need to decide questions, get ethics approval and contact some women. **Empathy testing - try carrying round a bag containing a bottle of water and an additional 500g weight to see how much of a difference it makes.** Get help understanding the physics and calculations to have a reliable figure on the power requirements. Research displays to show temperature/different alert mechanisms for if the temperature gets too high.
Materials	Can I justify the use of a harder, less flexible material that would result in a less universal fit? Are thermal conductive polymers a feasible solution to ensure flexibility/ manufacturabilty and What insulating materials am I going ahead with?	Sketching and CAD to explore how a material might have to expand/fold up to accommodate different bottle sizes. Researching conductive polymers
Form	Form is secondary to function for this product however I need to consider what users would like from the form. What aesthetic is desirable to users? Would users like the product to look discreet and make the contents kept incognito.	Sketching potential concepts to get feedback on the form and aesthetics. Speaking to potential users - need to decide questions, get ethics approval and contact some women.
User Interaction	How important is it to be able to use the product without having had remembered to freeze an ice pack and then bring it on the day?	Speaking to potential users - need to decide questions, get ethics approval and contact some women.
Compatibility/ Universality	Which popular bottles have the largest diameter? What is the difference in diameter between the largest and smallest bottles? How can I make the internals of my product hold different sizes snugly?	Revisiting page 39 where I collated dimensions of different bottle brands. Using this data to inform my PDS.
Security/ Spill prevention	Can I realistically make a product that always stays upright to prevent spills? Spills are mainly the fault of the bottle which I am not designing. Could I instead make the product watertight, so any spills don't go beyond the container? How can I make my product as easy to clean as possible?	Ensure ease of cleaning and watertight design are kept as a priority and kept in mind when designing. Research different closure methods that could keep the product watertight.

Summary of key findings

Very helpful to map out my thought process and next steps for the project.

Realised I've been working on the assumption that using an ice pack is a faff and makes existing products harder to use - **need to actually speak to some users and hear their thoughts.**

Need to find relevant facebook groups to speak to potential users.

Also need to consider market and competition when I update my PDS.

Thermal Conductive Polymers
Development

I&EC research
Industrial & Engineering Chemistry Research
pubs.acs.org/IECR

Recent Advances in the Rational Design of Thermal Polymer Co Polymer Composites

Xuhua He and Yuechuan Wang*

The thermal conductivity of polymer-based materials can be enhanced with highly thermally conductive additives, the materials of which are composed of the randomly mixed form. **Unfortunately, the enhancement effectiveness of the additives on the thermal conductivity of polymer composites, including the commercially available thermal grease, thermal pads, adhesives, and phase change materials, is far less than expected**, resulting from the interfacial thermal resistance between the additives and between the polymer matrix and the adjacent additives.

It is now understood that the **high thermal conductivity of the fillers cannot be fully utilized in the polymer composites due to the interfacial thermal resistance**, which is a result of not only scattering across the interface but also the suppression of thermal energy transport channels by the interface. Tremendous efforts have been devoted to improving the thermal conductivity of polymer composites with the consideration of multiple factors, including materials choice, polymer–additive interface, and preconstruction of composite microstructure.

However, a comprehensive quantitative theory of thermal conduction is still lacking and scalable production of rationally designed thermal conductive polymer composites is difficult to achieve. (He and Wang, 2021)

Thermal conductive polymer composites don't work as well as desired nor anticipated. The polymer used as a binding matrix in the composites still has a thermal resistance that has not as of yet been overcome.

Journal of Materials Chemistry C
ROYAL SOCIETY OF CHEMISTRY
REVIEW

Thermally conductive polymer-based composites: fundamentals, progress and flame retardancy/ anti-electromagnetic interference design

You Li, Yongxin Qian, Qinghui Jiang, Abubakar Yakubu Haruna, Yubo Luo* and Junyou Yang*

Recent studies concerning polymer-based composites have been widely reported, but they just focused on strategies for enhancing the thermal conductivity of polymers and did not report on the multifunctional design and strategies for the compatibility of heat conduction and anti-electromagnetic interference, heat conduction and flame retardancy, or even the compatibility of heat conduction, flame retardancy and anti-electromagnetic interference.

Adding high thermally conductive fillers into the organic polymer matrix is the most effective method at present to address the low thermal conductivity of polymers. Therefore, the improvement of the conductivity of polymers depends on thermally conductive fillers. There are three theories to explain the thermal conduction mechanism of polymer-based composites: heat conduction path theory, percolation theory and thermal elasticity coefficient theory.

The development of polymer-based composites with high thermal conductivity, flame retardancy and anti-electromagnetic interference performance is highly desirable for next generation electronic devices. However, there are still some problems to be addressed for thermally conductive polymer-based composites for thermal management in the electronic packaging field. (Li et al, 2022)

This study discusses other properties as well as thermal conductivity. It identifies issues with the development of conductive polymers which are mostly based around the lack of existing models to explain/understand thermal conductivity, chemical design methods, and a lack of sustainable flame retardants. This echoes what the last article mentioned about a lack of understanding of thermal conduction.

Polymer compounds with high thermal conductivity

Cite as: AIP Conference Proceedings **1779**, 030015 (2016); https://doi.org/10.1063/1.4965485
Published Online: 31 October 2016

M. Grundler, T. Derieth and A. Heinzel

The thermal conductivity of commercially available thermally conductive polymer-compounds is usually between 1 W/mK and 20 W/mK which means that they are already 10-100 times higher than the conventional unfilled polymer. During the development at ZBT the values for thermal conductivity of polymer-compounds could be increased to more than 30 W/mK.

In order to achieve such conductivities, the compound materials generally consist of a polymer, which functions as a binding matrix, and a high content (up to 80 wt.%) of conductive filler material. In various series of investigations the thermal conductivity but also the mechanical properties and the processing by extrusion and injection molding of the highly filled materials were evaluated. An orientation of filler particles by injection molding could be observed. Images by scanning-electron-microscopy of injection molded samples showed a structure of anisotropic layers which has a significant influence on the values of thermal conductivity. That's why a differentiation of "through-plane" and "in-plane" thermal conductivity is highly recommended. (Grundler et al, 2016)

Only one test conducted, based on one experimental material - not reliable enough nor available for me to use in my project.

Conductive silicone found on eBay as a conductivity of 6.9 W/mK

Conductivity of Alumnium and Copper are approx. 237 and 413 W/mK respectively.

Summary of key findings

The use of conductive polymers is an exciting prospect that I initially thought might have had a potential application in a removable, washable lining for my product that wouldn't hinder the Peltier's function.

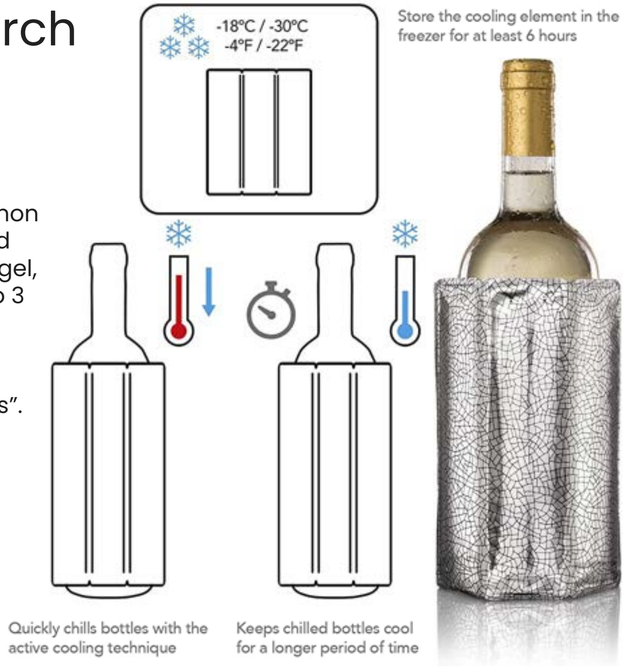
However they are relatively new and haven't been fully developed nor understood. Existing conductive polymers on the market have very poor conductive properties compared to metals. I also haven't been able to find information on whether or not they are food safe or washable as all testing to date has been in different use contexts, so this wouldn't be feasible to use for my application at this point in time.

Wine Cooler Research
Development

Cheap and simple wine cooler - common household item. Flexible shape can fold flat for freezing. Filled with a non-toxic gel, claims to keep a bottle chilled for up to 3 hours.

"Cools any size wine bottle from room temperature to chilled in just 5 minutes".

One of the only products I could find that actually cools the contents, rather than just keeping them cold. Also one of the cheapest options available at between £5-15. Need to research what these coolers are made of to see how I could apply this to my product.



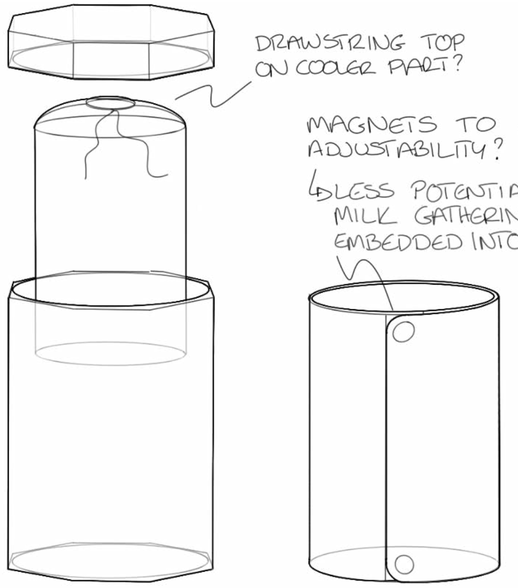
Essentially an insulated case for a wine bottle; "works off the shelf, so all you need to do is grab a cold bottle, put it in your Huski, tighten the lid and you're good to go"

Claims to keep wine chilled for up to 6 hours. Appears quite bulky for something that only insulates, doesn't cool.

One USP of this product is how well it fits around wine bottles (even ones of different heights) and holds them firmly in place. I might be able to achieve something like this using an inflatable lining or elements with springy properties to keep a bottle in place (like cup holders in a car).

Small and easy to store in the freezer ready for use. Stainless steel rod filled with a non-toxic ice gel. Claims to keep wine cool for up to one hour (with the wine initially at fridge temperature.

Having the cooling immersed into the wine maximises the contact surface area therefore improving the cooling, however this approach would not be feasible for my product given the sterilisation requirement for baby feeding products.



2 WIPE-CLEAN ONLY LID? COULD THE TOP STILL DISPLAY TEMP IF STORAGE BIT ADDED? AS WOULD ADD DISTANCE + INCREASE VOLUME

2 OPTIONAL STORAGE SECTION FOR STORING PUMP PARTS → KEEPS THEM COOL → CAN BE REMOVED IF NOT USED TO MAKE PRODUCT SMALLER

COULD THE BASE SCREW ON? & HAVE THE MAIN BODY BE MODULAR CYLINDERS
↳ NEED TO SEE HOW VACUUM FLASKS ARE MADE & IF IT WOULD WORK

MAIN COMPONENTS:

1. RIGID INSULATED OUTER
   - EITHER POLYMER OR STAINLESS STEEL VACUUM
   - IDEALLY DISHWASHER-SAFE
2. FLEXIBLE COOLING LINING
   - REMOVABLE & WASHABLE
   - SOFT & FILLS SPACE TO STOP CONTENTS FROM MOVING (INFLATABLE?)
3. LID
   - DOESN'T NEED TO BE DISHWASHER-SAFE (BUT SHOULD STILL BE SPLASH-PROOF)
   - DISPLAYS TEMP. OF CONTENTS
4. CARRYING STRAP/HANDLE MECHANISM

Summary of key findings

I'm going to focus on developing my product to use a pre-chilled cooling element such as the wine sleeve. Need to work out how I can use this in a way that keeps the bottle snug and has maximum contact surface area.

Could I have a back-up option for if the sleeve is forgotten or if it hasn't been pre-chilled?

Wine and Cool-Pack Research
Development

Wine cooler sleeves were invented to keep individual bottles of wine cold (or to chill down room-temperature wines) without using water. Wine cooler sleeves or iceless wine chillers are typically constructed in one of two following ways:

• A plastic tube with gel ice packs inside the exterior plastic or vinyl sleeve, as in the VacuVin photo to the top right.

• A double walled stainless steel or plastic container where air is used as the insulating layer between the two "walls." (Know Wines, 2020)

The Vacu Vin cooler is a plastic sleeve filled with six compartments of cooling gel. You keep the sleeve in the freezer; when you serve your bottle of wine out of the fridge, place the sleeve around it to keep the bottle from warming up. It works by insulating the bottle from heat, but also by preventing latent heat in the form of humidity from gathering around the bottle.

Vacu Vin have a second cooler product, shown to the right, that combines the flexible cooler sleeve with a hard casing that holds it in place and provides a more luxurious/ pleasant appearance than the cooler sleeve on its own.

This is probably the approach I'd go for with my product to allow me to have a flexible, wrap-around cooler pack inner and a hard, insulated outer. Need to check that having an insulated container wouldn't hinder the cooling.

Le Creuset WA126L-31 Wine Cooler Sleeve

• Claims to keep bottles chilled for hours
• Pierce-resistant nylon construction
• Two inner gel packs for optimal temperature retention

Use of elastic is a good idea to keep a snug fit and ensure contact surface is maintained, would be good to use in my product.

Not much information available online about the contents of wine cooler sleeves so I've been looking at ice/cold packs instead and assumed the contents are the same as reusable ice packs.

Instant cold packs require no freezing and can provide cooling right away. These are typically found in first aid kits and other medical applications, but their chemical composition prevents them from being suitable for food and beverage packaging. Reusable cold packs require time in a freezer in order to provide cooling but are suitable for food and beverage applications, since they lack chemicals. (Global Spec, n.d.)

Reusable ice packs
Reusable ice packs typically contain water, something to lower the freezing temperature, a thickening agent, silica gel, and non-toxic blue coloring. The ingredient used to lower the temperature is usually propylene glycol. Though the composition varies by brand, the water is usually supplemented with either hydroxyethyl cellulose or silica gel, coated with vinyl, to keep the water from freezing into a solid block of ice.

• The propylene glycol is a common ingredient found in antifreeze. This is a synthetic organic compound that's a viscous colorless liquid that also doesn't have any odour.

• Hydroxyethyl cellulose is an agent that's derived from cellulose. What makes it great for gel packs is that it can easily offer structural strength to the pack. The gel packs are created by adding hydroxyethyl cellulose and vinyl-coated silica gel into the bag. This, alongside propylene glycol, will help maintain the gel pack in a state where it can be reused multiple times without failure.

• The vinyl-coated silica gel is designed to keep all the ingredients of refrigerant gel together. It also brings in the overall mass of the entire structure. It's a crucial ingredient of the gel pack, and it helps maintain the cold that you get from the freezer.

• A thickener needs to be used in order to maintain the strength of these compounds. Without a thickener, you will not be able to reuse the gel packs. It's a mandatory thing to take into consideration here. (Pei, 2020) (Kinetic Labs, n.d.)

Instant/disposable ice packs
Instant cold packs comprise two chambers with a smaller bag inside the larger pack: one containing water and the other with ammonium nitrate or ammonium chloride.

When an instant cold pack is squeezed the inner pouch is ruptured, mixing the agents and causing a chemical endothermic reaction. Instant ice packs are commonly used for injuries and kept in first aid kits. These packs can stay cold for about 15 - 20 minutes; enough time for a person to receive emergency treatment for common aches and pains.

They're single-use packs, so once the chemical reaction is done, you have to dispose of the packs properly. You can't refreeze or reuse them after that. (Ice Wraps, 2019)

Summary of key findings

Ice cooler sleeves for wine are much more effective than I'd previously thought which gives me confidence that developing something similar for my project could work well. I need to investigate if keeping the bottle and cool pack in an insulated casing would work or if this would hinder the heat exchange required to cool the milk.

Instant ice packs would be good in terms of the lack of forward planning required, however the chemicals used may put off potential users, and they also have significant sustainability implications being single-use.

I also need to work out how my product could be used to store milk from multiple expressing sessions, as the NHS advises not to mix milk of different temperatures. This means freshly expressed milk cannot be mixed with previously expressed milk that has been chilled.

Could my product have two different stages, one for cooling and one for keeping cooled milk cool?

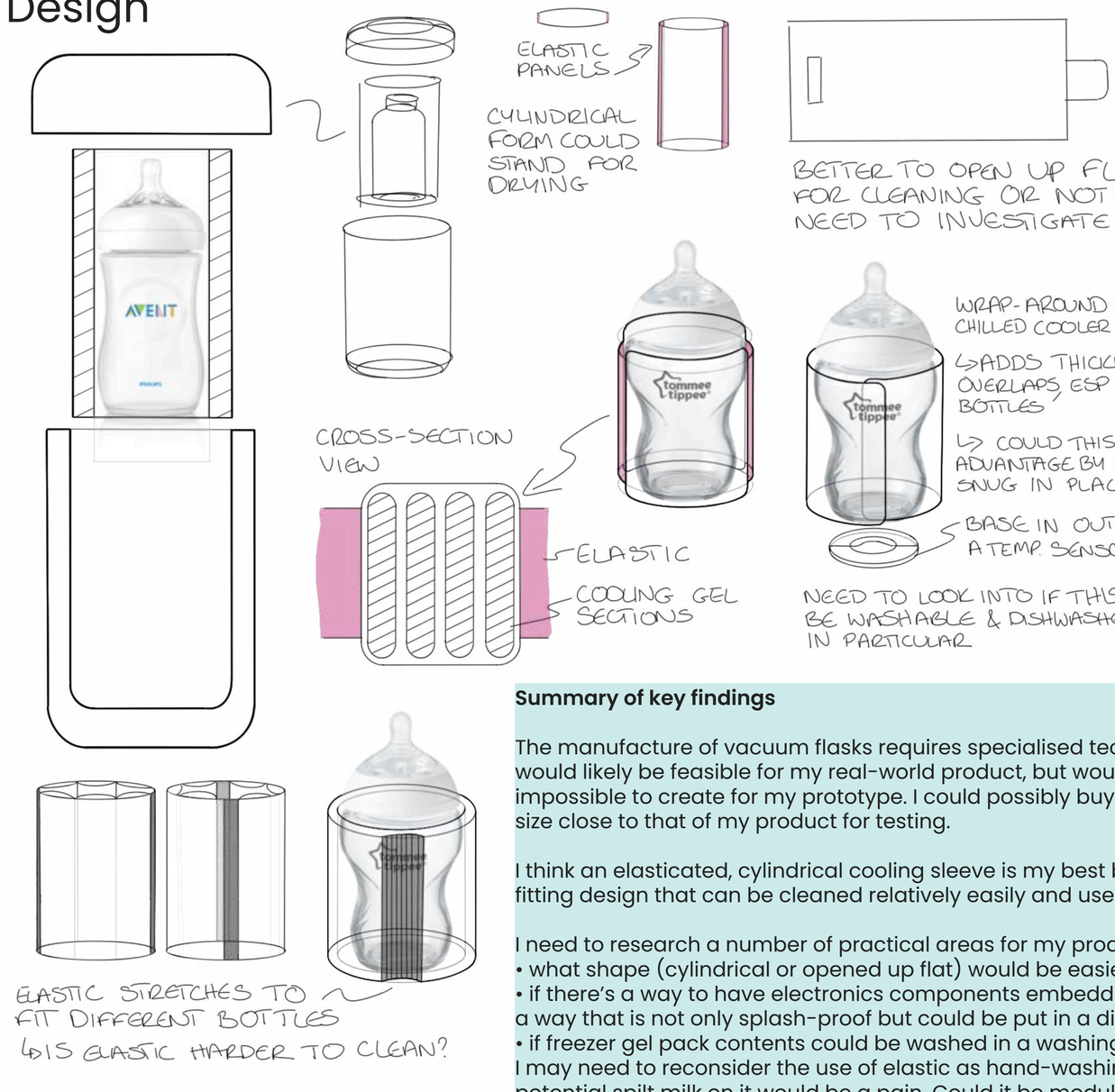
Vacuum Flask Research & Cooling Sleeve Design

Development of Functionality

1. Both walls welded together then a hole is made in the bottom of the outer wall. A glass bead/bead of solder is placed over the hole

2. Placed in a decompression chamber where the air is sucked out and a vacuum created

3. Flasks are then heated to melt the glass bead/ solder and seal the hole



Summary of key findings

The manufacture of vacuum flasks requires specialised technology that would likely be feasible for my real-world product, but would be pretty much impossible to create for my prototype. I could possibly buy a vacuum flask in a size close to that of my product for testing.

I think an elasticated, cylindrical cooling sleeve is my best bet for a universally-fitting design that can be cleaned relatively easily and used with minimal faff.

I need to research a number of practical areas for my product:
- what shape (cylindrical or opened up flat) would be easier to clean
- if there's a way to have electronics components embedded in the product in a way that is not only splash-proof but could be put in a dishwasher
- if freezer gel pack contents could be washed in a washing machine. If not, I may need to reconsider the use of elastic as hand-washing elastic with potential spilt milk on it would be a pain. Could it be modular to allow the cooling section to be removed? Or is this more faff for a mother?
- is it feasible to have heat transfer occurring within a vacuum space?

Market Research
Development

High awareness among target consumers, i.e. the awareness among lactating mothers, regarding the advantages of breastfeeding, is projected to create growth opportunities for the Europe breast pumps market over the forecast period. For instance, supportive initiatives undertaken by the governments, such as the breastfeeding initiative by UNICEF in the U.K., are anticipated to positively influence the growth.

As a result of these initiatives, the rate of breastfeeding increased to 43% in 2017 from 32% in 2010, which has led to a rise in regional demand. (Grand View Research, 2022)

Europe Breast Pumps Market Report Scope

Report Attribute	Details
Market size value in 2022	USD 535.71 million
Revenue forecast in 2030	USD 1.06 billion
Growth rate	CAGR of 8.84% from 2022 to 2030
Base year for estimation	2021
Historical data	2018 - 2020
Forecast period	2022 - 2030
Quantitative units	Revenue in USD million/billion and CAGR from 2022 to 2030
Report coverage	Revenue forecast, company ranking, competitive landscape, growth factors, and trends
Segments covered	Product, technology, application, country
Regional scope	Europe
Country scope	U.K.; Germany; France; Italy; Spain
Key companies profiled	Koninklijke Philips N.V.; Pigeon Corporation; Chiaro Technology Limited; Ardo Medical Ltd.; Ameda (Magento, Inc.); Medela AG; Albert; Mayborn Group Limited

Existing Products
Development

Product	Pros	Cons
Medela Cooler Bag, £27 	• Effective insulation for 8-11 hours according to reviews • Fits Medela bottles perfectly and compactly • Holds four small bottles • Allows the user to have different bottles of different temperature milks	• Bag doesn't have a velcro/clip on strap • Milk needs to be poured into these bottles unless using a Medela pump or thread adapter to express straight into the bottles • Lack of flexiblity with bottle size, teat, no space for pump parts
Ceres Chill, £68 	• Can express directly into the container • Effective insulation (claims to stay cold for 20 hours) • Uses ice rather than a specifically designed cooler element (ice is easier to obtain if the cooler has been forgotten/thawed)	• Need to pour milk directly into the container • High cost • Reviewers report it not withstanding dishwasher cycles • Only one container in which to store milk (issue of mixing different temperature milk)
Tommee Tippee, £12 	• Adjustable Velcro carrying handle/strap • Small and portable • 2-pack means two bottles can be transported at a time/have a spare if one needs cleaning •Fits different bottle brands/sizes	• Only provides insulation, not cooling • Insulation not very effective (approx 2 hours based on reviews) • Hard to clean due to creased nature of the material and shape
Nanobebe, £16 	• Includes an ice pack • Adjustable carrying handle/strap with a popper • Has a mesh pocket for carrying other bits • Holds up to three bottles • Reviewers mention using their own, bigger ice packs with it	• Ice pack is small and not very effective • Hard to clean due to the shape and seams inside • Pocket is at the bottom so contents have to be removed to access the pocket

Infant Feeding Survey 2010
Development

One in six working mothers in the UK (16%) said that their employer offered facilities to express milk.

Eight per cent said that they could breastfeed at work, and 19% said that at least one of these facilities were offered (up from 15% in 2005). Working mothers in Northern Ireland were least likely to report being provided with such facilities (14%), while working mothers in Scotland were most likely to report that they had these facilities at work (24%).

These figures may be under-estimates, as mothers who have no need to use such facilities may not be aware of whether or not they are offered. Working mothers who were breastfeeding at Stage 3 were among those most likely to say that such facilities were offered (35%). This may be an indication that breastfeeding women are more likely than non-breastfeeding mothers to be aware of workplace breastfeeding facilities, but equally it may be an indication that the existence of such facilities allowed women to continue breastfeeding for longer.

Nearly one in five mothers who were working when babies were eight to ten months old felt that their return to work had affected the way they fed their baby (19%), with over half of these mothers saying it had caused them to stop or cut down breastfeeding (56%).

Mothers of multiple births who breastfed initially (81% of all mothers):
- Most did so by a breastfeed (75% for first born and 80% for second born babies)
- Use of expressed breastmilk was also widespread (53% for first and second born babies)
- Very few mothers of multiple births had given their babies banked donor breastmilk (less than 0.5 per cent for first and second born babies).

Summary of Key Findings

Incidence of breastmilk expression: 53% of those who breastfed initially (42.93% of all mothers)

One in six working mothers in the UK (16%) said that their employer offered facilities to express milk.

19% of mothers who were working when babies were eight to ten months old felt that their return to work had affected the way they fed their baby. Over half of these mothers said it had caused them to stop or cut down breastfeeding (56%).

This amounts to 10.64% of working mothers stopping or cutting down breastfeeding due to their work.

Standards Research BS EN 12546 Part 1
Development

BRITISH STANDARD

BS EN 12546-1:2000
Incorporating Corrigendum No. 1

Materials and articles in contact with foodstuffs — Insulated containers for domestic use —

Part 1: Specification for vacuum ware, insulated flasks and jugs

Based on these definitions within the standard, my product seems most similar to a 'Food Flask' so I will follow requirements relating to this container type

2.1.2 non-vacuum insulated container
insulated container in which the insulant is not a vacuum.

2.2 types of insulated containers

2.2.1 flask
insulated container for liquid, intended to be transported, having a narrow mouth for pouring.

2.2.2 carafe
insulated container for liquid, intended for table top use, generally fitted with a side handle.

2.2.3 air-pot
insulated container, intended for table top use, whose contents are released by applying air pressure through a pump system so that the liquid contents are forced up from the bottom of the container and out of the container via a nozzle.

2.2.4 food-flask
insulated container for food, intended to be transported, having a wide mouth.

2.2.5 insulated cup
insulated container for liquid, intended for table top use, having a wide mouth, designed for drinking directly from the container.

2.2.6 cool jug / barrel
large insulated container with a capacity of usually more than two litres of liquid, intended to be transported and equipped with a device to retain and release the contents.

2.3 nominal capacity
volume of water at room temperature required to fill the insulated container, when in an upright position, to a level 10 mm below the lowest part of the inserted closure.

2.4 table top use
non-transportation use, such that if shaken or knocked over spillage is likely.

2.5 filler
inner container, usually of glass, metal or plastics material, of an insulated container.

Table 1 — Vacuum insulated containers

Clause	Requirement	flasks	carafes	air-pots	food- flasks	insulated cups
3.2	pouring	X	X	X	-	-
3.3	stability	X	X	X	X	X
3.4.1	heat loss	X	X	X	X	-
3.5	thermal shock	X	X	X	X	X
3.6	stopper leakage	X	-	-	-	-
3.7.1	seal leakage	X	X	X	X	X
3.8.1	impact	X	X	X	X	-
3.9	handle	X	X	X	X	X

Table 2 — Non-vacuum insulated containers

Clause	Requirement	flasks	carafes	air-pots	food-flasks	insulated cups	Cool Jugs / Barrels
3.2	pouring	X	X	X	-	-	X
3.3	stability	X	X	X	X	X	X
3.4.2	heat loss	X	X	X	X	-	X
3.5	thermal shock	X	X	X	X	X	X
3.6	stopper leakage	X	-	-	-	-	X
3.7.2	seal leakage	X	X	X	X	X	X
3.8.2	impact	X	-	-	-	-	-
3.9	handle	X	X	X	X	X	X

Table 3 — Minimum temperatures (°C) for vacuum insulated containers

Capacity (in ml)	flasks	carafes	food-flasks	air-pots
0 to 200	60			
201 to 400	65	60	50	50
401 to 600	70	65	60	60
601 to 800	75	70	62	70
801 to 1200	78	75	66	70
>1200	80	78	70	75

3.4.2 Heat loss for non-vacuum insulated containers
Temperatures measured in accordance with 5.4 shall be no lower than those specified in table 4.

Table 4 — Minimum temperatures (°C) for non-vacuum insulated containers

Capacity (in ml)	flasks	carafes	air-pots	food-flasks	cool jug / barrel
0 to 200					
201 to 400	38	38	38	35	35
401 to 600	40	40	40	37	37
601 to 800	45	45	45	42	42
801 to1200	50	50	50	47	47
>1200	55	55	55	52	52

3.3 Stability
The insulated container shall not overbalance when tested in accordance with 5.3.

3.4 Heat loss
3.4.1 Heat loss for vacuum insulated containers
Temperatures measured in accordance with 5.4 shall be no lower than those specified in table 3.

3.4.2 Heat loss for non-vacuum insulated containers
Temperatures measured in accordance with 5.4 shall be no lower than those specified in table 4.

3.5 Thermal shock
A container shall not be damaged when tested in accordance with 5.5.

3.7 Seal leakage
3.7.1 Seal leakage for vacuum insulated containers
There shall be no leakage between the outer protective case and the filler when tested in accordance with 5.7.

3.7.2 Seal leakage for non-vacuum insulated containers
If the container is manufactured with a seal, there shall be no leakage between the outer protective case and the filler when tested in accordance with 5.7.

3.8 Impact
3.8.1 Impact for vacuum insulated containers
The insulated container shall not break when tested in accordance with 5.8.1.

3.8.2 Impact for non-vacuum insulated containers
After testing in accordance with 5.8.2 the flasks shall not leak. Resulting damage shall not impair the thermal performance as given in 3.4.

3.9 Handle
Products with handles shall not be damaged when tested in accordance with 5.9.

The requirements for heat loss and impact will depend on whether or not I use vacuum or a different kind of insulation.

Even if I do use vacuum insulation I think heat loss won't apply as it seems the standard focuses on heat loss based on a hot liquid being kept hot in the container, as shown in the table to the left.

Standards Research BS EN 12546 Part 2
Development

Materials and articles in contact with foodstuffs — Insulated containers for domestic use

Part 2: Specification for insulated bags and boxes

3 Requirements

3.1 Capacity
The capacity measured according to 4.1 shall not differ from the nominal capacity by more than ± 5% for rigid containers and ± 10% for flexible containers.

3.2 Insulation performance
The insulation performance measured according to 4.2 shall be declared to the user by means of the pictogram shown in figure 1 where the declared time in hours is stated according to the following rules:

[X hours + Y minutes] is the time measured in 4.2

for (0 < Y ≤ 30) min declared time (hours): X
for (30 < Y < 60) min declared time (hours): X + 1

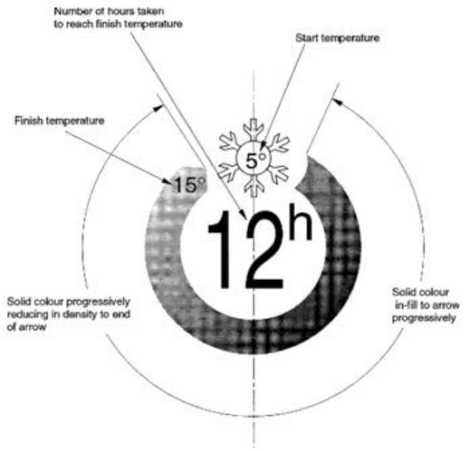


Figure 1 — Pictogram for insulation performance

3.3 Impact resistance
The impact resistance shall be such that when tested in accordance with 4.3 the insulated container shall suffer not more than superficial damage which does not impair its function.

3.4 Handle strength
The handle and its attachment when tested in accordance with 4.4 shall remain effective.

3.5 Cleaning
The inner container of the insulated container shall be designed in such a way that it shall be possible to clean it easily and completely.

Insulated containers in which the inner lining is not continuous or may allow seepage between the inner container, the insulant and the outer protective case (for example through stitched seams) shall be tested in accordance with 4.5 and shall show no traces of the coloured water used.

Standards Research BS EN Part 3
Development

Materials and articles in contact with foodstuffs — Insulated containers for domestic use

Part 3: Specification for thermal packs

3 Definitions

For the purposes of this standard the following definitions apply

3.1 cooler pack
sealed container filled with a cold-retaining medium intended for use in conjunction with an insulated domestic food container for example one complying with EN 12546-2:2000.

NOTE The pack is pre-cooled before use by, for example, storage in a domestic freezer or refrigerator.

4 Requirements

4.1 Contents
The cold retaining medium shall not be considered as dangerous (See Note 1). If water is used as the cold retaining medium or part of it, it shall be of quality fit for human consumption (see note 2). It shall be possible to present all data for checking compliance with the requirements of this clause.

4.2 Surface Coatings
4.2.1 A coating, if any, shall be firm and not removable when tested in accordance with 5.1.

NOTE 1: Attention is drawn to the Council Directive of 7 June 1988 (88/379/CEE) referrring to the classification, packaging and labelling of dangerous preparations and requiring that the cold retaining medium not be dangerous.

NOTE 2:Attention is drawn to Council Directive of 15 July 1980 (80/778/CEE) relating to the quality of water intended for human consumption.

4.2.2 The coating, if any, shall comply with the requirements of EN 71-3 for toxic metals in coatings if more than 10 mg can be obtained from the cooler pack by a physical method of removal.

4.3 Leak resistance
The cooler pack shall be leak resistant at any temperature between the service temperature limits and comply with the requirements of 4.4 to 4.7 after being subjected to testing in accordance with 5.2.

4.4 Load resistance
The cooler pack shall not be damaged so as to cause leakage at ambient temperature when tested in accordance with 5.3.

4.5 Thermal shock
A cooler pack shall be able to withstand a thermal shock without damage or leakage when tested according to 5.4.

4.6 Impact resistance
After testing in accordance with 5.5 there shall be no leakage or breakage of the cooler pack likely to affect future performance.

4.7 Puncture resistance
A cooler pack shall not leak after it has been subjected to the puncture test described in 5.6.

I'll need to think carefully about how the cool packs in my product are made and the materials used to ensure they adhere to this standard.
Is there a way I could use bought-in cooler elements that have already met the standards to make my life easier?

I hadn't previously considered impact resistance or handle strength, mentioned in Part 2 of the standard, so will need to bear this in mind when designing.

Product Design Specification, 20/04/2023
Development

1. Performance

1.1 User

Used by new mothers who are returning to work outside the home (as opposed to working from home) and want to continue breastfeeding.

1.2 Environment

1.2.1 Used in the workplace and on the go.
1.2.2 Used when expressing in a room that may not necessarily have all the required facilities, e.g. clean surfaces, running water, fridge, mains power supply.
1.2.3 Must be portable and work without mains power for 6 hours.

1.3 Function

1.3.1 Must be able to cool breast milk from body temperature (37°C) to fridge temperature (2-8°C) in under two hours.
1.3.2 Should keep the milk insulated for 4 hours after it has been cooled.
1.3.3 Must be able to hold and cool one bottle containing up to 250ml of milk.

1.4 Set-up Time

1.4.1 Cooling element must be sufficiently cooled within 6 hours.
1.4.2 Milk should be put away in the product for cooling within 2 minutes.

1.5 Cleaning Time

1.5.1 Product should be able to be cleaned overnight passively (i.e. in a dishwasher or washing machine)
1.5.2 Product should be able to be cleaned within 10 minutes actively (i.e. by hand)

1.6 Size

1.6.1 Product must be small enough to be portable and unobtrusive while still providing efficient
1.6.2 Should be no more than 150x150x250mm
1.6.3 Could also have a space to keep pump parts cool and sterile in between uses.

2. Market Constraints

2.1 Competition

No existing products that work universally with existing bottles to cool them and keep them cool without a power supply.

Existing products that work with specific bottles to cool breast milk are by Medela and Ceres Chill.

Existing products used to keep cold milk cold are by Tommee Tippee, Nuby and a couple of brands on Amazon.

2.2 Quantity

620,000 births per year in the UK. 43% of these mothers have expressed milk for their babies (equating to 266,600 women per year).

Assuming a 5% market share, I'd expect to sell 13,330 units per year.

2.3 Manufacture

Must be manufactured using a process suitable for mass production such as injection moulding.

2.4 Target Cost

Should retail for no more than £50.

3. Safety

3.1 Materials

3.1.1 Materials used must be food safe

3.1.2 Materials should be easy to clean with all elements being splash-proof

3.1.3 Non-electroncics containing materials must be suitable for repeated washes in a dishwasher and/or washing machine.

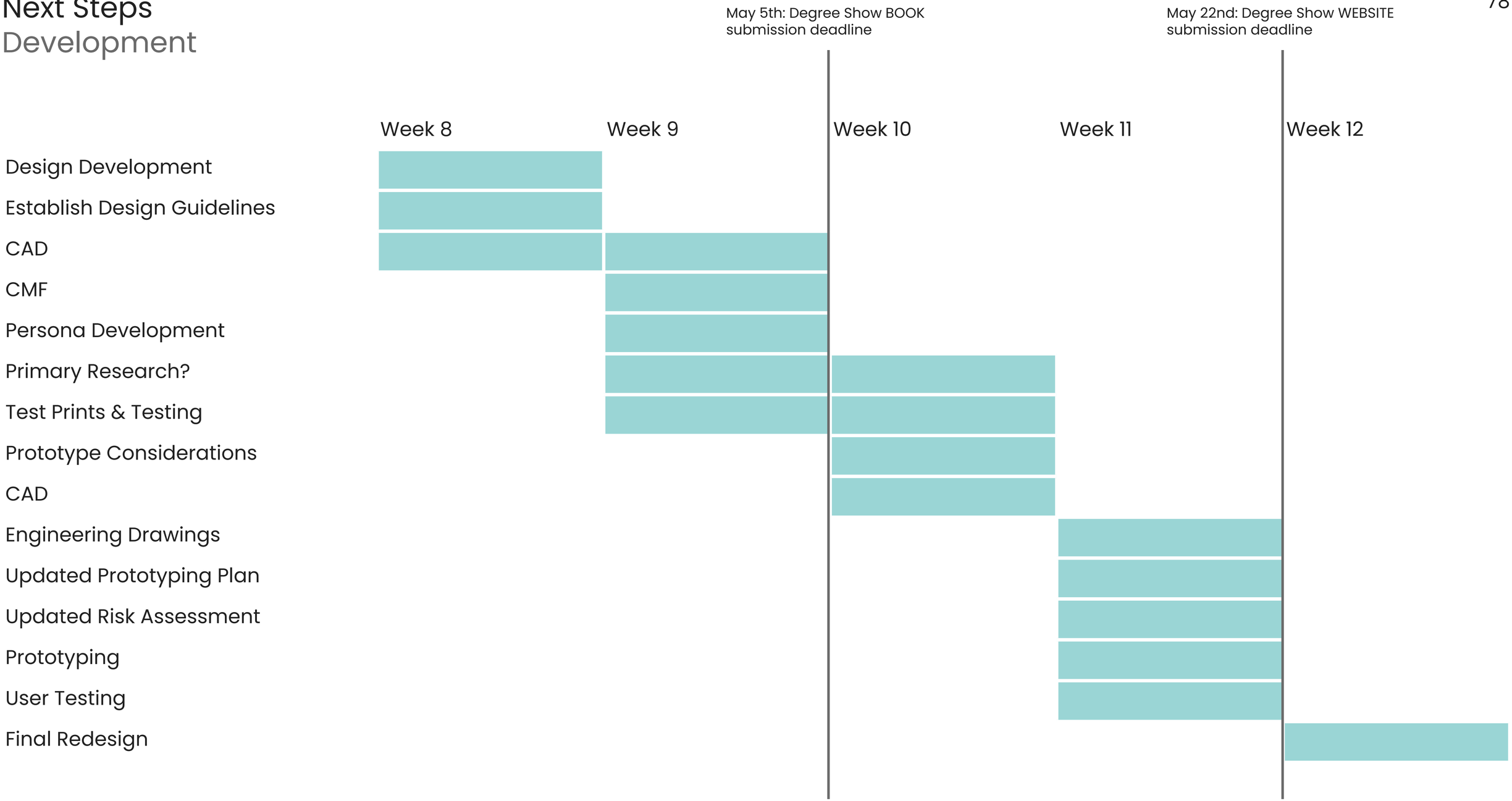
3.2 Standards

Must adhere to BS EN 12546-2000 parts 1, 2, and 3.

3.3 Ergonomics

Must be intuitive and straightforward to use without fiddly elements.

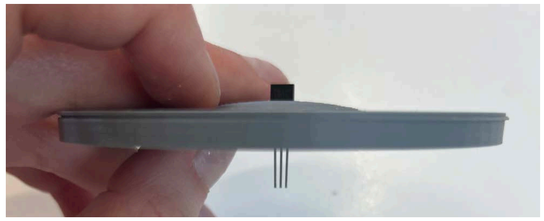
Next Steps
Development

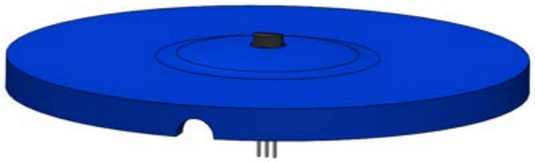


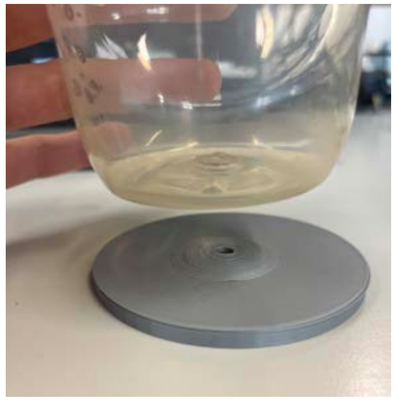
Temperature Sensor Element
Development of Functionality

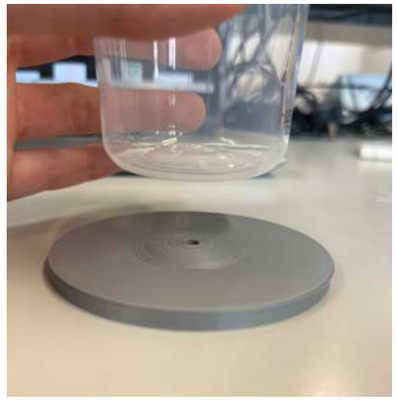
Using putty to try and determine the curvature and shape of the base of bottles.

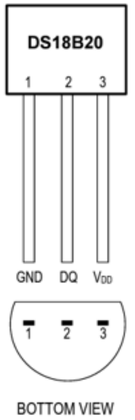
Could I embed a temperature sensor into a protruding base for my product to sit on?

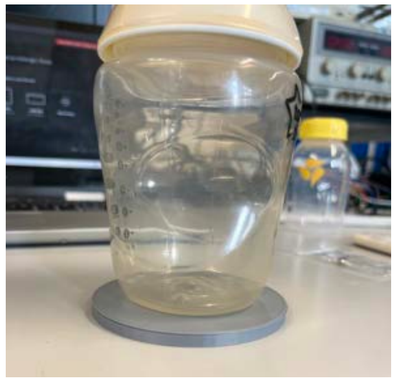


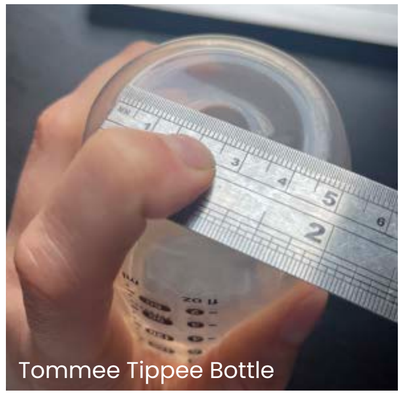


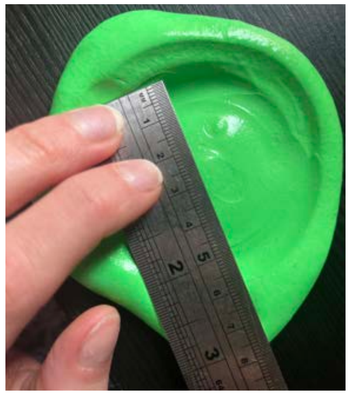


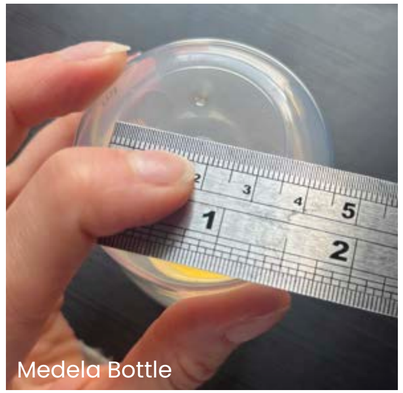


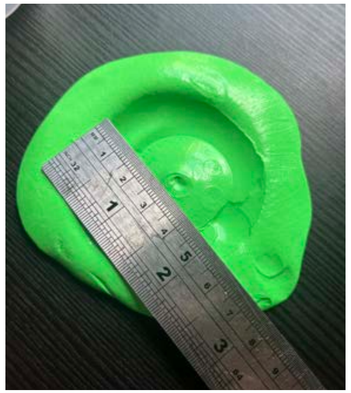


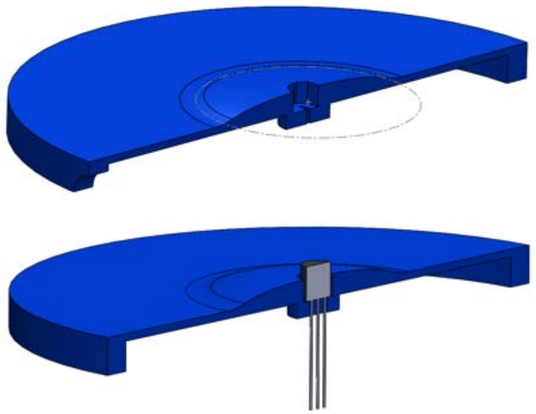



Tommee Tippee Bottle




Medela Bottle





Summary of key findings

This was helpful to mimic the curvature at the bottom of bottles. The two bottles I used are both extremes of bottle sizes available, so it makes sense to design the base to work with these two as it should therefore work with most bottles.

I made a CAD model of a base based on the putty experiment findings, and incorporated a cutout for the temperature sensor to sit in. Both bottle sizes fitted well on this base when I printed it.

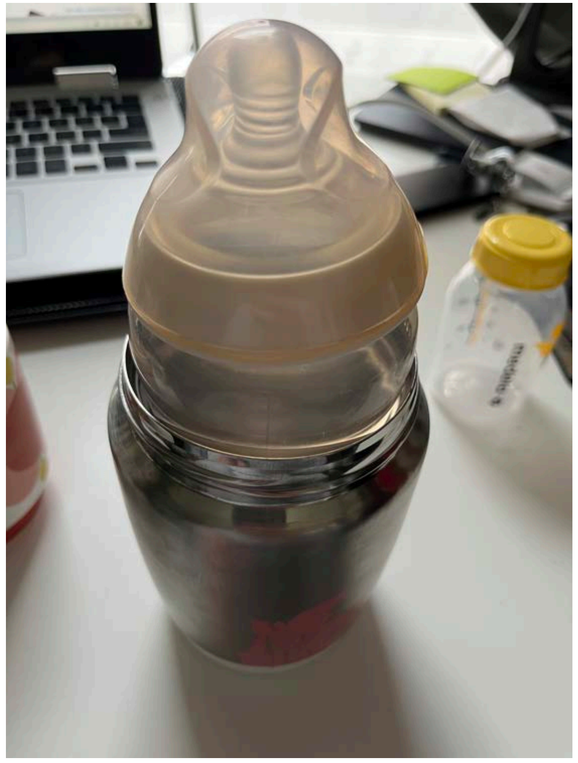
I realised that I couldn't test the sensor embedded in this base, as the pins are quite long, so I'll need to raise the base plate off the surface of the table to test the sensor in-situ.

Thermos Flask Testing
Development of Functionality

I tried to see if I could test the effectiveness of the flexible cool packs at cooling a bottle in a thermos flask.

3 Reusable Mini Ice Packs
★★★☆☆ (28 reviews)

£4.99



Summary of key findings

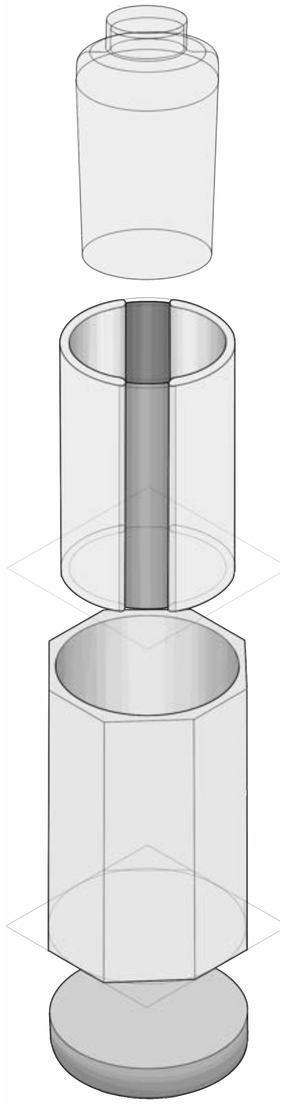
My attempt to test the cooling of a bottle in an insulated flask was unsuccessful, as I hadn't fully considered the size of the bottles available to me.

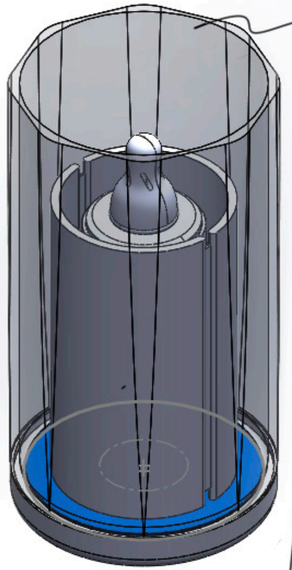
The 150ml Medela bottle, one of the smallest bottles available on the market, fitted in my thermos flask with plenty of room, however the height was too great to screw the lid onto the flask. The Tomee Tippee bottle, one of the largest available, didn't fit in the flask.

This highlighted to me the extent of the range in size of different bottles, and the challenges with ensuring a universal fit. This is a particular issue with bottles such as the Tommee Tippee, which are made up of complex curves with a large variation in radius.

I'll need to carefully consider the design of the cooling element to make it fit universally and make reliable contact with the bottle.

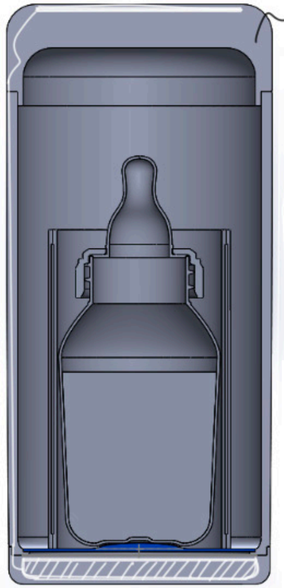
Initial Concept
Development of Functionality





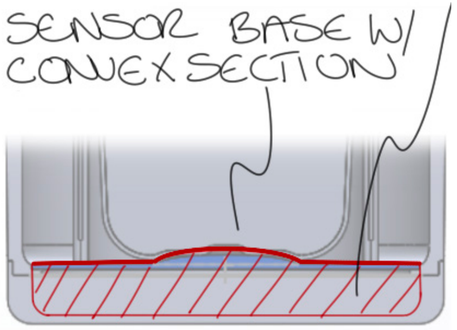
OUTER INSULATED CASING: OCTAGONAL SHAPE ADDS GRIP FOR UNSCREWING

SCREW-ON LID

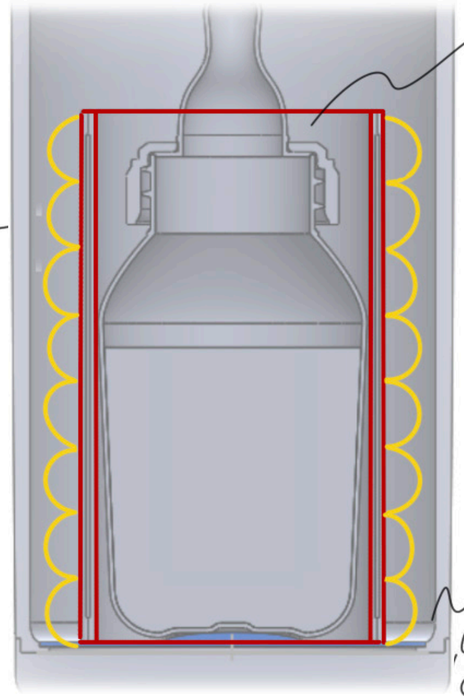


SCREEN WOULD GO HERE IF POSSIBLE

ALTERNATIVELY COULD LINK TO A PHONE APP TO ALLOW FOR ALERTS/MONITORING WITHOUT NEED FOR A SCREEN



SENSOR BASE W/ CONVEX SECTION



ELASTICATED COOLING SLEEVE – IDEALLY WOULD INFLATE TO FILL SPACE & INSULATE + PREVENT MOVEMENT & POTENTIAL SPILLAGE

INFLATED SECTION WOULD NEED TO BE ON OUTSIDE SO IT DOESNT INSULATE THE BOTTLE FROM THE COOLING ELEMENT

ELECTRONICS ENCASED AT BASE FOR CONTACT BETWEEN BOTTLE & SENSOR – NEED TO WORK OUT WATERPROOFING AS ANY SPILLAGE WOULD TRICKLE DOWN TO BASE

IF USING A SCREEN TO DISPLAY TEMP. THIS WOULD GO TOWARDS THE TOP – COULD I HAVE WIRING GOING THROUGH THE BODY TO THE SCREEN?

Summary of key findings

Sketching out and then CAD modelling my concept was helpful as it allowed me to visualise my thoughts and test the concept's viability. CADding it to scale helped me realise the challenges of ensuring a universal fit, as a smaller bottle rattles around in a container that can hold a larger bottle.

From there I had the idea of the cooling sleeve being inflatable which has a few advantages; it would fill the excess space to the bottle is kept in place, a level of insulation would be added as heat transfer through convection is prevented, and the

Week 8 Tutor Meeting
Development

USP → Really focus on what's special

Monitoring the temp is unique – no other products do this

+ universality/portability ☺

Thermistors / thermocouples for temp measurement

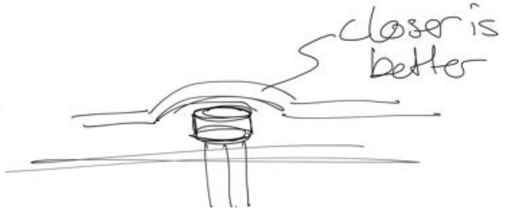
thermistor is easier

Gwaydon arduino

Look at temperature sensor pages

Probs could have wire running through if not doing vacuum.

Wiring may justify 3D print of base



Document the height difference between bottles
→ show dimensions
→ relate back to my development.

Maximised contact between cooling & bottle

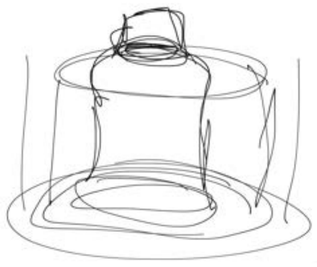
Think about form & change in diameter within a bottle

how does the expansion of the inflatable bit make the cooling contour around the bottle.

Warning system is good - how to relate this to the user

Make a judgement call on soft v. hard very soon.

Work out balance between size of twisty bit & space for cooling element



Play around with screen to display temp

2 Consider if screen would actually deteriorate the discreetness.

2 could it have a cover?

Summary of key findings

I need to focus on the USPs of my product, which are:
• the use of a sensor to tell the user the temperature of the contents without having to open the container and check (therefore letting heat into the bag)
• the portability and versatility of the design to allow users to clip it onto their everyday bag or a pram
• the ease of cleaning compared to similar products on the market

I need to make a decision on the form and materials for the outer casing quickly. If the threaded outer casing works this would validate the casing being hard (either polymer or possibly a metal of a low conductivity).

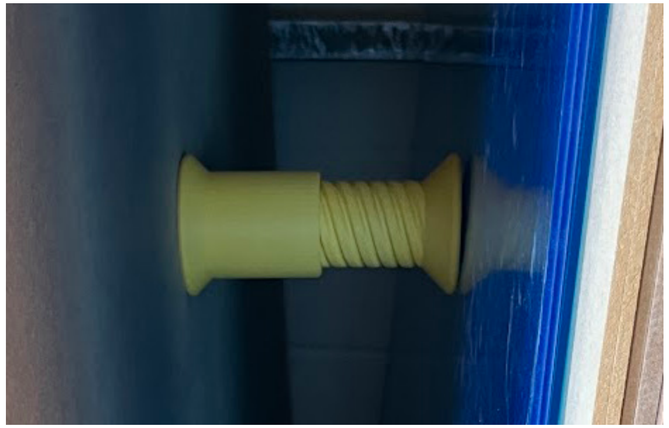
Contact surface area between the bottle and cooling sleeve is of great importance. I need to work out how this contact can be maintained with different bottle shapes, particularly ones with varying radius like the Tommee Tippee ones

Alert system for the milk temperature has potential - I need to think about how I'd do this so it's not anxiety-inducing, e.g. can it give the user an hour's notice before the milk exceeds fridge temperature, to give them time to find a solution. Can I provide an emergency backup solution??

Adjustable Height Body
Development of Functionality

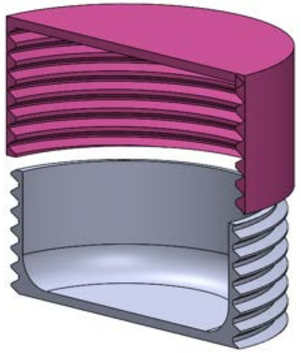
I had initially thought of using a kind of concertina/ collapsible form to allow the height of the exterior body to be adjusted, however a conversation with a technician led me to consider a threaded inner and outer form, similar to the spacers shown below.

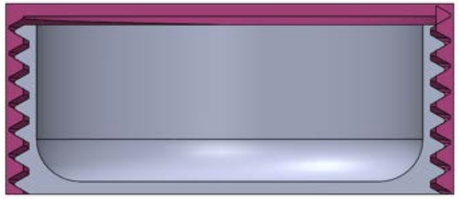
This will allow the height to be adjusted while also providing a layer of insulation via the air pockets in the polymer and air in the threaded section.

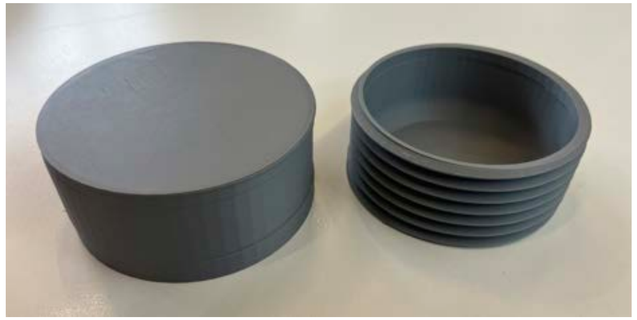


THREAD HEIGHT IS RELATIVELY SMALL, MANY TURNS REQUIRED TO OPEN IT ▷ IMPROVE THIS IN NEXT ITERATION

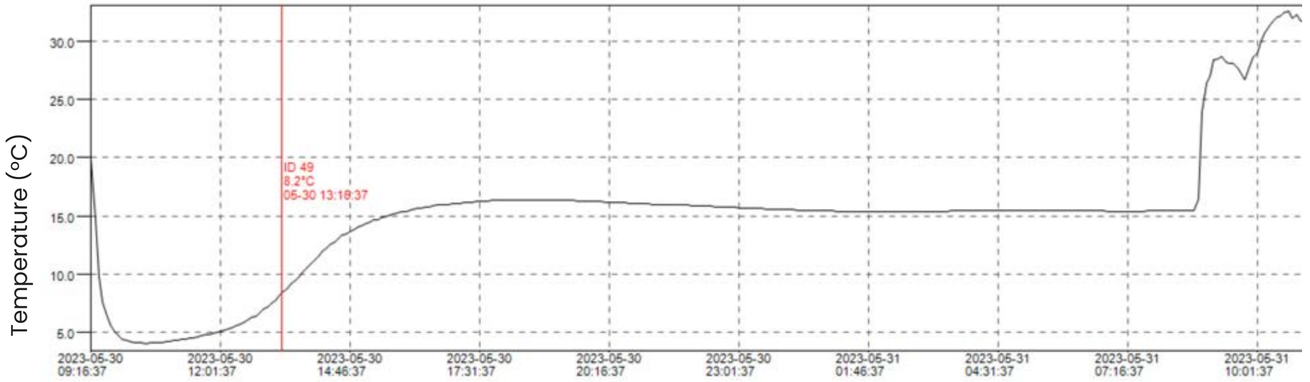
↳ THOUGHT THE CONTAINER COULD OPEN THIS WAY BUT NOW REALISE A SEPARATE LID WOULD BE MORE CONVENIENT







Temperature inside the 3D-printed threaded container containing a flexible ice pack over 24 hours:



Summary of key findings

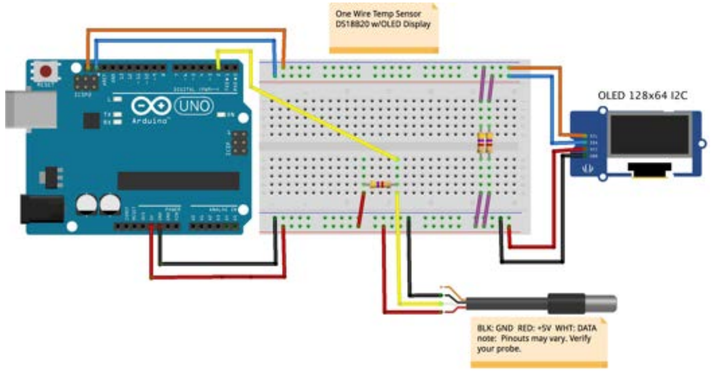
The container was closed at 9:18am and first exceeded 8°C after just under four hours, after which it remained at a reliable 15-16°C until I took the data logger out and put it in my pocket at 8:30 am the next day (23 hours!), despite an ambient temperature of 21°C.

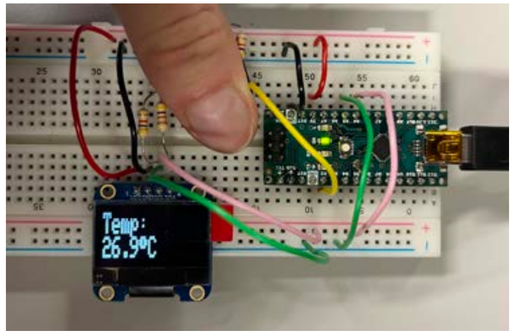
Although the inside of the container didn't stay at fridge temperature for as long as I'd need it to, the fact that a difference between the internal temperature and ambient temperature remained consistent for so long is promising. I should be able to increase the four-hour fridge temperature with further development.

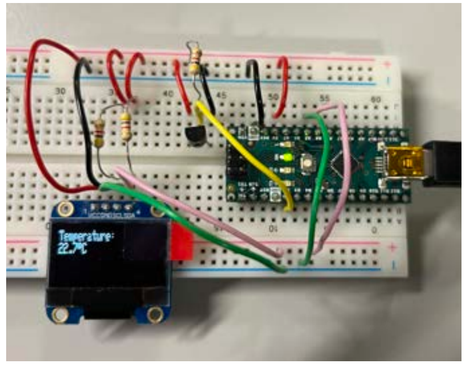
Electronics Revisited
Development of Functionality

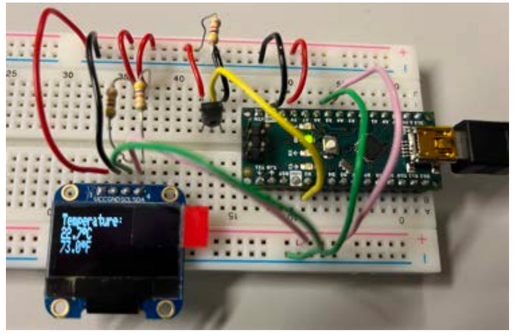
SSD1306 screen

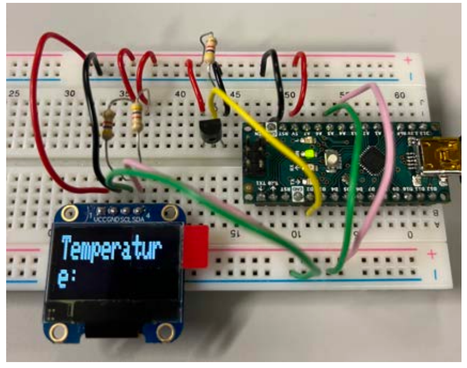
Testing out displaying the temperature sensor's reading on a screen. I initially used a borrowed SSD1306 screen, while waiting for my full-colour OLED to arrive. This display is two-colour and has four pins. I got this to work fairly easily to display the temperature. The sample code displayed it in both Celsius and Fahrenheit so I amended this as only Celsius is relevant to my requirements. I also played around with text size and wording used.









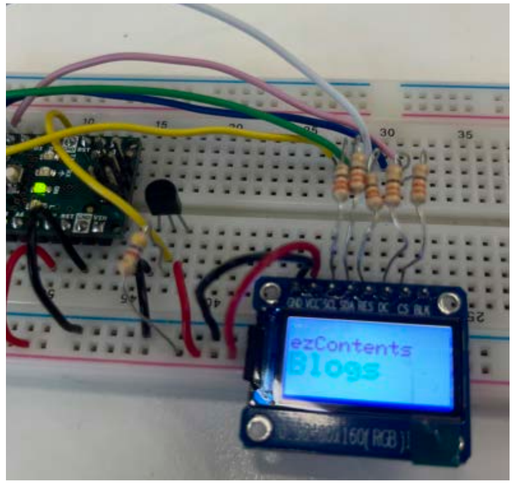


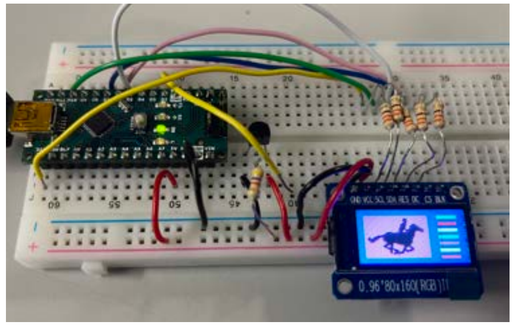
ST7735 screen

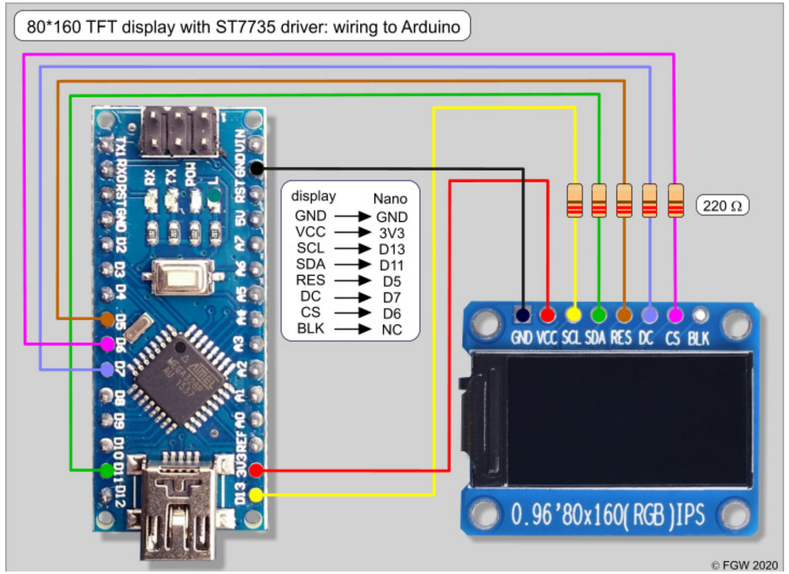
I tested my screen using two example codes, one showing a graphic of a horse and one displaying text and colourful shapes. This was helpful to understand the structure of the code used to program the ST7735.

I then combined the code used to display the text with the code used to display temperature on the SSD1306.

I wasn't able to test this combined code, however, due to some issues that arose with my Arduino and the cable. It took some time to effectively troubleshoot the issue, which I narrowed down to my Mini-B cable, so I ordered a replacement and put electronics aside while waiting for the delivery.







Summary of key findings

It was reassuring to bring the electronics together and successfully test the sensor and convey the results on a screen.

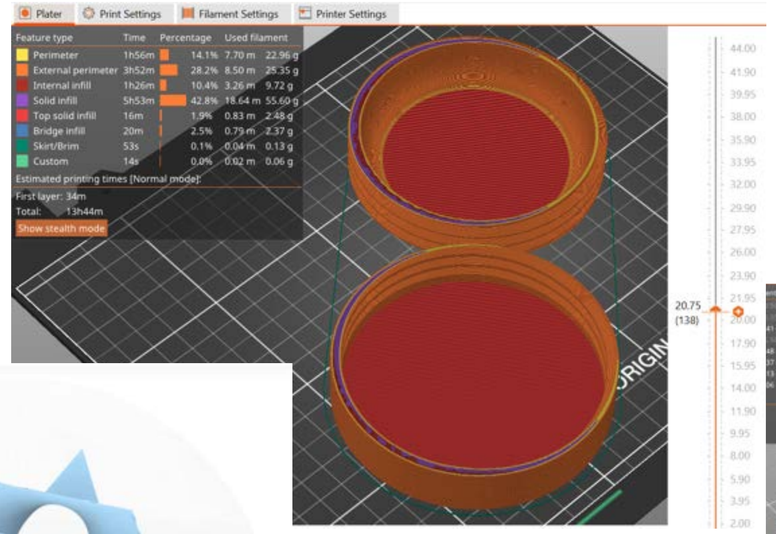
I found it quite frustrating being unable to test the code I'd combined after having put the work in to code it. The code compiled but I wanted to see if it worked in reality, which I wasn't able to.

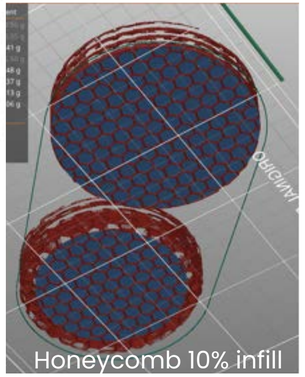
3D Print Insulation
Development of Functionality

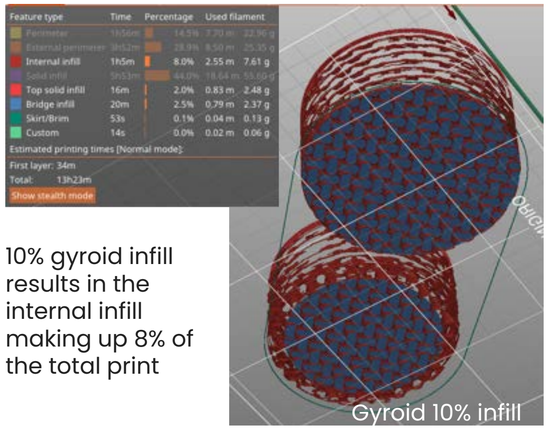
Best infill patterns for insulation are 3D Diamond and 3D Gyroid Skeleton formations

The infill I used in my test print is shown to the right - the density of the PLA is quite high with not many air bubbles.

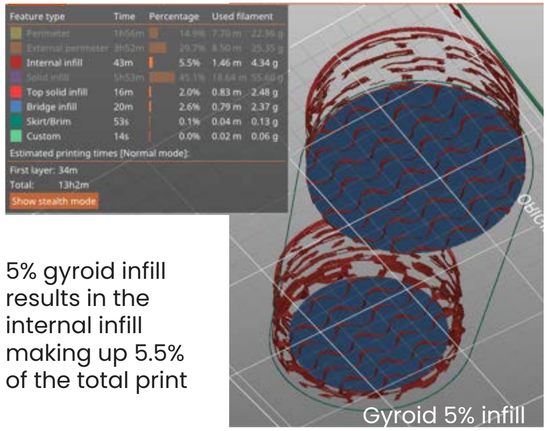
I played around with different infill patterns and densities to see which stored the most air and therefore insulation by hiding the perimeter and solid features of the print.







10% gyroid infill results in the internal infill making up 8% of the total print



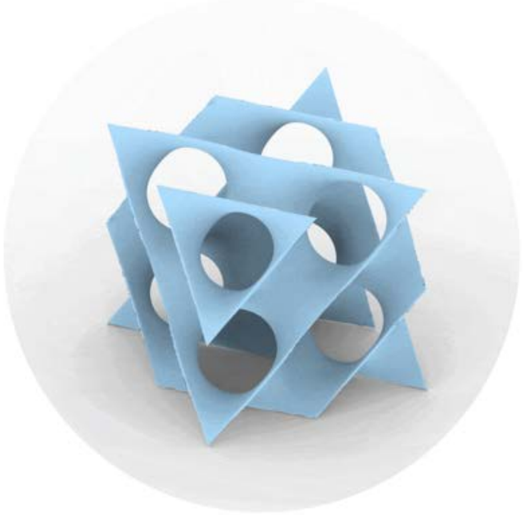
5% gyroid infill results in the internal infill making up 5.5% of the total print

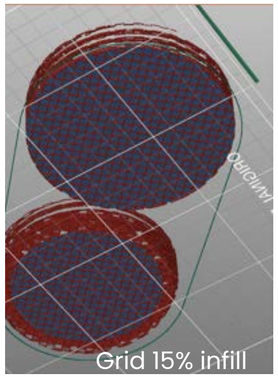
3D Diamond infill

- Evens out mechanical strength on all directions (isometric)
- Reduces print time by up to 10% for infill densities smaller than 15% (compared to crossed diagonals (described later) at the same density)
- Reduces object weight and material use
- Surface area and channel connectivity properties can be used for a variety of applications: from tissue scaffolds, biofilters, metamaterialsfor thermal and sound insulation or photonic manipulation

When to choose this infill type?

This infill type should be chosen for low-density prints. Where low weight is needed, as most of the part will be empty.



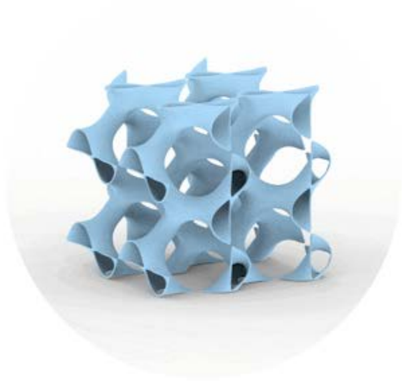


3D Gyroid Skeleton infill

- Evens out mechanical strength on all directions
- Reduces object weight and material use
- Surface area and channel connectivity properties can be used for a variety of applications: from tissue scaffolds, biofilters, metamaterials for thermal and sound insulation or photonic manipulation

When to choose this infill type?

This infill type should be chosen when reducing material is a priority.



Summary of key findings

Based on tutor feedback I realised I need to focus on what's innovative about my product and how I can use technology to my advantage. If I use a primarily 3D-printed design I could experiment with infill types and densities to maximise the amount of air pockets in the casing to make the casing as insulating as possible.

There's little research of 3D printing used as an insulating material available online. I found some mention of insulating properties in an guide to different infill patterns. They recommended 3D diamond and 3D gyroid skeleton infills, neither of which I could find on Prusa Slicer

I played around with Prusa Slicer and analysed the design I'd already printed using different infill types and densities. From this I found the grid infill to have the lowest material density relative to the infill density.

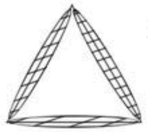
Inflatable inner sleeve
Development of Functionality

Self-Inflating Nozzle Valve
Quick and easy inflation and deflation

SELF-INFLATING NOZZLE WOULD BE EASIER FOR USER

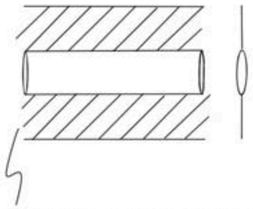
↳ NEED TO TEST FEASIBILITY OF THIS

IS IT REALISTIC TO USE VALVES LIKE ARMBANDS?



3 x VERTICAL PANELS, SIMILAR TO AN ARMBAND

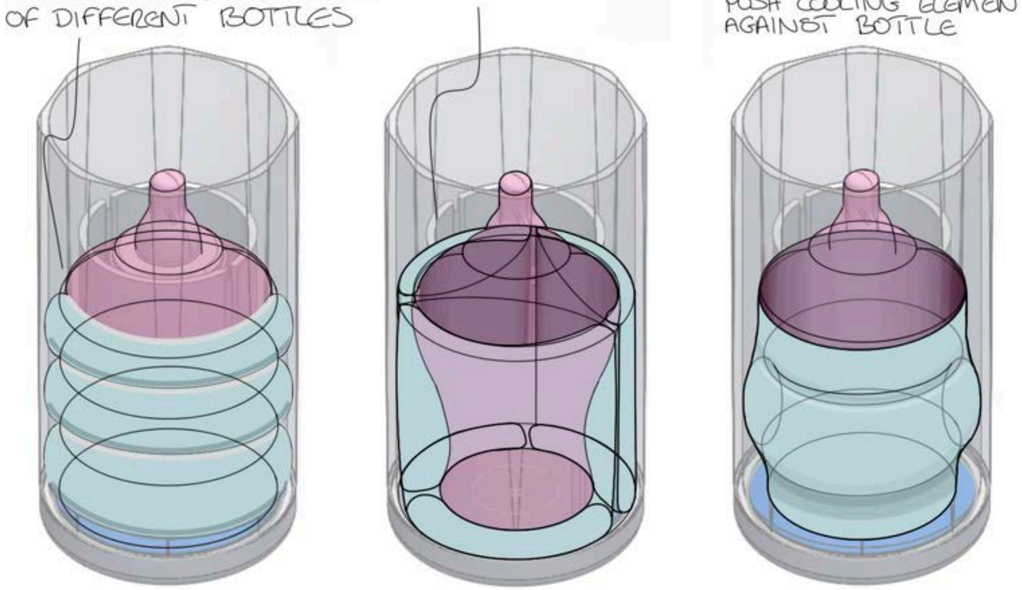
NOT SURE IF AIR WOULD FILL SPACE IF INFLATED AFTER INSERTING INTO OUTER CASE



OR WOULD CROSS-SECTION BE UNIFORM THROUGHOUT?

3 x SECTIONS INFLATE INDEPENDENTLY TO MOULD AROUND CONTOURS OF DIFFERENT BOTTLES

INNER THIRD INFLATES TO HOLD BOTTLE + PUSH COOLING ELEMENT AGAINST BOTTLE



Inflatable containers ('air column bags') for shipping wine bottles - come with a pre-inserted valve for air to be pumped through. Acts as a sort of one-way valve as it's essentially a plastic tube with nothing visibly keeping the air inside. I think it must be the way that the bag is sealed and the columns made that makes up the one-way system. Not sure if this is suitable for my project as I want it to be easily deflatable for cleaning.

Summary of key findings

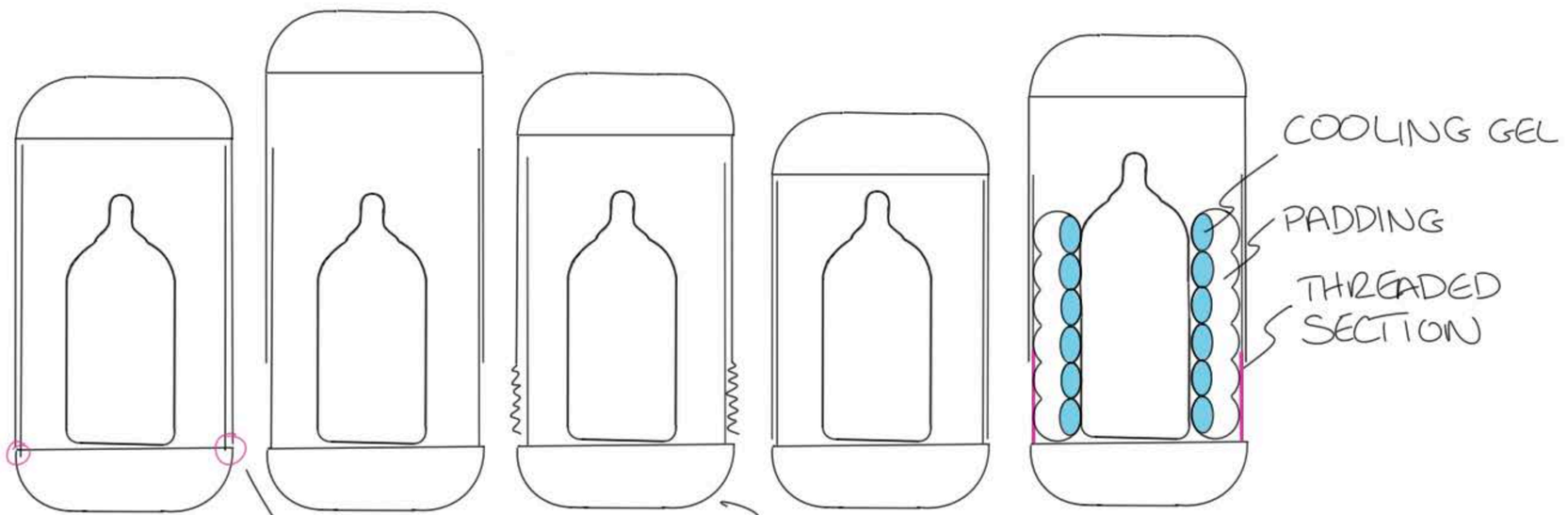
Best option is to have horizontal panels that inflate independently to allow this to work with different bottle sizes and ensure contact surface between the bottle and the cooler, even if the bottle has an unusual shape.

I tried cutting up an air column bag used for wine, using a hot knife to cauterise the material, however this wasn't particularly useful as I couldn't experiment with inflating different sections in different amounts. Balloons might be the best thing to use at this stage to experiment with this.

I've ordered a self-inflating valve of the kind used in camping mats, I'll try and see if I can hook this up to a balloon and test how well it can inflate it.

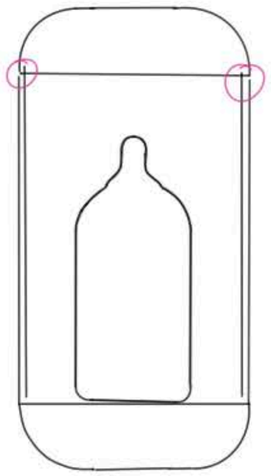
I need to work out how this will work alongside the cool pack element. Would there now be two inserts? Or one sleeve with two layers?

Casing Development
Development of Functionality



NO WAY TO SECURE

IF EXCESS LENGTH IS ON OUTSIDE, NOTHING'S STOPPING IT FROM EXTENDING TO FULL LENGTH

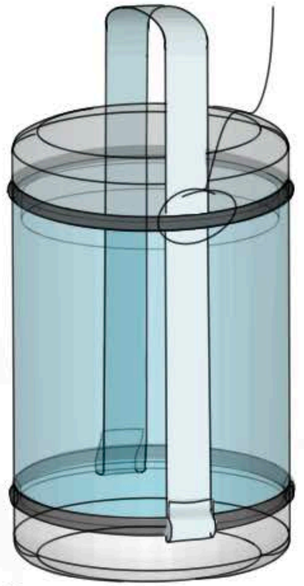


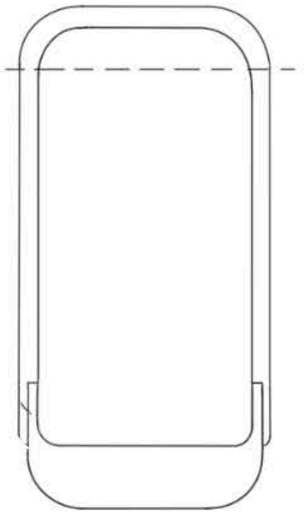
INNER & OUTER SCREW TOGETHER TO SECURE AT EITHER TOP OR BOTTOM

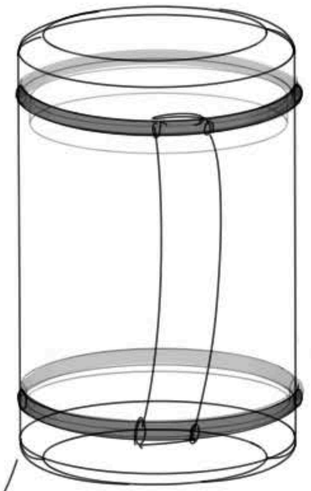
IS THE PURPOSE TO FIT DIFFERENT BOTTLES OR TO BE COLLAPSIBLE WHEN NOT IN USE? NEED TO DECIDE

LID UNSCREWS HERE

NOT PRACTICAL TO OPEN







BUT WOULD BE GOOD TO HAVE FLEXIBILITY W/ STRAP

Electronics
Development of Functionality

Power requirements if using the Arduino Nano I currently have:

Component	Current Draw	Max. voltage
0.96" ST7735S Display	Current draw is based on LED backlight usage: with full backlight draw is ~25mA	3.3-5V
Arduino Nano	19mA	5V
Total	44mA	5V

Power requirements if using the Arduino Nano 33 IoT (which I have ordered):

Component	Current Draw	Max. voltage
0.96" ST7735S Display	Current draw is based on LED backlight usage: with full backlight draw is ~25mA	3.3-5V
Arduino Nano	19mA	3.3V
Total	44mA	3.3V

I'll need at least a 3.3V battery supply to power my electronics. Although the Nano IoT can take a voltage input up to 21V, I want the electronics to be as compact and space efficient as possible, so will use the lowest voltage I can achieve that's above 3.3V.

Battery options available to me:

Battery type	Voltage	Capacity	Comments
Rechargeable AA	1.2V	1,300-2,500mAh	Widely available and convenient. 3-4 batteries would be required, however, which takes up space
Non-rechargeable AA	1.5V	2,000-3,000mAh	
9V	9V	550-1,200mAh	Less widely available and have a lower capacity than using a few AA's

Tech specs

The Arduino Nano 33 IoT is based on the SAMD21 microcontroller.

Microcontroller	SAMD21 Cortex®-M0+ 32bit low power ARM MCU (datasheet)
Radio module	u-blox NINA-W102 (datasheet)
Secure Element	ATECC608A (datasheet)
Operating Voltage	3.3V
Input Voltage (limit)	21V
DC Current per I/O Pin	7 mA

Different Ways to Power Arduino Nano

Arduino Nano has 3 different ways of power:

- USB Port
- VIN Pin
- 5V Pin

The Arduino Nano working voltage is 5V. It has an on -board voltage regulator (**LM1117**) which converts incoming voltage to regulated 5V. Power from the VIN pin is regulated using this LDO regulator. To connect Arduino Nano with battery we have to look at the power requirements of this regulator.

LM1117 specifications:

Regulator	Output Voltage	Max Input Voltage	Max Output Current
LM1117	5V	20V	800mA

Lithium Cell 18650 Batteries Pack Li-ion 2200mAh 5V Rechargeable Battery with USB

Product Model: 18650 5V 2200mAh Lithium Battery Pack

Product Description:

- Safety and economical

The battery cell can provide more than 500 charge and discharge cycles. This makes it extremely economical, and provides an expected life similar to that of the device in which it is used.

- Excellent discharge characteristics

Have low internal resistance and high flat voltage characteristics during strong current discharge, which ensures a wider application field.

- Long cycle life

Provide long storage life with few limiting conditions. It offers problem-free charge after long storage, permitting to use in a wide range of applications.

Summary of key findings:

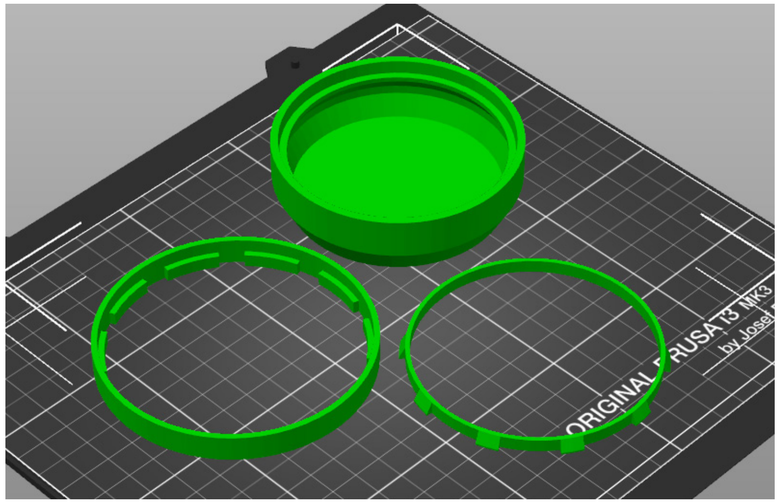
This was helpful to work out the power requirements for my design, and establish whether an Arduino nano 33 IoT would be more suitable for my project, as it has a lower voltage requirement and additional functionality.

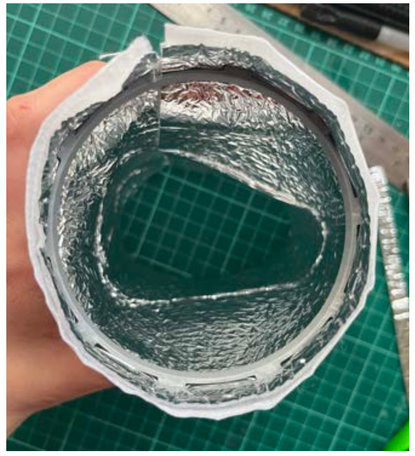
I concluded that the IoT functionality and ability to link to an app is not something I need to prove in my prototype.

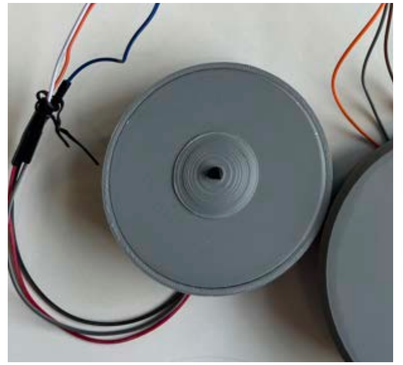
I looked at various rechargeable battery options, including induction charging which I ruled out as an option for my prototype due to the cost and complexity. One option I considered was a rechargeable 5V battery pack, however this is charged using a male micro-USB, which doesn't meet the water- or splash-proof requirements for my design.

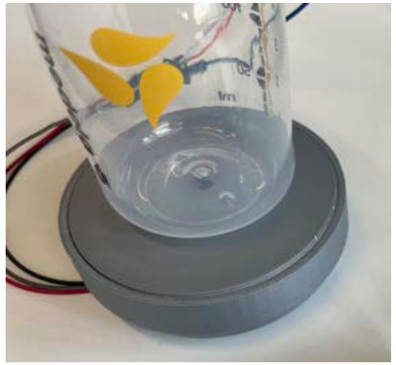
I decided to stick with my Arduino nano and power it using AA batteries for my prototype as these are widely available and convenient for the user.

Soft & Hard Interfacing + Base Print
Development of Functionality









Summary of key findings

I printed a pair of rings to test how I could use these to clamp the fabric in place. I added chamfered notches on the inner ring to allow it to be gradually pushed in.

The outer ring had notches that matched the inverse of the inner ring, and was also meant to have a solid lip on the inside to stop the inner falling through, however I made a mistake in the CAD and forgot to add this.

The gap between the two rings was too small for me to use them to clamp thick insulating material between them, so I used a thinner fabric instead.

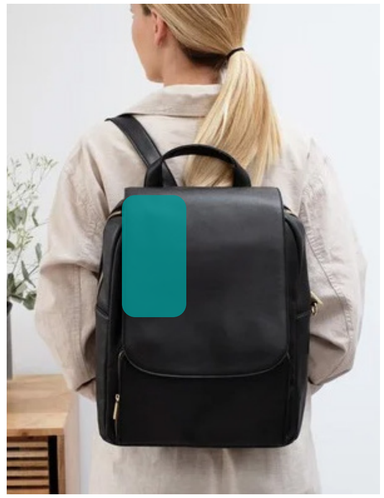
I realised the gap between rings to effectively clamp insulating material has to be significantly larger than I expected.

I also printed a base to hold the plate with the temperature sensor in, to raise the plate and create a space for the sensor's pins. This worked well and my tolerancing was correct. I had forgotten to add a cutout for the wires to lead out from, so drilled a hole in the base when I was testing.

The base fitted in the clamping system I'd roughly prototyped in cardboard, although it was hard to ensure it was sitting straight in the rings, and also I hadn't considered how I'd incorporate the base into the clamping system and bring the design together.

Use Case/Handle Design
Development of Interaction










Week 9 Tutorial
Development

Process - not just final.

SOFT

Temp. Batteries

What alert system is appropriate?

Inspo from other products.

Good to show technical.

Arduino IoT - we know BT works. - waste of time

App has alot of potential

Think about what would be meaningful to convey

Different bottle lids

2x hooks

Don't fixate on leakage.

Could test bottles myself

Don't only speak to one user.

Air pesure.

Blood pressure monitoring cuffs

2 Spend more time on this.

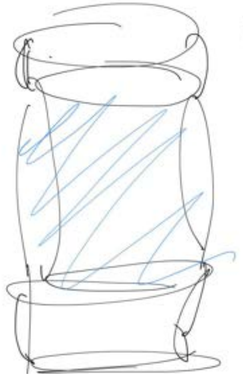
Does the sleeve being removable add value?

Coated probes

2 in lid.

Critical part is the cooling - more important than bottle security.

cushioning cooled bottom & bottom



Gel packs - how would they fit around bottle?

Elastic.

Marking rubric - satisfy all the sections

Marks missed if any section missing

Key developments

Insights

Bringing developments together, showing what went on in my brain

exploded view

Summary of key findings

I need to spend more time focusing on the cooling sleeve rather than the outer casing/insulation, as the cooling is the core function and central to the success of my product.

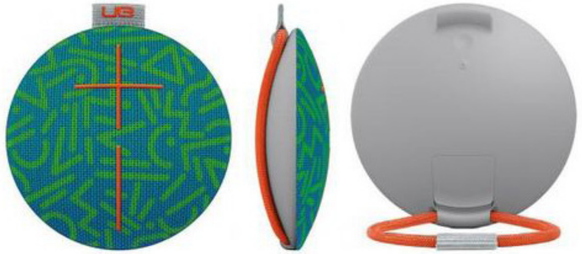
Ensuring the cooling material makes sufficient contact with a bottle, regardless of its diameter or curvature, is another area I can't ignore.

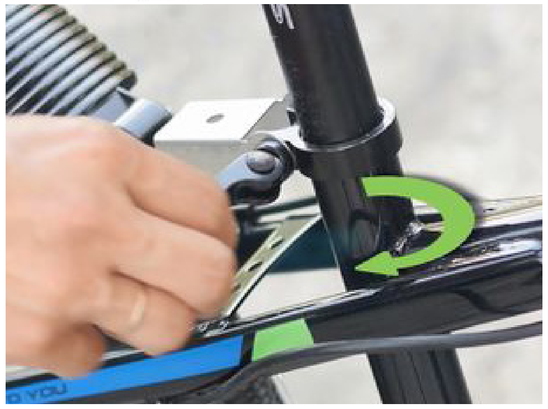
An alert system for the milk temperature has potential, I need to consider what the best way to do this is.

I've moved away from the idea of the sleeve being removable. I concluded this won't necessarily add value, as the diameter of the container would be large enough that the user can stick their hand in to wipe the interior with a cloth. **KEY DECISION.**

Clip Mechanisms

Development of Functionality + Aesthetic





Summary of key findings

I've looked at various strap mechanisms that would allow me to make the height, and potentially the diameter, adjustable.

An over-centre latch, similar to the straps used on ski boots or ice skates, was considered to clamp a carrying strap perpendicular to the container, and fitting around the rigid upper and lower parts of the design.

I moved away from this idea though, as I realised it would make the product harder to open, and add grooves/ridges that would be hard to clean.

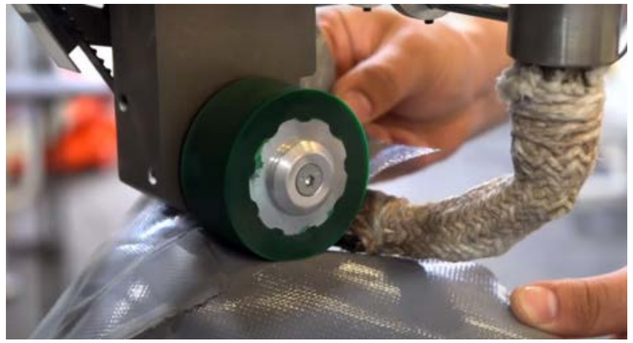
I instead decided on horizontal rubber straps that go around the top and bottom, that add grip when opening the container, and have knobs on which the carrying strap can be hooked on to. The carrying strap would have multiple holes, similar to a watch strap, that allow the user to adjust the height of the container by fixing them closer together, as the sleeve materialm is soft and flexible.

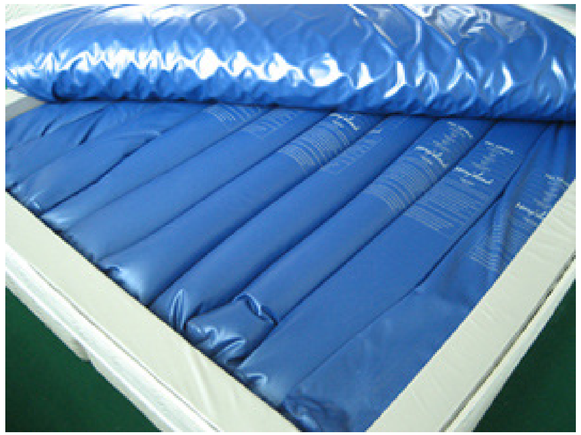
Inflatable Product Research
Development of Functionality

Inflatable pool toys/armbands - made of PVC. Sheets are cut to size and 'sewn' together with the seams sealed. The process is called hot air tape welding to bond PVC layers together.

Although this is useful for the inflatable element, the gel section in my product would be more complex than a standard inflatable, so I'll need to look into how I could make this.

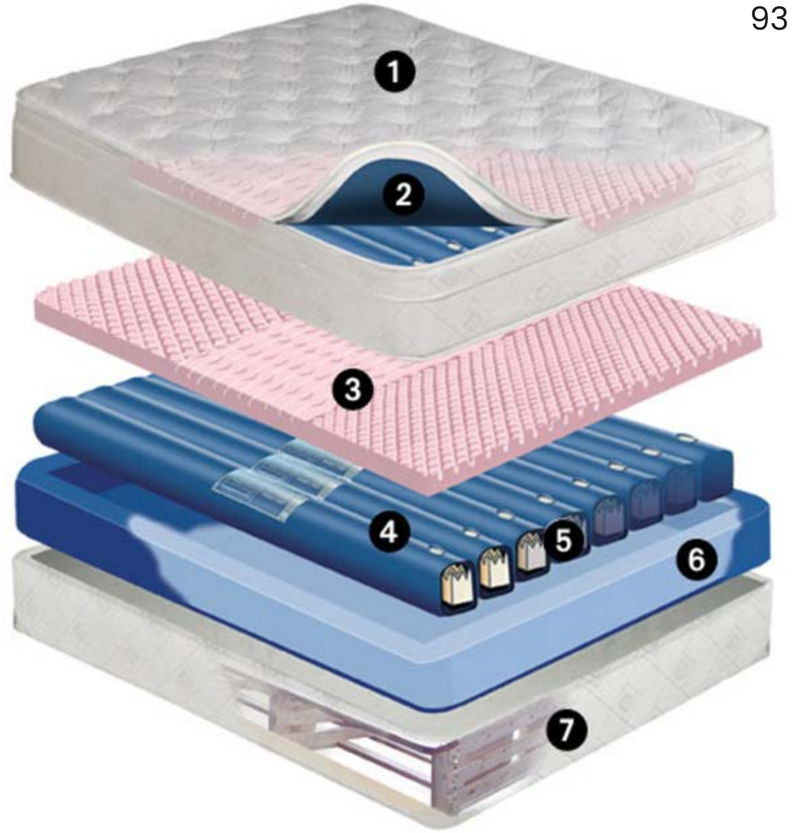
Need to speak to technicians about how I could prototype this.





You can purchase inflatable travel pillows with 'cooling' gel sections, which suggests the DfM of my product should be feasible. The manufacture of my prototype, however, will need consideration.

I also looked at waterbeds and how they're constructed to see if I could take inspiration from their design. Many waterbeds are made up of individual, replaceable tubes held together in a sleeve/soft casing.



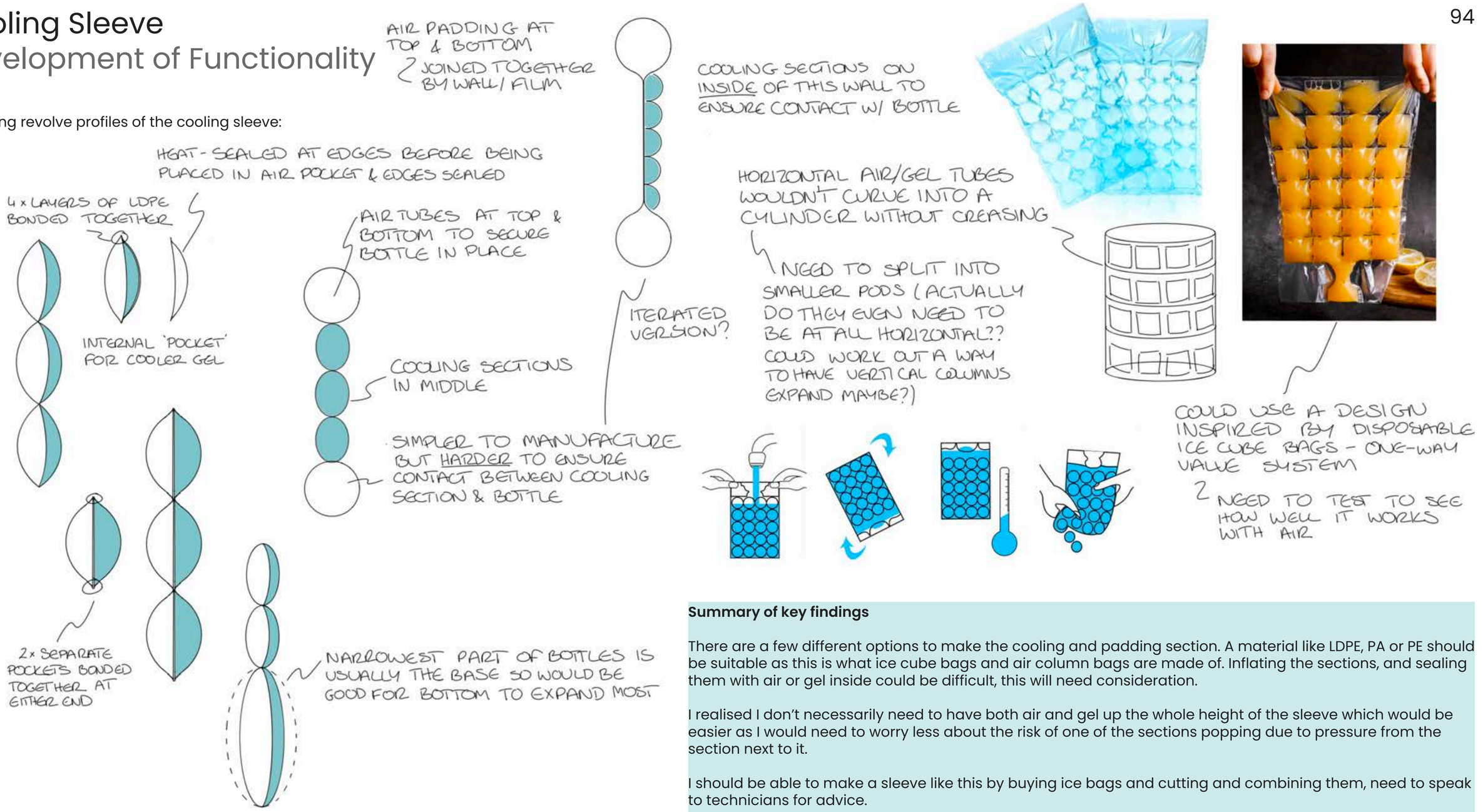
Summary of key findings

Making tubes from a flexible PVC is definitely possible in an industrial context, as well as inflatable products with a separate compartment for cooling gel.

I need to speak to technicians in the school about how I could prototype this, and what materials would work best.

Cooling Sleeve
Development of Functionality

Sketching revolve profiles of the cooling sleeve:



Summary of key findings

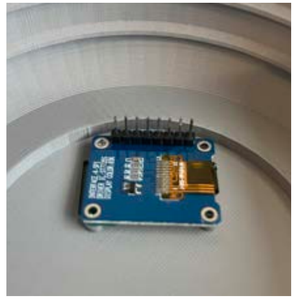
There are a few different options to make the cooling and padding section. A material like LDPE, PA or PE should be suitable as this is what ice cube bags and air column bags are made of. Inflating the sections, and sealing them with air or gel inside could be difficult, this will need consideration.

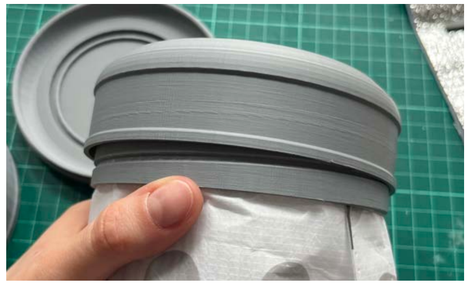
I realised I don't necessarily need to have both air and gel up the whole height of the sleeve which would be easier as I would need to worry less about the risk of one of the sections popping due to pressure from the section next to it.

I should be able to make a sleeve like this by buying ice bags and cutting and combining them, need to speak to technicians for advice.

Soft & Hard Interfacing
Development of Functionality

Base





Summary of key findings

The print for the top half worked well, with the insulated fabric space fitting almost perfectly between the inner and outer top ring. The cutout at the top of the lid worked perfectly to fit the screen and the screw holes matched up. The threaded ring screws well into the lid, although I realised cutting the thread looks odd as you'd normally expect the base part to have an extruded thread on it.

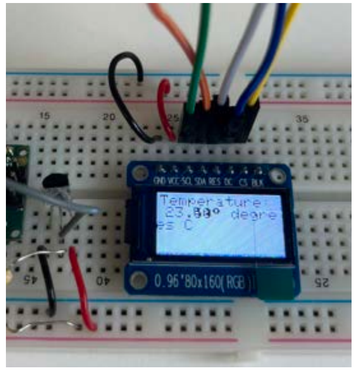
Having the thread on the whole width of the outer ring also meant I didn't have any extra surface to grip onto while screwing the lid on or off.

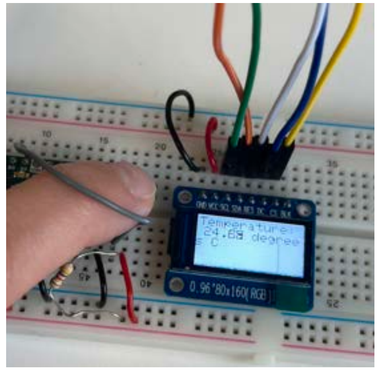
Although I thought I'd left a large gap between the inner and outer sections for the base of the product, the threads fitted together snugly without any room for the insulated material. The inner section (that holds the sensor plate) was too large, and I struggled to fit it into the tube of insulating material once I'd stuck it down at the right diameter for the top half.

Next steps are to reprint the bottom inner smaller, add more grip to the top threaded ring, look into TPU printing for the strap, and research contact pins to connect the screen at the top to the circuit at the bottom of the product.

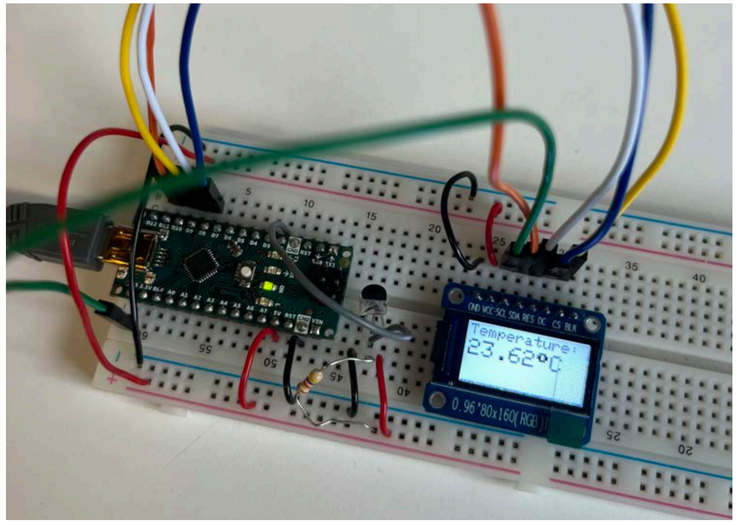
Display Development
Development of Interaction + Functionality

Successful temperature readings showing change after holding my finger on the sensor, text size initially set to 2:



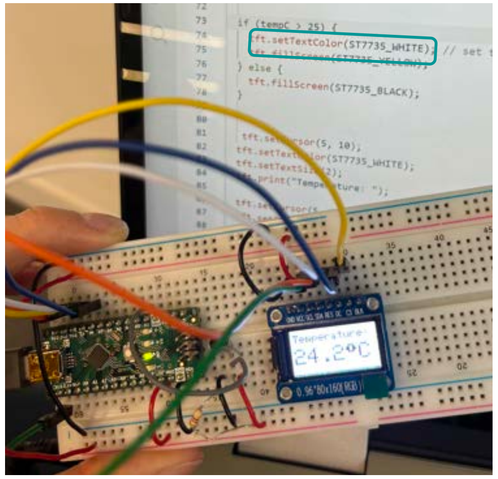


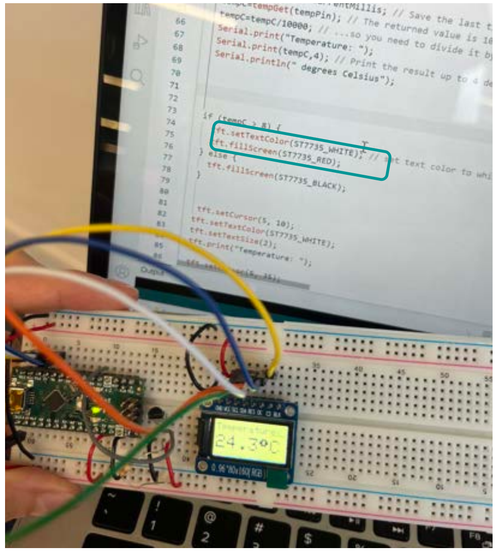
Text size of temperature increased to 2 and degree symbol added to reduce number of characters required:

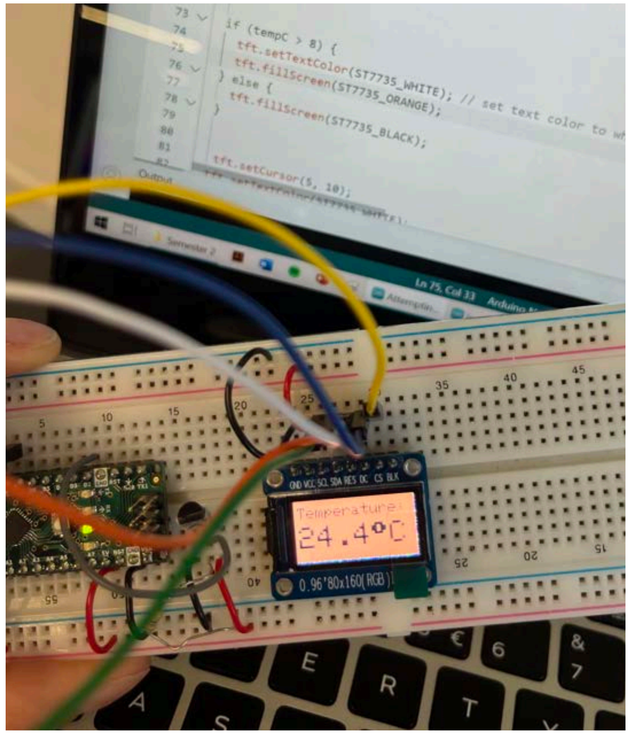


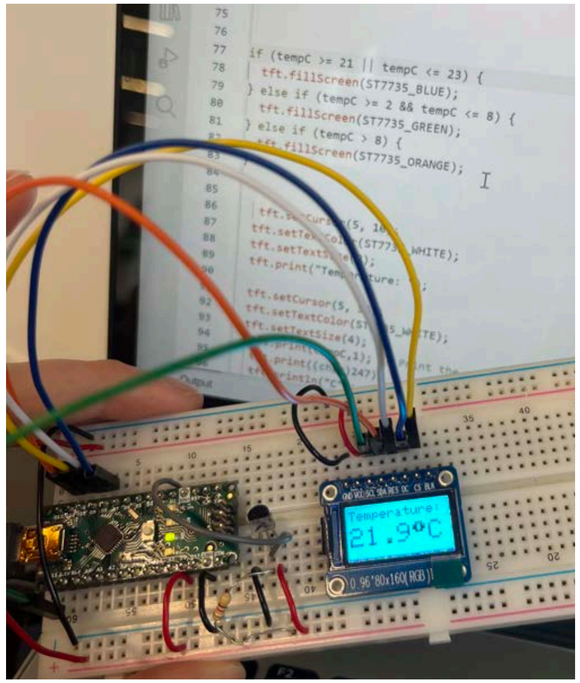
Temperature limited to one decimal place and text size increased, addition of if statements to colour-code the screen based on temperature readings.

I found the colour settings of my screen confusing at first, as it's an off-brand Adafruit screen and the colour it displayed didn't match the colour stated in the code.





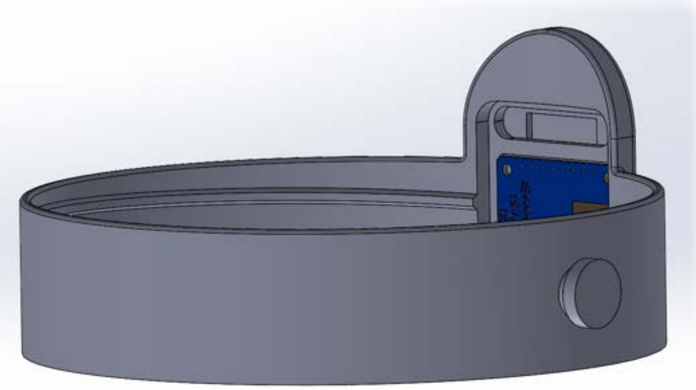


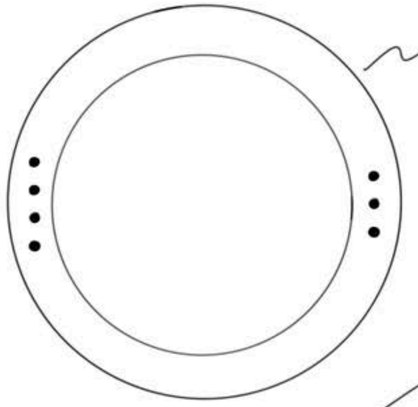


Electronics Hardware
Development of Functionality

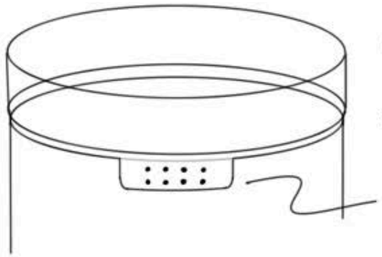
Some sort of contact probes are necessary to complete the circuit between the screen at the top and the sensor, batteries and main components at the base.

The screen has seven pins, so would require seven contact probes/pogo pins between the top and bottom of the product. I initially struggled to find a seven-pin connector so looked at using two four-pin ones. Currently the lid screws on, this could raise issues with pogo pins as there's a high risk of the wrong pins making contact.

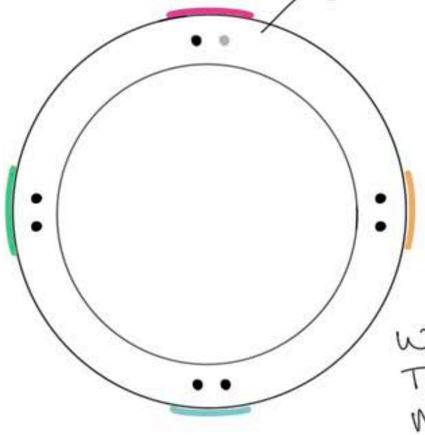




EASIER TO ENSURE CORRECT CONTACT IF SPLIT INTO FEWER SECTIONS OF PINS?



COULD HAVE THE PINS ON A SEPARATE TAB RATHER THAN ON CIRCUMFERENCE OF TOP



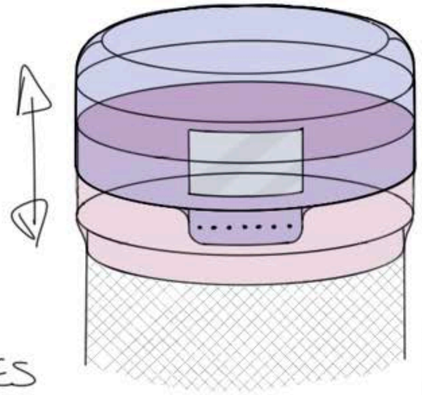
COLOUR CODING/ MARKING ON OUTER COULD ENSURE CORRECT CONTACT

↳ BUT MORE EFFORT/ THOUGT REQUIRED OF USER

↳ WORKING ON ASSUMPTION THAT LID SCREWS ON, BUT A MAGNET COULD WORK

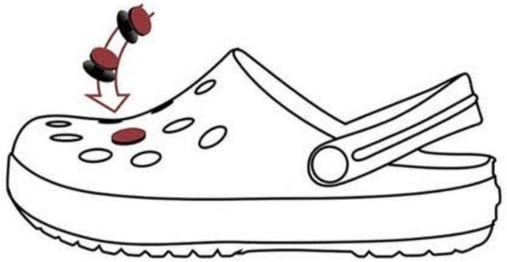
VERY CHUNKY

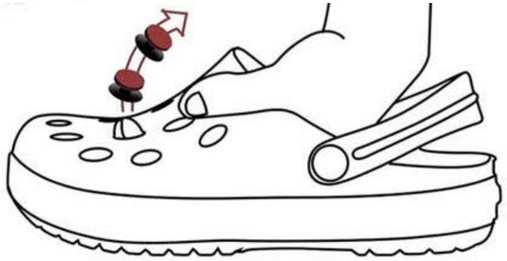
HAVING SCREEN ON SIDE MEANS LID COULD BE SLIMMER



+ CONNECTION BETWEEN PINS ON SCREEN & CONTACT PROBES IS SECURE

↳ SCREEN, ALSO WOULDN'T BE OBSCURED BY STRAP THIS WAY





Having the knob be part of the lid would reduce the number of stages in the manufacture, and also mean the prototyping of the strap would be much simpler.

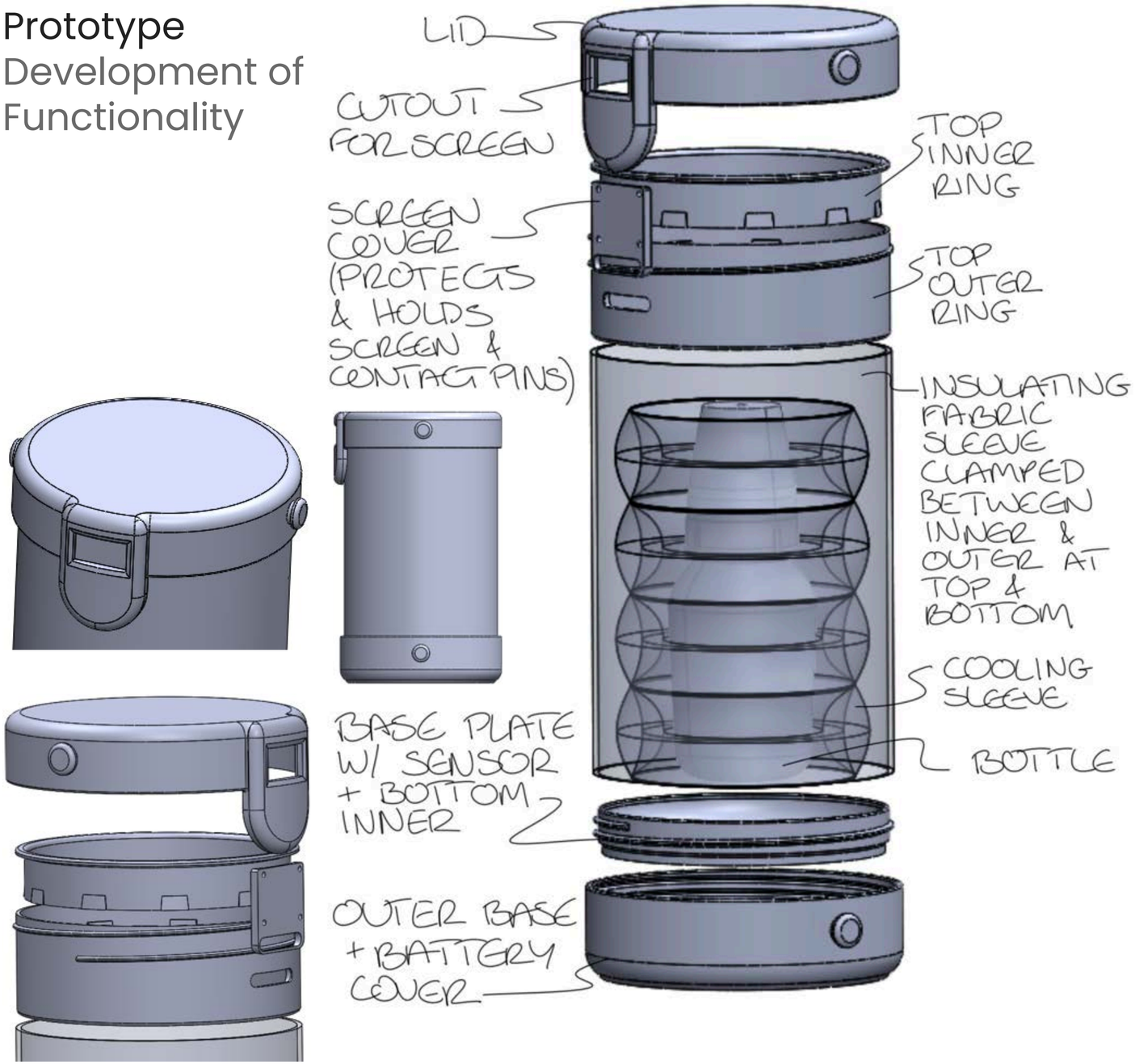
Having a hard PLA knob and a softer strap (TPU) would work similarly to the charms on Crocs shoes that can be popped in and out.

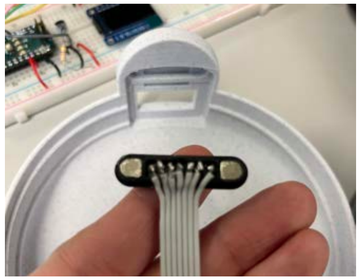
Summary of key findings

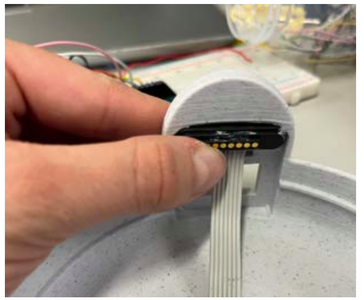
I found and ordered some pogo pins suitable for my project, and adapted the design to incorporate these.

I made the decision to move the screen to the side as this allows me to place the screen and pins next to each other, means the screen won't be obscured by the strap, and also adds a bit of aesthetic interest so the design isn't simply a revolve.

Prototype
Development of Functionality







Summary of key findings

This model has the updated positioning of the screen, based on the addition of pogo pins and realisation the screen could potentially be obscured by the carrying strap if at the top. I'll need to work out the best way to design the strap for this new position.

Iterated design has the knobs for the strap as part of the lid, rather than on a separate band, to reduce the number of parts and materials contributing to the cost. This also limits the number of areas with potential for dirt/grime to gather.

Top Prototype
Development of Interaction + Functionality

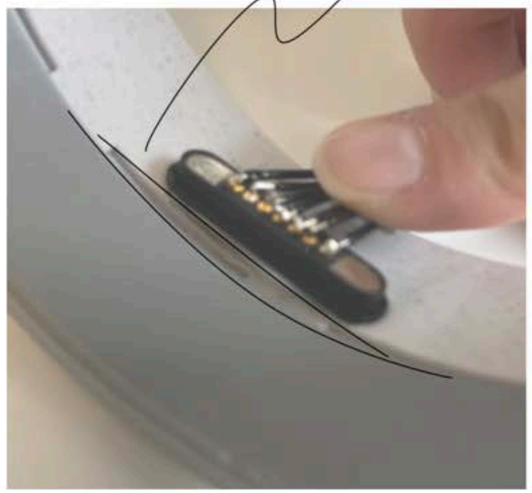
TOP OUTER RING

SLOT NOT BIG ENOUGH

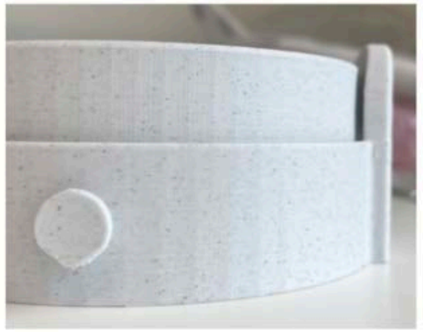
CURVATURE OF RING MEANS CONTACT PINS DON'T SIT FLAT

+THERE'S A BIG GAP

2 WOULD NEED TO GREATLY INCREASE THICKNESS TO RESOLVE THIS



CUTOUTS I DESIGNED FOR CONTACT PINS TO SLOT INTO AREN'T BIG/DEEP ENOUGH



TOP OUTER RING + LID

DOESN'T SCREW ON PROPERLY -CONTACT PINS PROTRUDE TOO MUCH

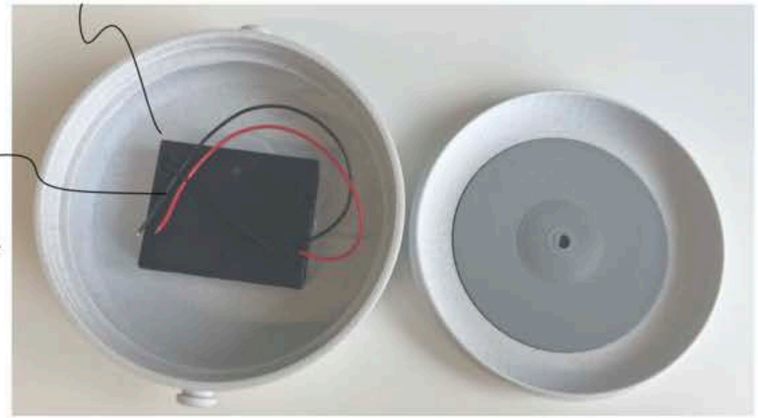
GAP NEEDS TO BE BIGGER

Summary of key findings

Base Prototype
Development of Interaction + Functionality

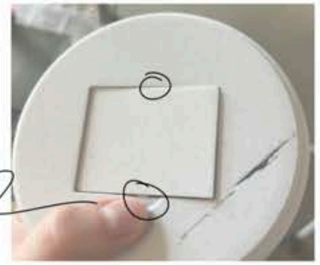
BATTERY HOLDER FITS UNDER BASE PLATE & SENSOR

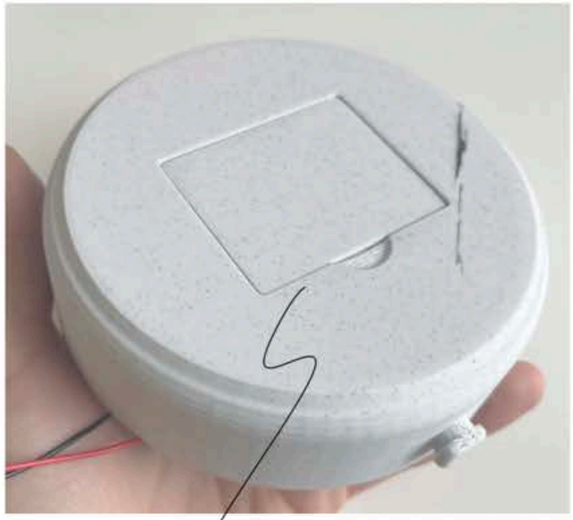
NEED TO WORK OUT HOW TO SECURE PCB IN THIS SPACE



BOTTOM INNER PROTRUDES TO MAKE IT EASIER TO SCREW IN AND SECURE OUTER INSULATING SLEEVE

BATTERY COVER WOBBLES AS ONLY SECURED IN TWO PLACES





COVER SNAPS IN PLACE WELL

GOOD FIT, SECURED BY 2x RIDGES ON INSIDE (BUT CAN STILL PULL OUT SO MORE IS NEEDED)

Conversation with a technician

Development of Functionality + Considering Viability

I have a pack of these mini ice packs that have gel in individual sections making the pack flexible and also means I can cut it. I showed this to the technician I spoke to alongside an air column bag.

3 Reusable Mini Ice Packs

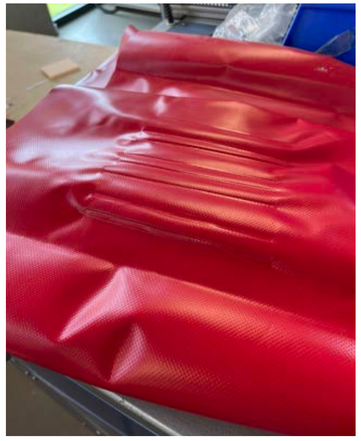
★★★☆☆ (28 reviews)

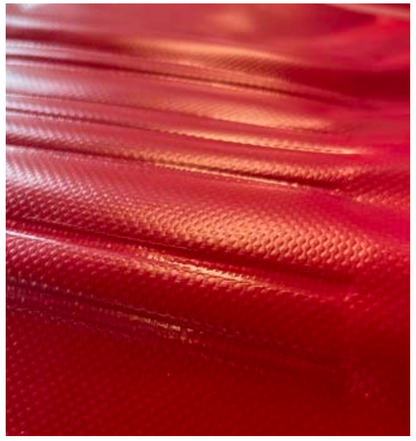
£4.99

Product Features

- Pack of 3 reusable mini ice packs
- Keep packed lunches cool
- Perfect for picnics
- Contains non-toxic food safe liquid
- Flexible and easy to wrap around picnic items
- Lakeland 3 year guarantee included

Examples of high-frequency welded PVC made in the workshop. The welding process is a lengthy one, and the material is rather thick and inflexible, so I'm not sure if using something like this would be suitable for my purpose.





UPVC & High frequency welder.

Put a soldering iron to a corner.

Inflating is a pain, needs valve.

Impact adhesive?

Superglue?

Fabrics. (interfacing/ hemming)

Double up the cooling packs to strengthen shear.

Summary of key findings

After this conclusion I concluded it would be difficult to make my own inflatable sleeve, as the high frequency welder in the school have only ever been used with PVC/ UPVC and this is all that's covered in its risk assessment.

Even if I could make separate, air tight sections, inflating them would be a big project requiring valves, and I'm not sure how I'd seal them as I wouldn't be able to use the welder. Sealing the cooling gel in plastic would be even more challenging. Cauterising with heat might work but isn't very reliable or repeatable.

I concluded that adapting bought-in cooling packs is the most feasible solution to use in my prototype, as the manufacturability of such products has been proven.

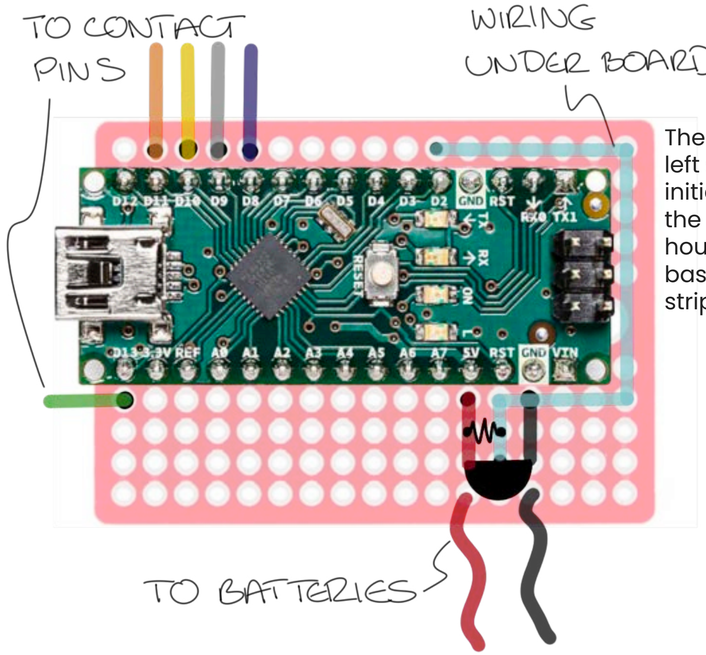
The cooling packs I have have narrow seams at the edges so I don't have much material to work with to connect the packs to each other, or to elastic or another material. Sewing is likely not an option, as the material looks to tear easily, similar to a crisp packet or cellophane.

I was advised on some types of glue that may work, but would require experimentation to find the best option. I also could test how the cooling packs respond to heat by using a soldering iron on a corner of one.

The technician suggested doubling up on the cold packs, i.e. by fixing one of the packs to the midpoint of the next one, so they partially overlap. This would add strength and give the sleeve more opportunity to stretch without failing due to shear.

Looking at some readily available cool packs that I could use in my prototype:

Circuit
Development of Functionality



The image to the left shows my initial plan for the electronics housed in the base, using stripboard.

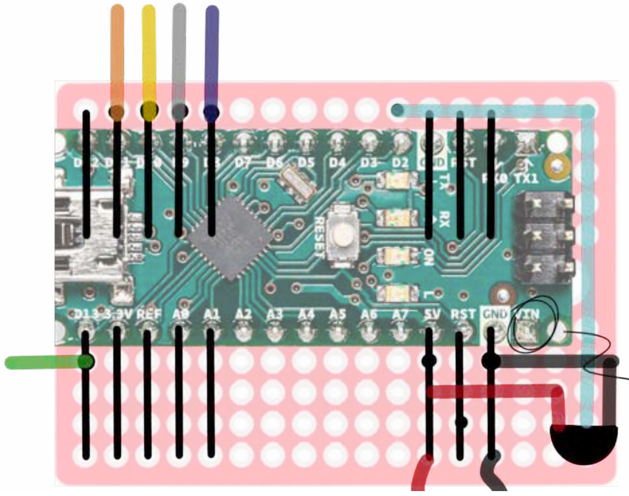
After soldering some of the components into my board, I realised the stripboard was actually a miniature breadboard, with the columns of pins connected. This meant the data pin on the temperature sensor would incorrectly go to the 'RST' pin on the Arduino.

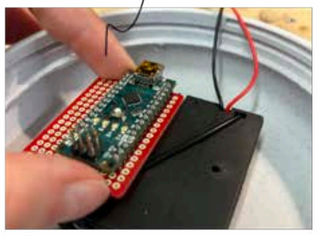
I decided I'd have to unsolder everything and buy a basic stripboard to move my circuit onto.

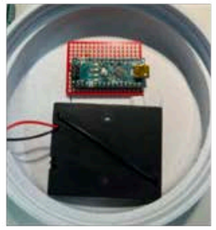
I identified a second issue whereby the board with the components on it was too tall to fit in the housing with the battery holder, illustrated below.

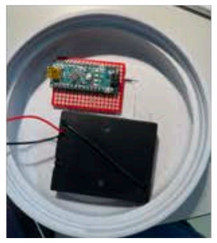
However I later realised:
- the circuit doesn't necessarily need to be positioned so the sensor is at the centre as I can use wires to connect the sensor to the circuit
- The columns of pins being connected isn't a major issue as I can use a knife to cut through the bridge between pins, and use the board as I had originally intended to in the image to the left.

I redesigned the base, as in the following pages, to reflect these changes





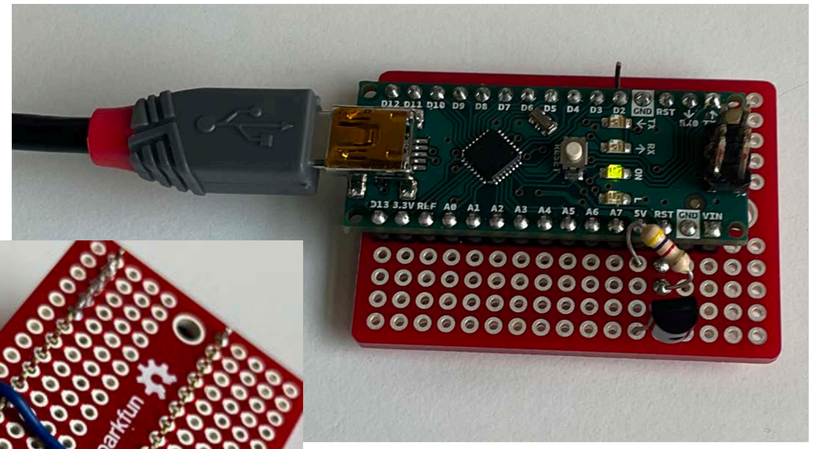


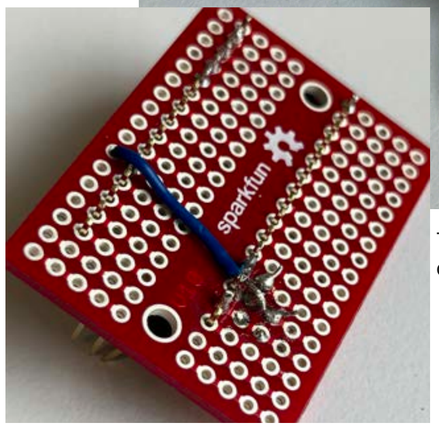


DON'T HAVE ENOUGH FREE ROWS LEFT TO USE SENSOR ON THIS BOARD

NEED TO REDESIGN TO EITHER:
- MAKE THIS SECTION DEEPER
- HAVE THE CIRCUIT & BATTERY SIDE-BY-SIDE

2 BUT SENSOR NEEDS TO BE AT CENTRE OF BASE





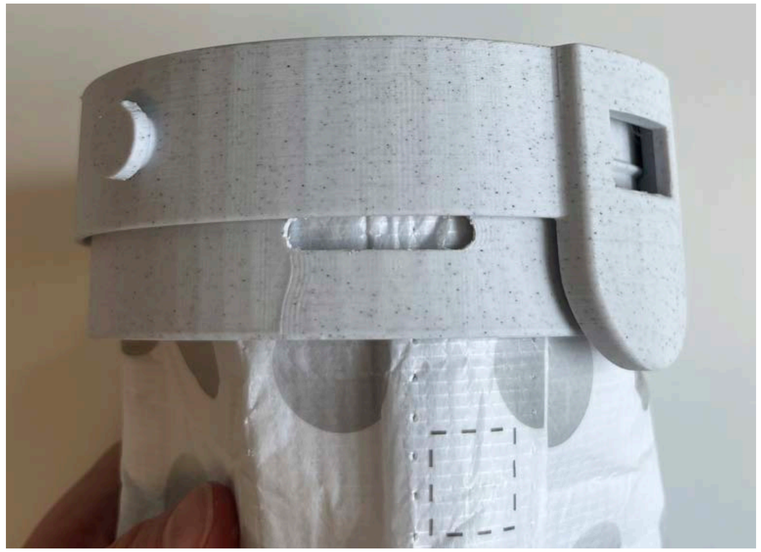
The image below shows my initial plan for the electronics housed in the base, using stripboard.

Summary of key findings

My original plan to use the stripboard can go ahead after all.

I wasn't able to test the stripboard circuit, however, as my Arduino was playing up and refusing to upload the code to the Arduino after I moved the circuit to the board.

Prototype Iteration
Development of Functionality



Summary of key findings

The model worked well, and the tolerancing at the base was improved. I could, however, pop out the inner ring and fabric, which is a slight issue

I should stick/sew the fabric into a tube before clamping it in place with the hard parts at the top and bottom, as currently it moves around a bit and sits wonky.

I need to add more layers of material to see how well this works with the clamping system, as I will need at least one more layer of insulating material and an outer fabric, to insulate the contents but also to sandwich the wires between so they're protected.

I also struggled to get the 'knobs' for the strap to line up when I screwed the lid on, and the slot for the contact pins didn't line up, so I'll need to amend the CAD to fix this.

Prototype Iteration
Development of Aesthetic + Interaction

Full height:

I used kids' craft foam to model the strap that will be made of silicone. This was helpful to visualise the final product's form better.

Reduced height:

I then tried adding additional holes to the strap to test the adjust-ability of the product's height by fastening the strap with a shorter distance between the top and bottom.

Summary of key findings

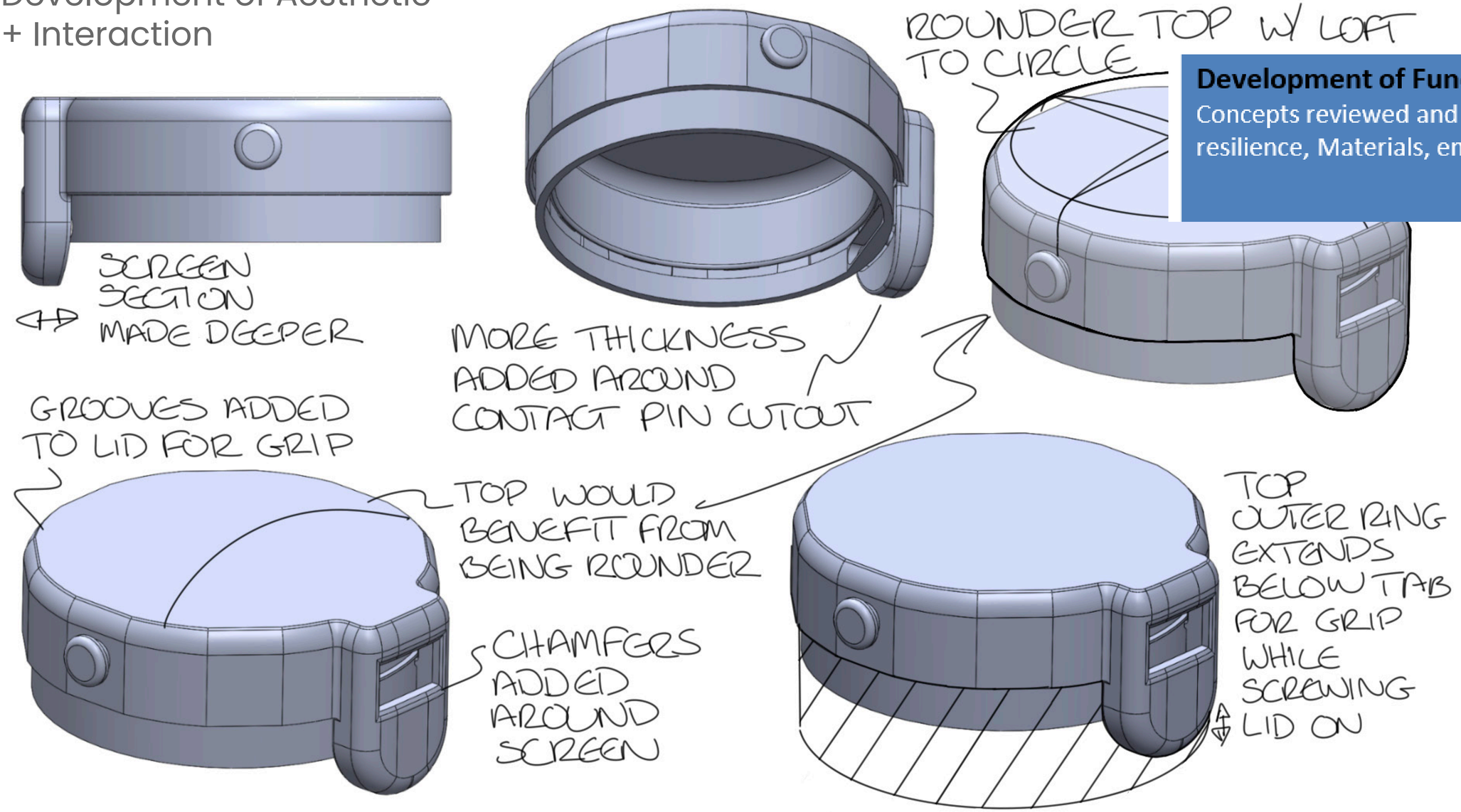
I identified an issue where depending on where the clamping elements at the top and bottom were fixed, the knobs didn't necessarily line up. This was resolved by adjusting the base section.

I'm not sure about the aesthetic of the product with the reduced height, the crinkly material looks odd.

Having multiple holes in the strap isn't ideal for a few reasons (aesthetic, potential for getting dirty, potentially weakening the strap).

Next steps are to test and work out the optimal length for the strap. I may need to reinforce the foam with a harder plastic where the holes are.

Prototype Iteration
Development of Aesthetic + Interaction



Development of Functionality

Concepts reviewed and advanced; e.g. integrity, resilience, Materials, embedded technology

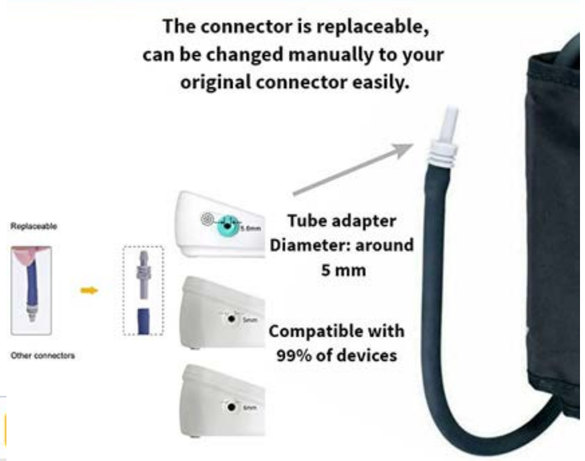
Summary of key findings

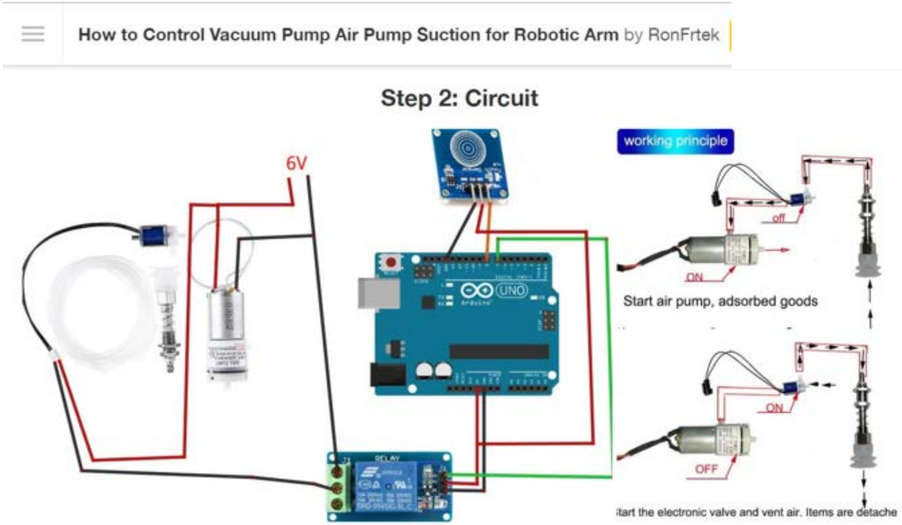
I explored a few ways to develop the design of the lid assembly to improve the aesthetic and ease of use:

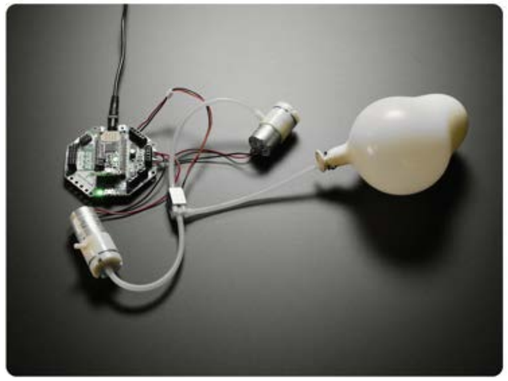
- adding grooves to the lid,
- extending the top ring, to make it deeper and allow the user to grip it while screwing,
- making the 'tab' section where the screen is deeper,
- chamfering the area around the screen, and
- reducing the diameter of the top and bottom assemblies so they can be held more easily by women's hands

Blood Pressure Monitor Cuff
Development of Functionality

I looked at either disassembling a blood pressure monitor and using it to inflate the outer sleeve of my product, or buying a replacement cuff for a blood pressure monitor and building a circuit myself to inflate this with. I concluded this would be too large to work with my existing design and the electronics would be too complex to work out in the limited timeframe.







Air Pump and Vacuum DC Motor - 4.5 V and 2.5 LPM - ZR370-02PM
Product ID: 4699
$7.95
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1 Add to Cart
Also include 1 x Silicone Tubing for Air Pumps and Valves - 3mm ID - 1 Meter Long ($2.50)

Qty	Discount
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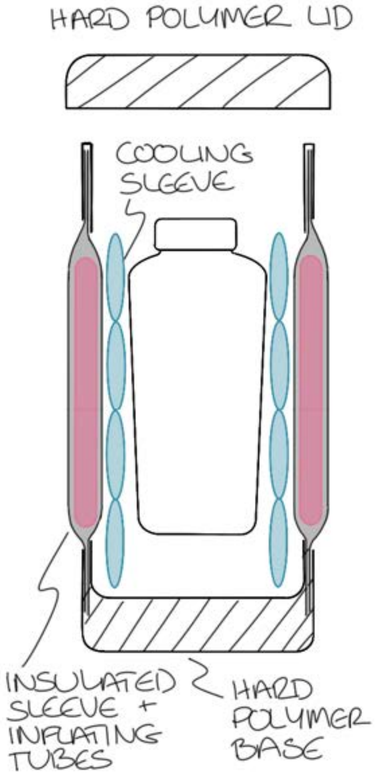
100+	$6.36



I then discovered wrist blood pressure monitors, which are smaller, and have much smaller electronics. I've ordered one to have a look at and see if I can fit this in my design.

Salter BPW-9101-GB Automatic Wrist Blood Pressure Monitor, Single User 60 Memories, Compact and Portable, Irregular Heartbeat Detection, One Button Measurement, Adjustable Cuff, Low Battery Indicator
Visit the Salter Store
4.5 ★★★★½ 2,959 ratings | 45 answered questions
£22.98
prime One-Day

Summary of key findings

I watched a few blood pressure monitor teardowns which helped me understand how they work and conclude that recreating one isn't feasible.

I have ordered a wrist blood pressure monitor as these are smaller and have smaller circuits. I'll have a look at that and see if it's worth taking apart to use parts of in my prototype. This is mostly constrained by time, and isn't essential as an inflatable cuff is proven to work and widely used.

Week 11 Tutorial
Development

Arduino not relevant to fdio.

Multiple velcro straps

2 Different contours/radii

Anthropometric data on women's hands.

Texture on screw lid - can double as aesthetic.

Document moving of screen.

Silicone also adds shock absorption + grip on lid

2 also CMF can add colour.

Top has a large footprint - branding could add a logo/ graphic.

Embossed/silicone insert.

BP cuff

2 don't add to physical prototype, won't have time.

Marks mostly come from CAD, not prototype

L Does this make sense in the context.

Concept exists so don't need to put it in prototype

How would a user interact?

Experiment with buttons & testing.

2 In the concept world rather than physical.

Contact pins
- work backwards in solidworks

Max. overlap between lid & top outer.
then work at screw.

Knobs lining up - can have base rather than top only worry about contact pins at top.

Show that I know:
- screw mechanism
- that knobs need to line up.

Ethics for survey
- is it covered by SI ethics?

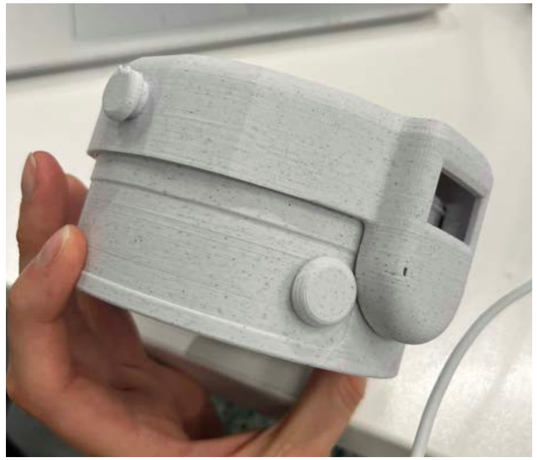
- Show CAD development
  - in context renders
  - storyboard
- Focus on CAD rather than physical prototype.

Summary of key findings

Use of silicone in the strap has some CFM advantages I hadn't previously considered, such as the possibility of adding colours and texture to the design. I could also use silicone overmoulding at the top to add branding to the design.

At this point I should focus my any development on my CAD, as this is a faster way to show my thinking and make changes to the design.

Prototype Iteration
Development of Aesthetic + Interaction

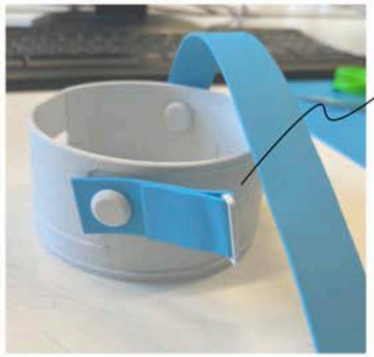


The updated lid worked well and was more comfortable to hold and unscrew, partly due to the reduced diameter

• The wider screen section worked better with the screen inside it, however the gap between the screen's tab and the top is very small, so this needs to be amended.
• The cutout that makes a flat surface for the

The 'knobs' on the outer ring of the container

LONGER STRAP MAY BE NEEDED W/ LID ON + DIFFERENT CONFIGURATIONS



LOOP A BIT TIGHT

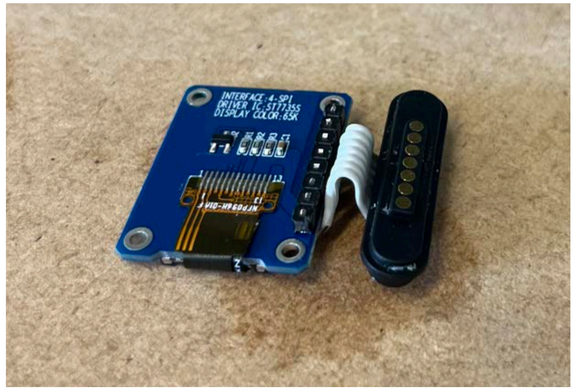
STRAP ALREADY WRAPS TO BOTH KNOBS

WHERE WOULD ADDITIONAL LENGTH GO?

Electronics Development
Development of Functionality

Soldering the screen onto pogo pins + screwing in place.

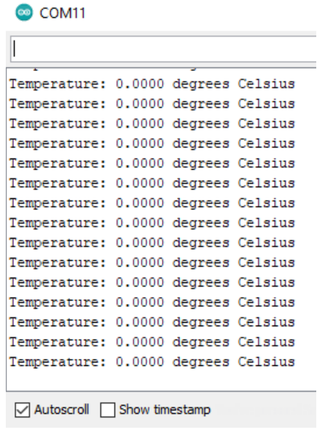
I wasn't able to actually test the functionality of the pogo pins, or the whole circuit put together, due to the issues outlined to the right.

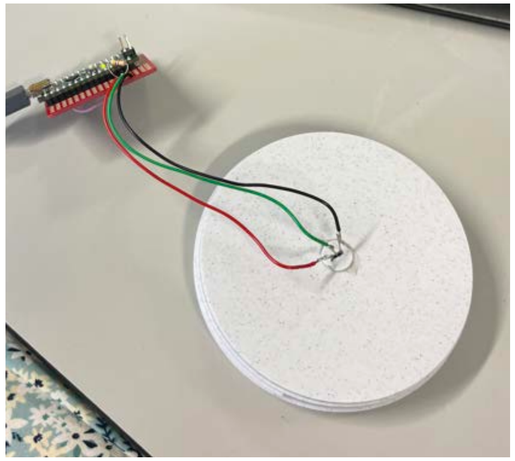


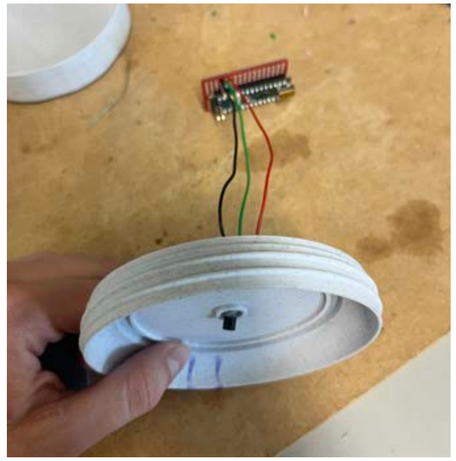
Electronics Troubleshooting
Development of Functionality

With help from a tutor, I was able to diagnose my Arduino issues as the fault of my computer, as we were able to upload the code to the Arduino and get the temperature displayed on the serial monitor when using a different computer.

However this wasn't the only issue, as even when the code uploaded from a different computer, the temperature was read as being 0 degrees, and all the data on the serial monitor was also 0. This was hypothesised to have been caused by the sensor not being soldered into the board, and just placed in it.







By recreating the circuit on a breadboard with an Arduino Uno, and then a clone Nano, we were able to obtain accurate readings from the sensor.

This meant the issue was not with the sensor(s), but with either the soldering in my circuit, or with my Arduino Nano.

Further testing is required to diagnose and resolve the issue.

Soldering the sensor into place didn't resolve the problem, nor did resoldering the wire connecting the data pin from the sensor to the relevant pin on the Arduino to ensure the connection was reliable and not touching any other pins.

I then swapped out the temperature sensor for another DS18B20 sensor, which also provided readings of 0.0000 degrees.

Summary of key findings

Various issues have arisen that have made completing and putting aside the electronics difficult, this has been very frustrating and stalled the process of developing my prototype.

Aesthetics
Development

LID HAVING CUTOUT IS SATISFYING

RIDGES ADD GRIP

SATISFYING GROOVE - GOOD ON A LID

SMOOTHING INTO BODY IS SATISFYING + WON'T COLLECT GRIME

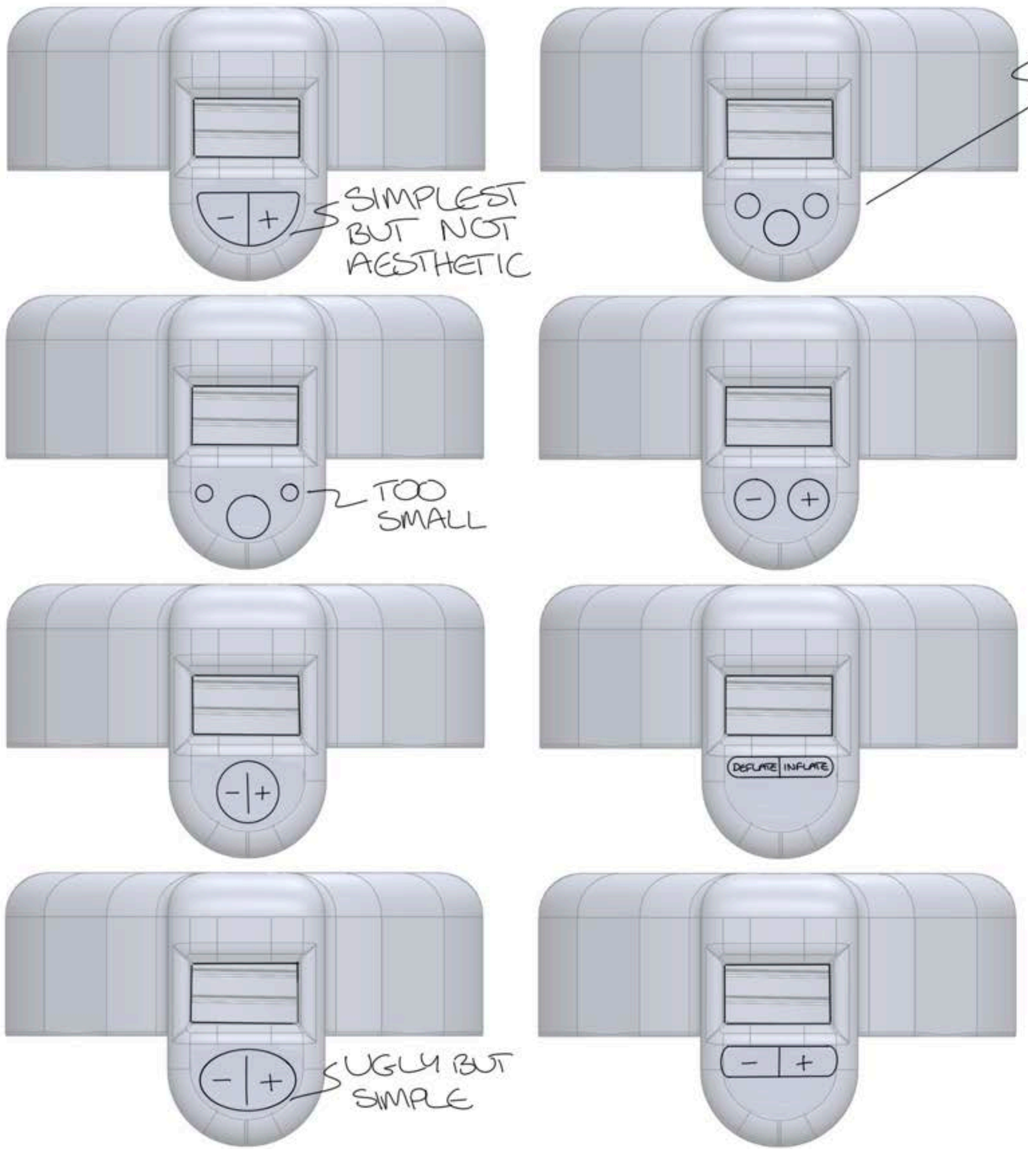
MORE COMFORTABLE GRIP - GOOD TO MAKE LARGE DIAMETER EASIER TO USE

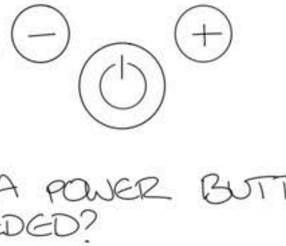
EXTRUDED RIDGES & GOOD GRIP BUT MAY COLLECT DIRT

INTRIGUING TEXTURE

NOT VERY AESTHETIC

Prototype Iteration
Development of Interaction



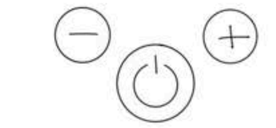


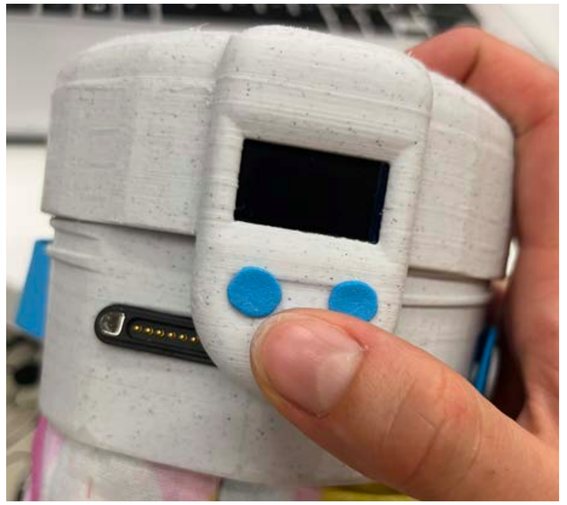
IS A POWER BUTTON NEEDED?

COULD BE USEFUL TO TURN OFF INFLATING SYSTEM + SCREEN WHEN NOT IN USE - SAVE BATTERY

↳ WANT TO ENSURE SCREEN WON'T GET TURNED OFF BY ACCIDENT

Turn off device?
Press + and − to confirm





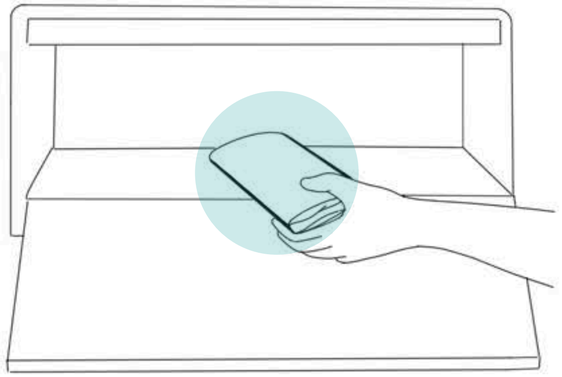
Summary of key findings

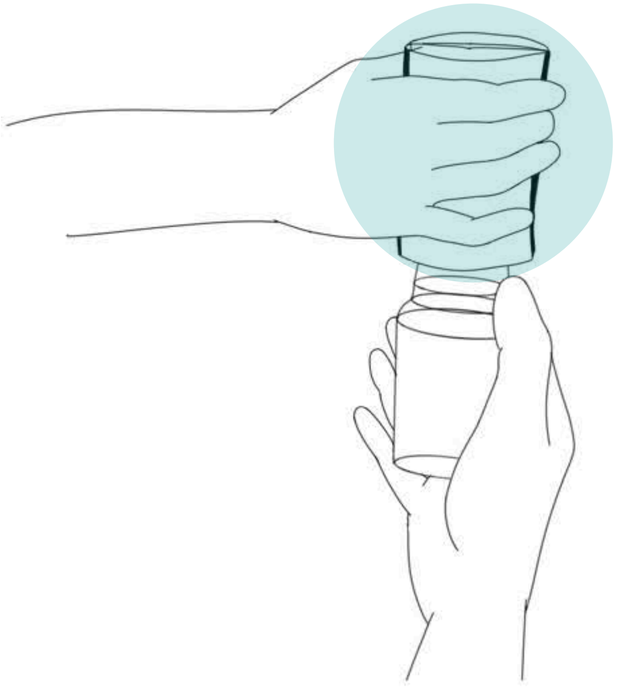
I initially didn't think I needed a power button, however have realised it could be beneficial to save battery when the product's not being used.

When holding the model I wasn't sure if I'd be able to fit the buttons onto the screen tab, however having cut out buttons from foam I think they work fine.

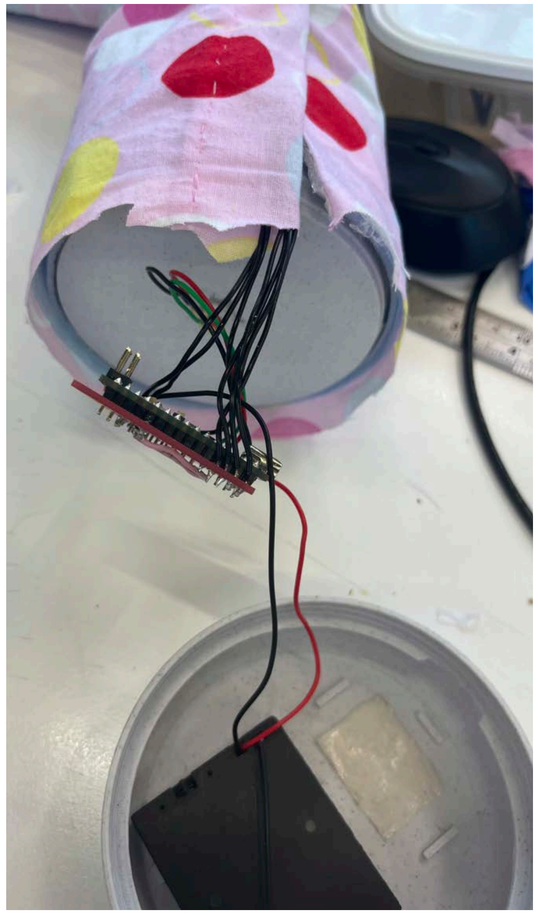
User testing should validate the button sizing and positioning.

Scenario Board
Development of Interaction





Prototype Assembly
Development



Summary of key findings

I initially didn't think I needed a power button, however have realised it could be beneficial to save battery when the product's not being used.

When holding the model I wasn't sure if I'd be able to fit the buttons onto the screen tab, however having cut out buttons from foam I think they work fine.

User testing should validate the button sizing and positioning.

Final Prototype
Development

Evaluation Plan
User Testing Approach

Should I perform user testing, PDS metric testing or both?

User testing is important to the success of my product to understand how intuitive it is to use, how well users think it works, what the best way to convey the temperature to the user is.

PDS metric testing of some of the functions is also important to confirm whether or not my product actually can, or could feasibly, cool the milk and keep it cool.

What does my product do and how does it communicate this to the user?

My product chills breast milk to allow it to be safely stored when outside the home. It doesn't communicate this to the user, as my research showed that many women feel shame and stigma surrounding breastfeeding, expressing, and how they store their breast milk.

The temperature is displayed on the outer so the user can monitor it and ensure the temperature is safe. User testing can help determine whether users want this to be communicated quite so clearly or if an alternate method, such as phone notifications would be preferable.

Who are my users?

My users are mothers who are doing paid work outside of the home and are apart from their babies for extended periods of time.

I do not have access to many mothers of babies, so my user testing will primarily be carried out amongst other students.

Will my prototype(s) allow participants to complete the whole task/tasks that the product enables, or a sub set?

My prototype allows participants to complete the initial task of placing a bottle of milk in the container, but not the inflating of the sleeve to secure the bottle in place. They can, however, interact with the interface that would trigger the inflation.

Completing the task of waiting and monitoring the temperature over a number of hours is not realistic in the timeframe, however.

If not how can I simulate parts of the task/tasks if the prototype is only partially working?

Could I 'wizard of Oz' alter the display on the screen to mimic the contents of the container exceeding fridge temperature? What would I gain from this? It would be good if I could have tested different alert mechanisms but this is not feasible in the timeframe.

Background information:
• Breastfeeding, and expressing is a mentally and physically draining process, which uses up a lot of energy, and also interrupts sleep to feed your baby at night.

• Breast milk is often referred to as 'liquid gold', and mothers joke that it's okay to cry over spilt milk if it's breast milk. To quote one blogger, 'There's really no such thing as overreacting when it comes to the loss of breast milk'.

• Expressing, commonly known as pumping, is often required to allow a mother to keep up her supply when apart from her baby. A frequent routine is to express milk to take to childcare the next day to be given to the baby so they can enjoy the benefits of breast milk.

However breast milk has to be stored carefully as babies have limited immune systems. The NHS guidelines are:

• breast milk can be safely stored at room temperature for up to one hour
• once it's been cooled in the fridge it can be carried in a cool bag with ice packs for up to 24 hours.

Scenario:
• You have finished expressing breast milk in a designated private, locked room in your workplace
• You have five minutes to put the bottle away and pack everything up to get back to work

Task:

• Put the bottle in the cooling sleeve,
• Put the bottle and cooling sleeve in the container,
• Turn the container on
• Secure the bottle in the container
• Check the bottle's temperature once in the container
• Remove the bottle from the container

Key interactions:

1. picking it up
2. putting sleeve on bottle
3. putting bottle in casing
4. screwing lid on (order not decided, may be switched with no. 5)
5. inflating the outer (order not decided, may be switched with no. 4)
6. checking the temperature
7. adjusting the strap
8. cleaning

Inputs:

• inflating the sleeve

Outputs:

• temperature reading

Things to consider/questions to answer:

• Time to complete a task
• Were mistakes made?
• Was the interface confusing?
• Do they find the aesthetic appropriate?
• Do they think the product or interaction has any flaws or areas for improvement?

Summary of key findings

Allowing users to complete the task was hindered by the issues with the Arduino, which meant the screen couldn't be used in the prototype in the user testing.

I'm instead using Powerpoint to test user interactions with the interface. This was actually advantageous as it meant I could artificially speed up the cooling process and test the way temperature is fed back to the user.

Product Semantic Analysis
User Testing Approach

Cool pack

I think the sleeve looks easy to use

I feel confident this could keep liquid cool

Exterior

I think the product’s exterior looks high quality

I find the choice of materials to be appropriate

Stylish

Reassuring

I like the aesthetic

I dislike the aesthetic

I think this product would go well with my bags and accessories

I think the design looks intimidating

I find the design off-putting

Strap

I think the strap looks sturdy

I think the strap looks strong

I think the strap looks reliable

I think the strap looks high quality

I think the strap looks easy to use

Interface

I think the interface looks straightforward

Easy to use

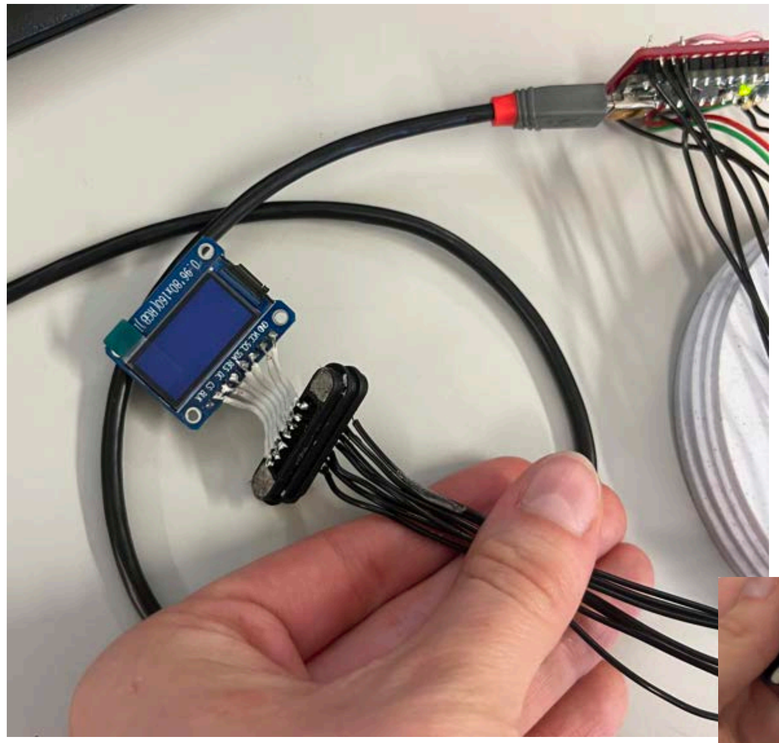
I think the screen should be bigger

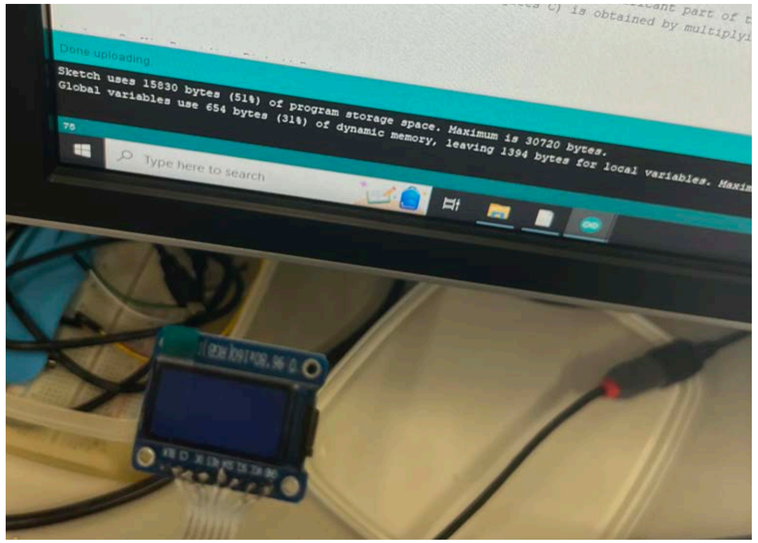
I think the screen placement is appropriate

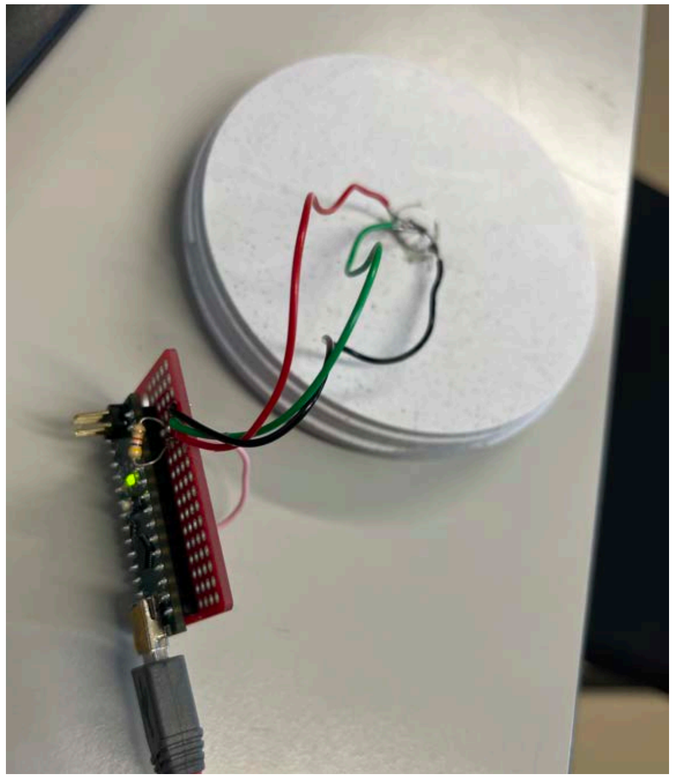
Electronics
Development of Functionality

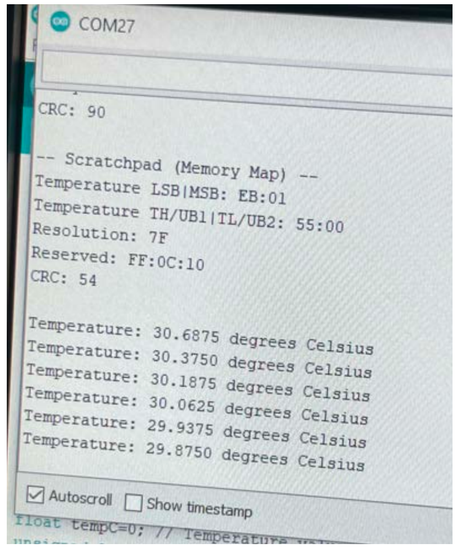
After a lot of troubleshooting and checking the circuit with a multimeter, I realised the bridging between one of the rows was damaged, so the temperature sensor wasn't receiving the power supply from the Arduino's 5V pin.

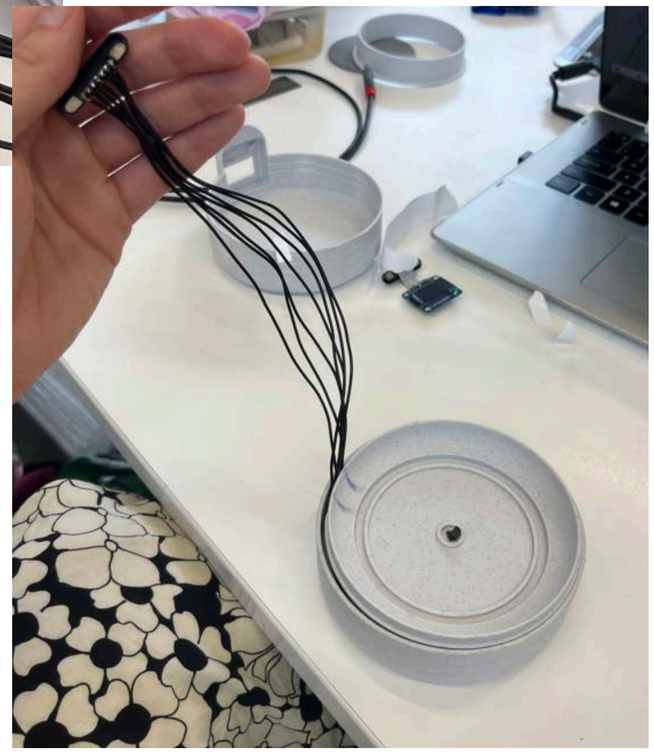
This was fixed by bridging the row with solder and was able to successfully provide readings via the serial monitor.











Summary of key findings

It was a relief to fix the circuit and read the temperature.

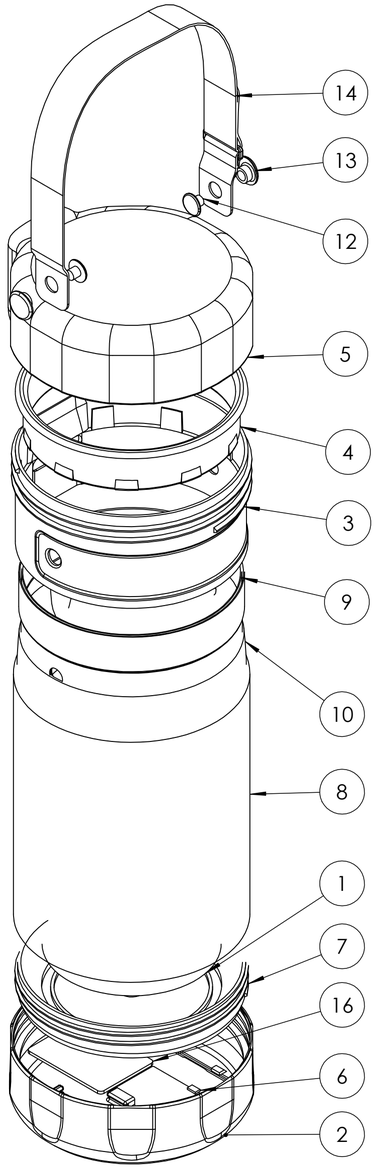
Knowing the Arduino and circuit worked meant I could move on and solder the screen in place to finalise my electronics.

The code that I had gotten to work previously, on page 96, uploaded to the Arduino and turned the screen on but didn't display the data. I checked the soldering was all secure and confirmed the power supply was reaching the screen via multimeter.

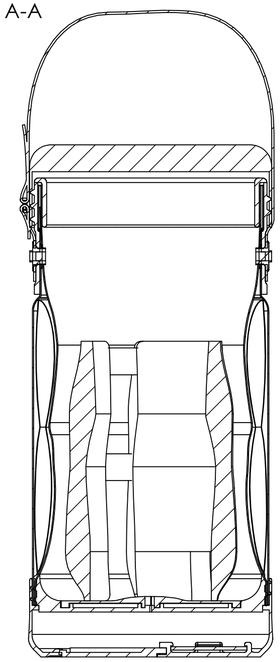
I had to move on and put the electronics aside to allow me to assemble my prototype and test it with users.

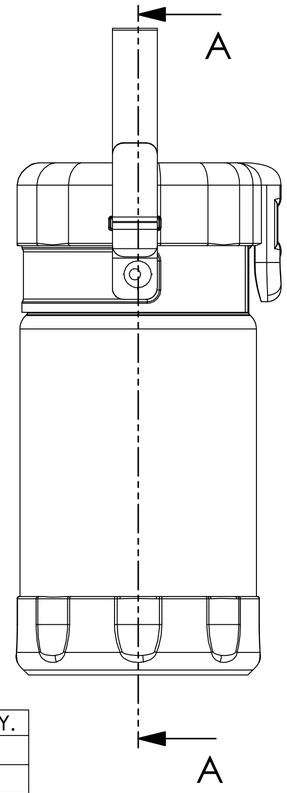
Engineering Drawings 1
Analysis of Feasibility

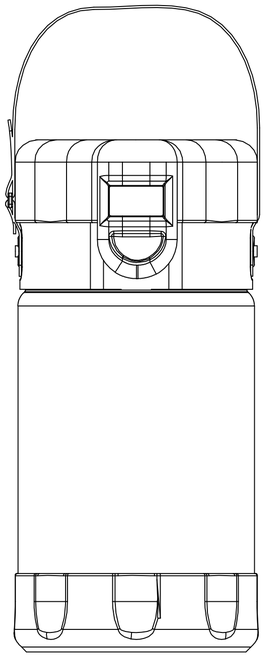
* Exported as A3 and scaled down in portfolio so scale is not accurate



SECTION A-A
SCALE 1 : 2







ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	Base	Injection moulded PET	1
2	Outer base	Injection moulded PET	1
3	Top outer	Injection moulded PET	1
4	Top inner	Injection moulded PET	1
5	Lid	Injection moulded PET	1
6	Battery cover	Injection moulded PET	1
7	Under sensor plate	Injection moulded PET	1
8	Fabric outer	Oilcloth	1
9	Fabric inner	3M Thinsulate CS150	1
10	Inflating Tubes	PVC	1
11	Cool pack	PU pouch	1
12	Inner Pin	Injection moulded PET	2
13	Outer pin	Injection moulded PET	2
14	Velcro	Bought-in strap	1
15	Elastic	Bought-in elastic	1
16	PCB	Laminated plastic	1

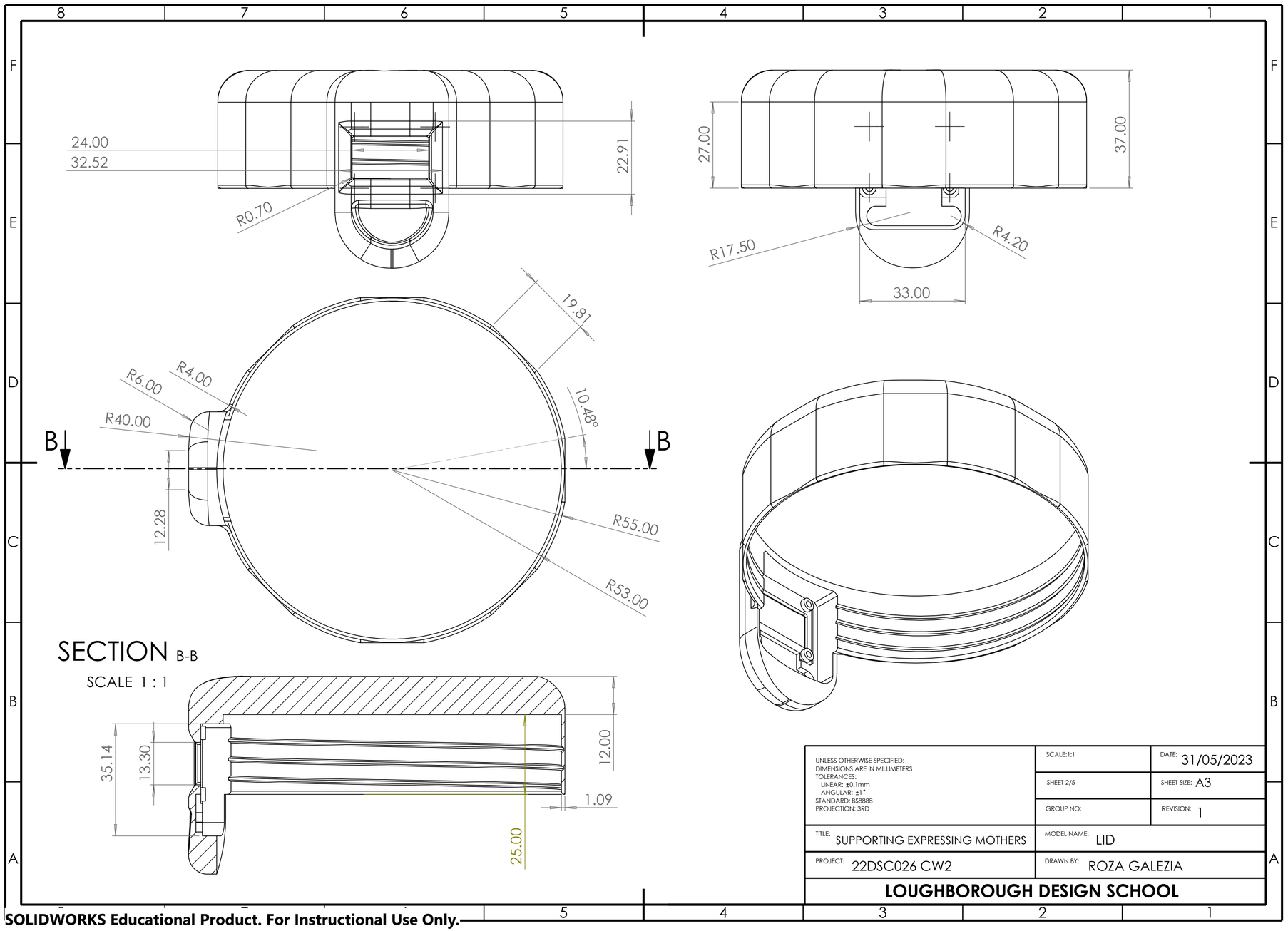
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MILLIMETERS
TOLERANCES:
LINEAR: ±0.1mm
ANGULAR: ±1°
STANDARD: BS8888
PROJECTION: 3RD

SCALE:1:2	DATE: 31/05/2023
SHEET 1/5	SHEET SIZE: A3
GROUP NO:	REVISION: 1
TITLE: SUPPORTING EXPRESSING MOTHERS	MODEL NAME: GENERAL ASSEMBLY
PROJECT: 22DSC026 CW2	DRAWN BY: ROZA GALEZIA

LOUGHBOROUGH DESIGN SCHOOL

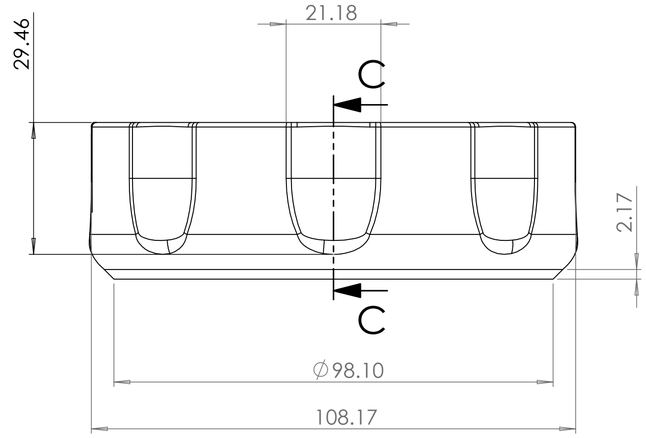
Engineering Drawings 2
Analysis of Feasibility

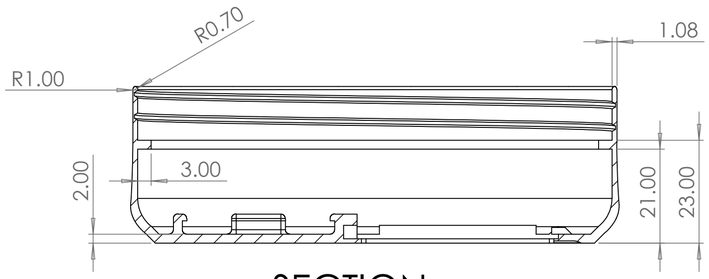
* Exported as A3 and scaled down in portfolio so scale is not accurate



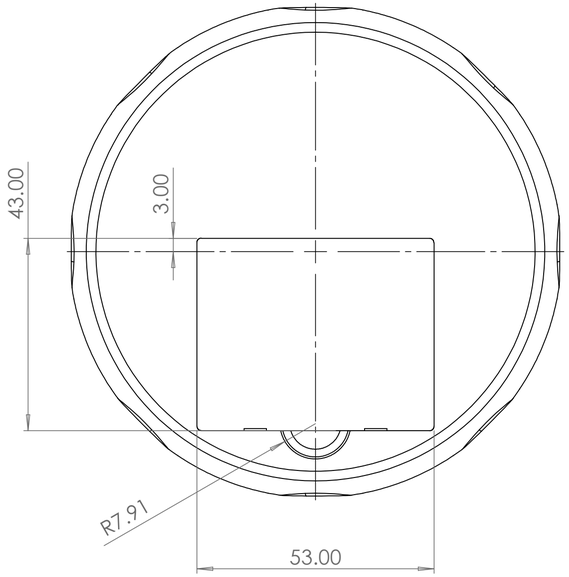
Engineering Drawings 3
Analysis of Feasibility

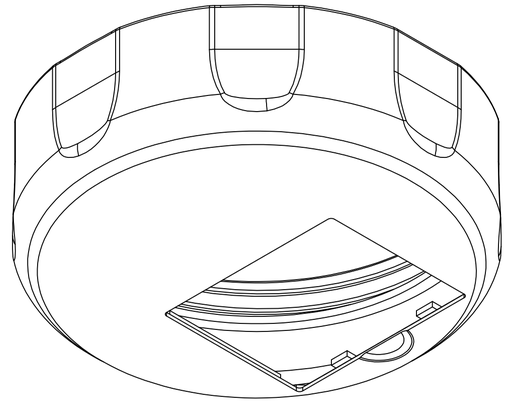
* Exported as A3 and scaled down in portfolio so scale is not accurate





SECTION C-C

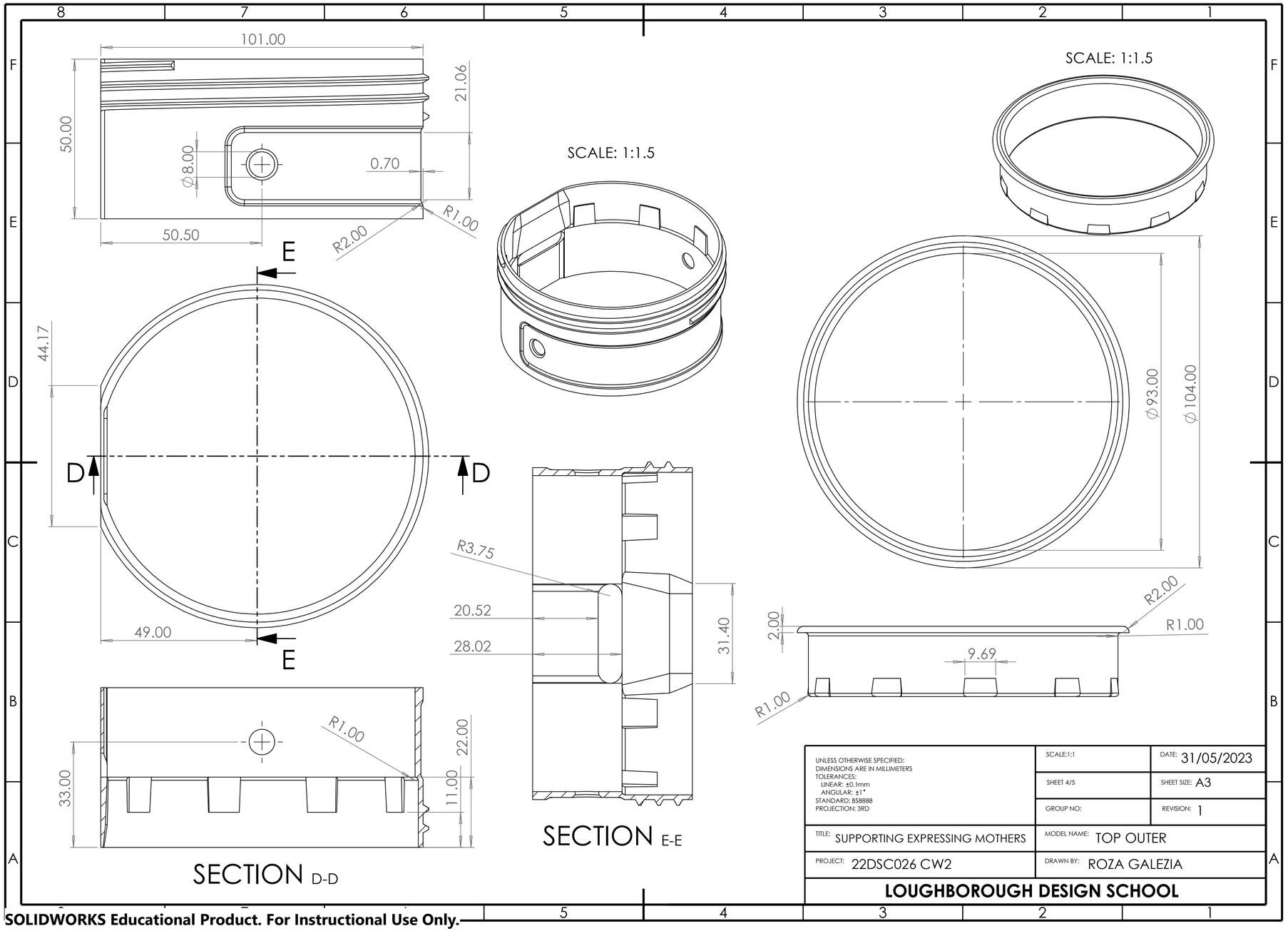




UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS TOLERANCES: LINEAR: ±0.1mm ANGULAR: ±1° STANDARD: BS8888 PROJECTION: 3RD	SCALE:1:1	DATE: 31/05/2023
	SHEET 3/5	SHEET SIZE: A3
	GROUP NO:	REVISION: 1
TITLE: SUPPORTING EXPRESSING MOTHERS	MODEL NAME: OUTER BASE	
PROJECT: 22DSC026 CW2	DRAWN BY: ROZA GALEZIA	
LOUGHBOROUGH DESIGN SCHOOL		

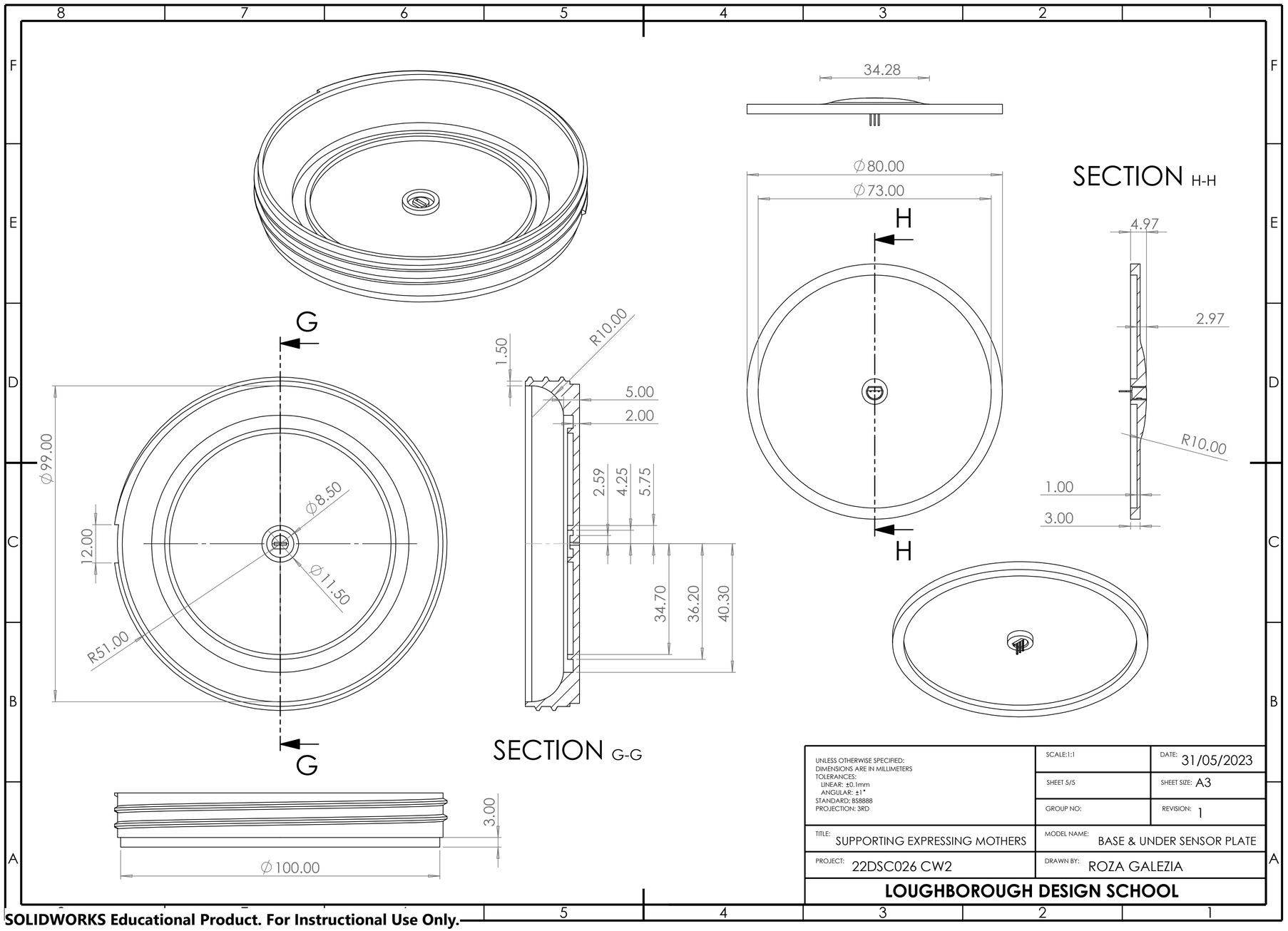
Engineering Drawings 4
Analysis of Feasibility

* Exported as A3 and scaled down in portfolio so scale is not accurate



Engineering Drawings 5
Analysis of Feasibility

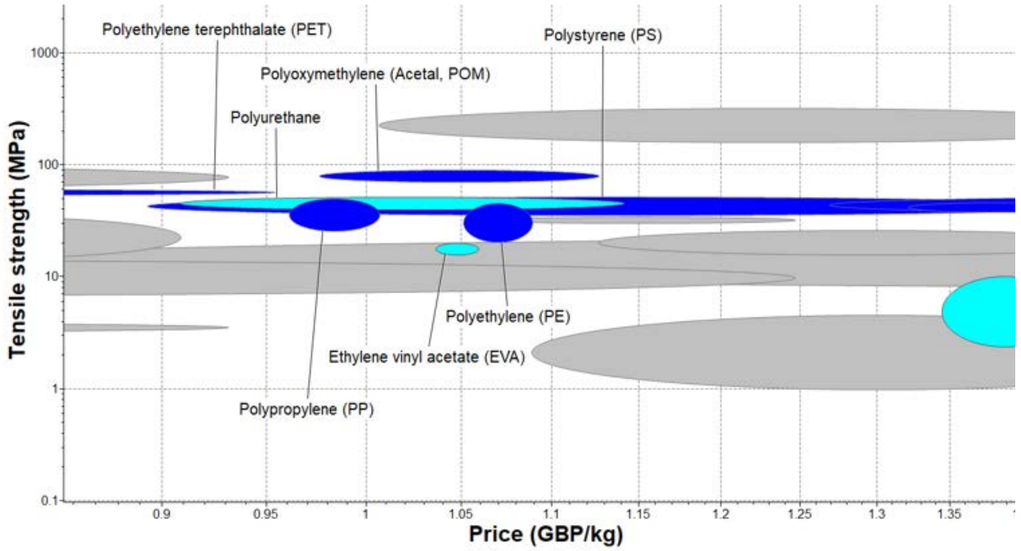
* Exported as A3 and scaled down in portfolio so scale is not accurate

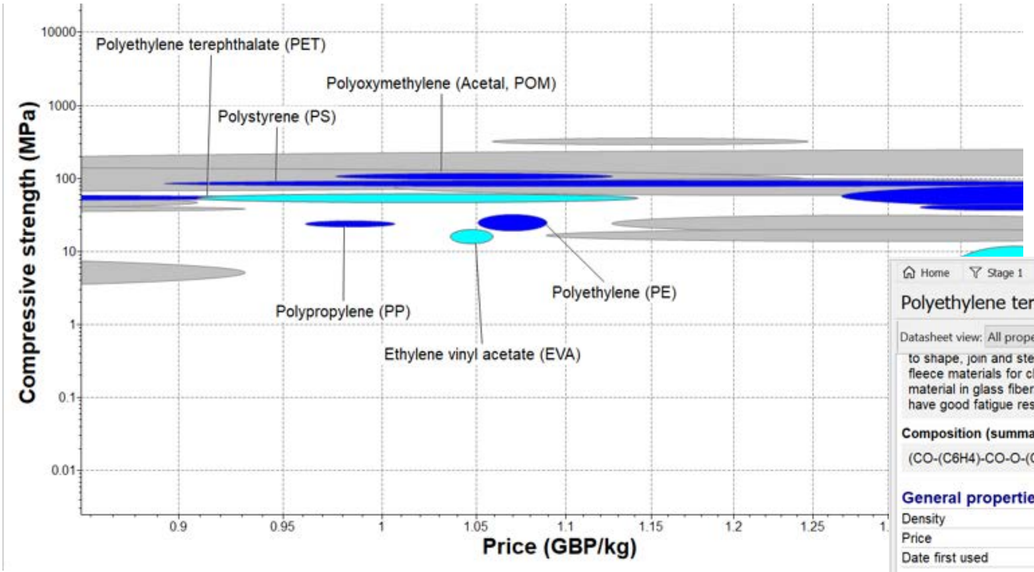


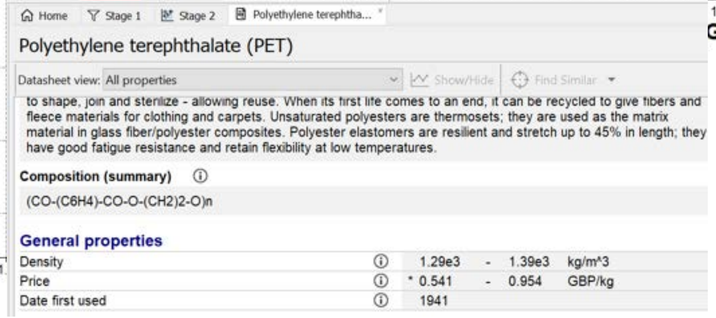
Market Understanding
Analysis of Feasibility + Viability

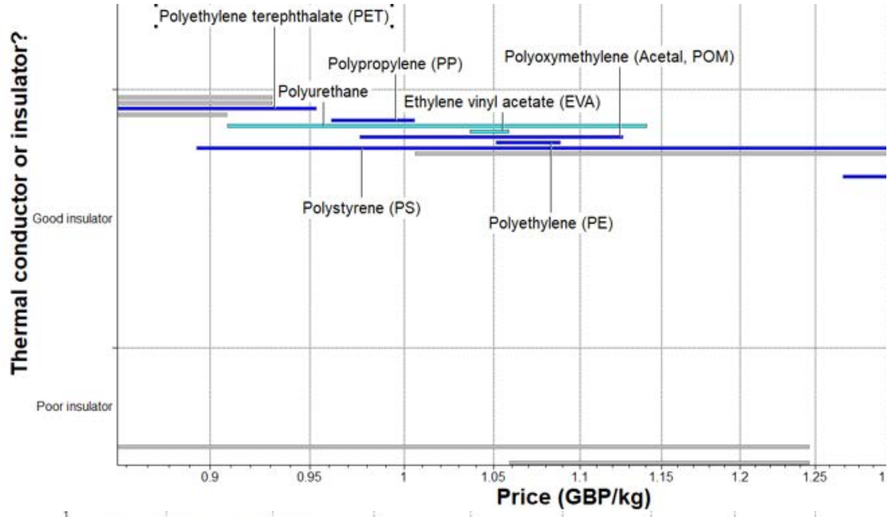
Buyer	The product would likely be bought by individual consumers; either the new mums using the product, or potentially for the mum by someone in her support network, e.g. friend or family
User	- Mothers who are returning to paid work outside the home and are keen to continue breastfeeding and keeping their supply up. - Mothers who don't have access to a fridge in their place of work, or feel self-conscious and would rather not use it. - Mothers who do have access to a fridge but have a long commute and want to keep the milk cool on their way home. - Mothers who travel or are on the go a lot and want to keep their breast milk cool while out of the house.
Market	- 266,600 UK women express milk for their babies per year. Assuming a 5% market share, I'd expect to sell 13,330 units per year. - The European breast pump market was valued at USD 535.71 million and forecast to reach USD 1.06 billion in 2030. (free data on the UK-specific market value was not available) - My product would be sold in the UK as breastfeeding rates are some of the lowest in Europe. The UK's parental leave is the least generous in Europe, and has some of the lowest rates of statutory maternity pay, coming in at 22 on a league table of 24 European countries. Many women go back to work sooner than they would like because they cannot afford to stay at home with their baby.
Delivery	Retail and potentially wholesale through shops such as Boots, MotherCare, John Lewis etc.
Volume	- Annual volume of 13,000 units in the UK - Assuming a lifespan of 10 years, 130, 000 units could be sold over this period - Assuming a ramp up volume to the EU market which has 4.09 million births per year. Assuming 40% of mothers expressing milk for their babies (compared to 43% in the UK due to the UK's worse maternity leave) and a 5% market share, 81,800 units could be sold
Costs	- Would ramp up to injection moulding however this may not be feasible at first, when sales would be lower - Point of Sale price of around £60

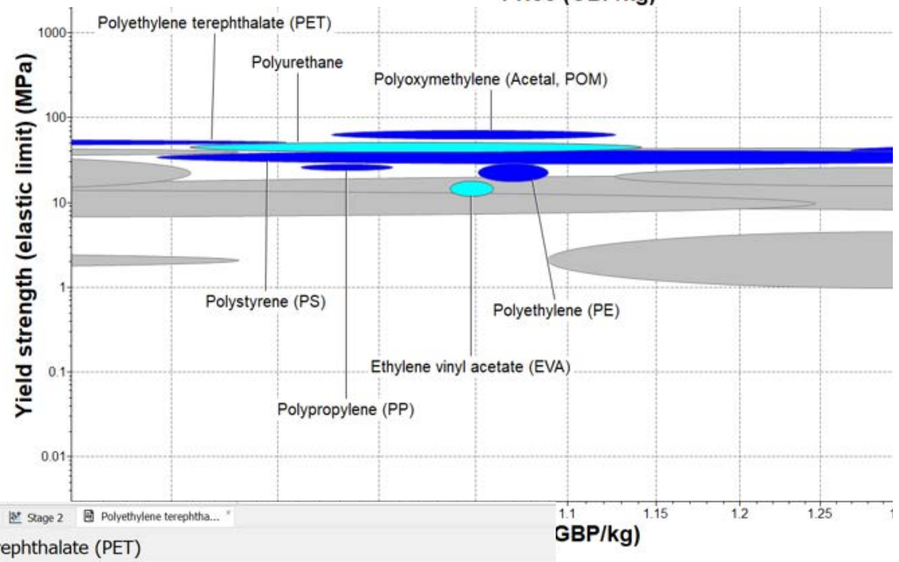
Materials Research
Feasibility + Design for Manufacture











A typical list of food-grade plastics includes:

Natural Grade Nylon 6 (without additives)
Acetal
Polypropylene
Polyester (PET)
PVDF
PTFE (also known as Teflon)

There are also some plastics that can be food-safe if they have the right chemical make-up. These include:

Other forms of Nylon
PVC
Polystyrene
Polycarbonate
Acrylic

([The Plastic People, 2021])

Summary of key findings

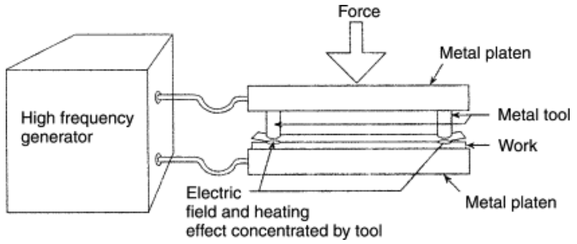
I had initially had polypropylene in mind as the material of choice for the main hard parts of the product, however Granta CES revealed that PET has the same or better properties at a lower cost, and is also food safe, even when recycled.

It was also reassuring to read that PVC can be food safe, as even though the inflatable section will be several layers away from the milk, I'd still like to avoid the use of materials that could raise concerns from the user.

Materials
Feasibility + Design for Manufacture

Part	Requirements	Properties & Characteristics	Chosen Material
Outer base	Impact resistance/shockproof	Suitable for injection moulding, relatively low cost, recyclable, high tensile and compressive strength	PET
Battery cover	Toughness	Impact resistance, durability, suitable for injection moulding, relatively low cost, recyclable	PET
Inner base (under sensor plate)	Food safe and chemically stable	Suitable for injection moulding, relatively low cost, recyclable	PET
Sensor plate	Food safe	Suitable for injection moulding, relatively low cost, recyclable	PET
Insulating lining	Food safe, wipe-clean	Good thermal insulation	3M™ Thinsulate™ CS150
Cool pack	Must stay cold for a long time, be flexible	Antifreeze properties	Polyurethane pouch filled with propylene glycol, water, hydroxyethyl cellulose, and vinyl-coated silica gel
Inflating tubes	Elasticity	High elasticity	PVC
Outer fabric	Wipe-clean	Waterproof and good chemical resistance	Oilcloth (cotton fabric with a hot melt PVC coating)
Lid	Impact resistance/shockproof	Suitable for injection moulding, relatively low cost, recyclable, high tensile and compressive strength	PET
Top outer ring	Food safe, tough and durable	Suitable for injection moulding, relatively low cost, recyclable	PET
Top inner ring	Food safe, tough and durable	Suitable for injection moulding, relatively low cost, recyclable, high tensile and compressive strength	PET

Process Selection
Feasibility + Design for Manufacture



Pros and Cons of Ultrasonic Welding

Pros	Cons
No consumables	Requires capital investment
High-volume production capabilities	Specific joint design (energy director) required
Easy setup and data capture	Vibratory energy can impact delicate components
High-strength seals, often stronger than parent material	Typically requires dedicated tooling
Minimal equipment maintenance	Limited to certain part geometries and contours
Easier scale-up; automation-friendly	Noise, depending on frequency and part size

Pros and Cons of Adhesive Bonding

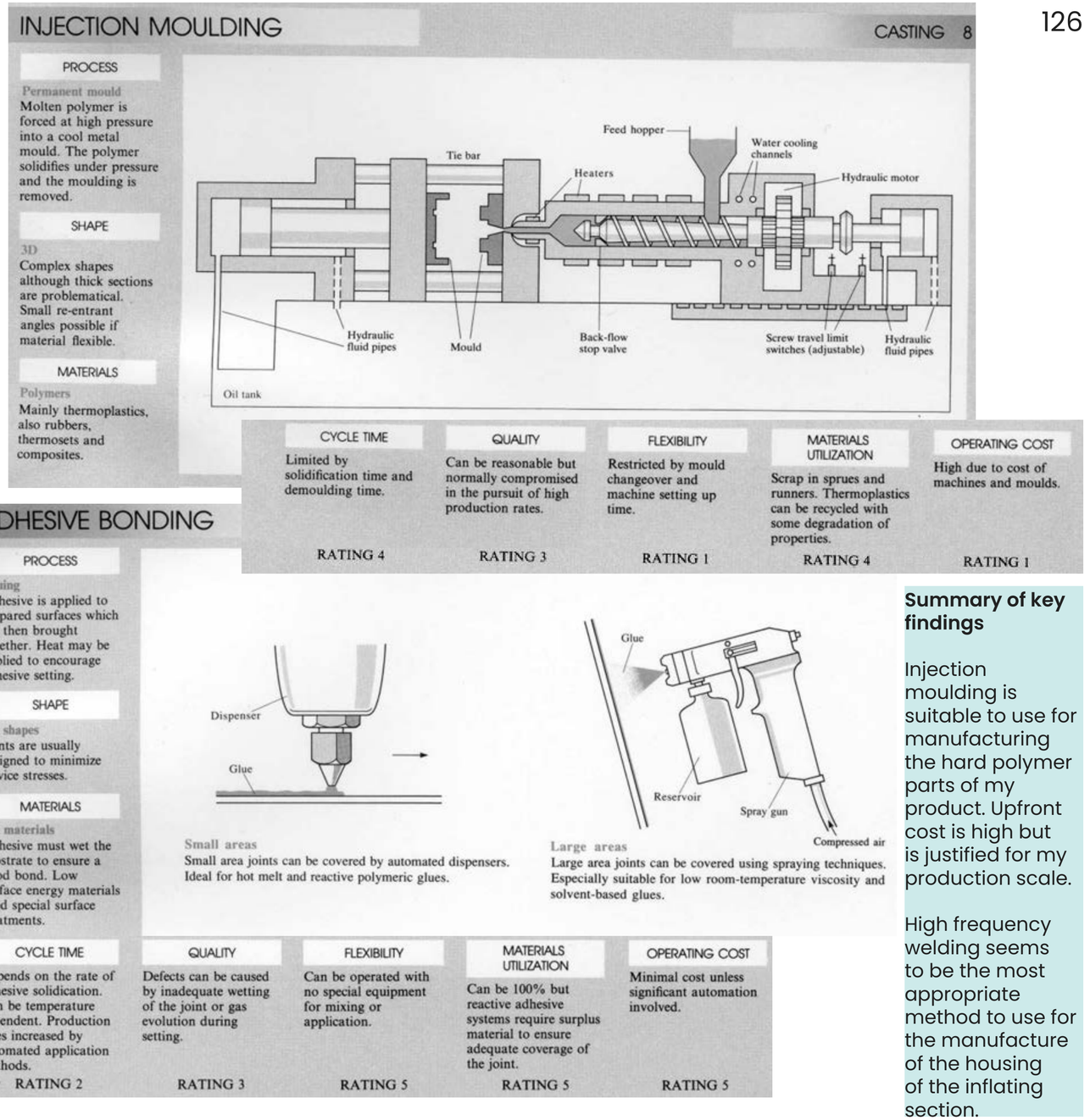
Pros	Cons
Flexibility in part design	Adhesive is a consumable
Can adhere dissimilar materials	Cure time adds to cycle time
Low capital expense	Equipment maintenance; limited data capture
Works with a variety of part sizes and geometries	Parts must be clamped while curing; UV curing equipment requires transmissive surface for exposure to UV light
Great for low-volume production and prototyping Requires chemical compatibility; certain plastics will degrade	Device volume scale-up can be challenging; cure time considerations for production line expansions

Advantages of high frequency welding:
There are many processes by which PVC components can be bonded to PVC film or other PVC parts, such as ultrasonic welding, friction welding and hot air. Chemical methods are also utilized, e.g. PVC bonding adhesive or cyclohexanone. However, high frequency welding is often preferred for the following reasons:

- Rapid welding cycles
- Inexpensive tooling
- Clean process
- No subsequent drying/hardening

Materials compatible with high frequency welding
The most common materials are polyvinylchloride (PVC), and urethane. Other materials such as EVA, PET-G and a number of types of formulations in the PET family are also welded with great success using this method. Additionally, a number of adhesives which are activated by the High Frequency field can be used to weld materials that are not normally considered compatible with this process, e.g. cardboard to cardboard or thermoformed blisters to cardboard in a packaging application.

Common products manufactured with high frequency welding are tarpaulins, tents, ceilings, advertising banners, waterbeds, inflatable boats, medical and especially blood and urine-bags, tensile structures, conveyor belts, rain clothing etc. (Carmo, n.d.)



Summary of key findings

Injection moulding is suitable to use for manufacturing the hard polymer parts of my product. Upfront cost is high but is justified for my production scale.

High frequency welding seems to be the most appropriate method to use for the manufacture of the housing of the inflating section.

Costing (of design pre-evaluation)
Feasibility + Design for Manufacture

Polyethylene terephthalate (PET)

Composition (summary)

(CO-(C6H4)-CO-O-(CH2)2-O)n

General properties

Density	1.29e3	-	1.39e3	kg/m^3
Price	* 0.541	-	0.954	GBP/kg
Date first used	1941			

Granta CES used to estimate PET cost:

Assuming a price of 0.7475 GBP/kg

0.7475/m^3

						$M_i = V \times C_{mt} + R_c \times P_c$													
Component Details						$M_c = V \times C_{mt}$						$R_c = C_c \times C_{mp} \times C_s \times [C_{ft}]$										
Part No.	Part Description	Material	Process	Production quantity per annum	Shape Complexity	Volume of part (V) mm3	Volume in m3	Material cost per unit volume (C_{mt})	Waste Coefficient (W_c)	**Material cost (M_c)**	Basic processing cost (P_c)	C_c	C_{mp}	C_s	Tolerance (mm)	C_t	C_f	C_{ft}	R_c	**$P_c \times R_c$**	**M_i**
1	Base	PET	Injection moulding	13000	A1	7605.96	7.60596E-06	7.475E-10	1	5.68546E-06	7.5	1	1	1.1	0.2	1	1	1	1.1	8.25	8.250005685
2	Outer base	PET	Injection moulding	13000	A4	915552.06	0.000915552	7.475E-10	1	0.000684375	7.5	2	1	1.1	0.2	1	1	1	2.2	16.5	16.50068438
3	Top outer	PET	Injection moulding	13000	A4	31471.8	3.14718E-05	7.475E-10	1	2.35252E-05	7.5	2	1	1.1	0.2	1	1	1	2.2	16.5	16.50002353
4	Top inner	PET	Injection moulding	13000	A2	14890.41	1.48904E-05	7.475E-10	1	1.11306E-05	7.5	1.2	1	1.1	0.2	1	1	1	1.32	9.9	9.900011131
5	Lid	PET	Injection moulding	13000	A4	128274.18	0.000128274	7.475E-10	1	9.58849E-05	7.5	2	1	1.1	0.2	1	1	1	2.2	16.5	16.50009588
6	Battery cover	PET	Injection moulding	13000	C2	4641.75	4.64175E-06	7.475E-10	1	3.46971E-06	7.5	1.2	1	1.1	0.2	1	1	1	1.32	9.9	9.90000347
7	Under sensor plate	PET	Injection moulding	13000	A3	38623.97	3.8624E-05	7.475E-10	1	2.88714E-05	7.5	1.3	1	1.1	0.2	1	1	1	1.43	10.725	10.72502887
8	Screen cover	PET	Injection moulding	13000	C3	1230.23	1.23023E-06	7.475E-10	1	9.19597E-07	7.5	1.8	1	1.1	0.2	1	1	1	1.98	14.85	14.85000092
13	Inner pin	PET	Injection moulding	26000	A4	182.18	1.8218E-07	7.475E-10	1	1.3618E-07	4.2	2	1	1.2	0.2	1	1	1	2.4	10.08	10.08000014
14	Outer pin	PET	Injection moulding	26000	A4	337.41	3.3741E-07	7.475E-10	1	2.52214E-07	4.2	2	1	1.2	0.2	1	1	1	2.4	10.08	10.08000025
																					123.286

TOTAL product cost (per product, in pence)

Material cost for processes/materials not covered in Swift & Booker:

Part	**Dimensions**	**Chosen Material**	**Commercial material cost**	**Explanation**	**Cost per unit**
Insulating lining	285x186mm = 53,010mm^2 **0.053010m^2**	3M™ Thinsulate™ CS150	Based on Alibaba I'd expect to pay $2.32 (£1.85) per metre, totalling £851	Available in 1.5m width, so I'd need 460 metres.	£0.065
Cool pack	915550.88 mm^3= **0.00091555088m^3**	Gel	Ice packs are sold on Alibaba for $0.66 (£0.528) each	Based on Alibaba prices for the volume I'm looking at.	£0.53
Inflating tubes	799690.3853,010mm^2= **0.799690m^2**	PVC	£0.96 per kg, so £3,408 total	Alibaba charges $1.20 (£0.96) per kg. I'd need 3,550kg assuming 0.2mm thickness.	£0.26
Outer fabric	332x187.7mm = 62,299.37mm^2 **0.062299m^2**	Oilcloth (cotton fabric with a hot melt PVC coating)	Based on Alibaba I'd expect to pay $1.96 (£1.5648) per yard, totalling £874	Available in rolls 1.45m wide, so I'd need 558.54 metres of this.	£0.067
Total					£0.92

Summary of key findings

I used Swift & Booker to estimate the cost of the injection moulded parts, approximating some of the coefficients to 1 where I wasn't sure of the actual value.

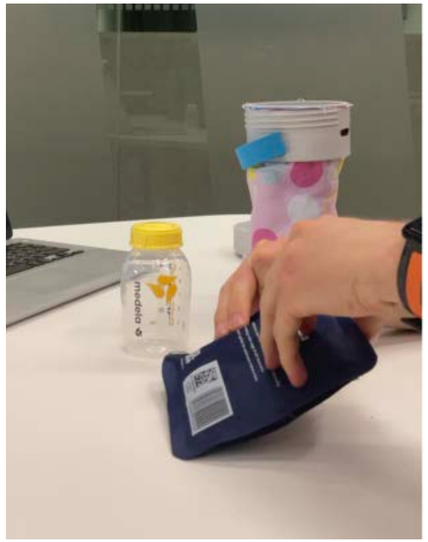
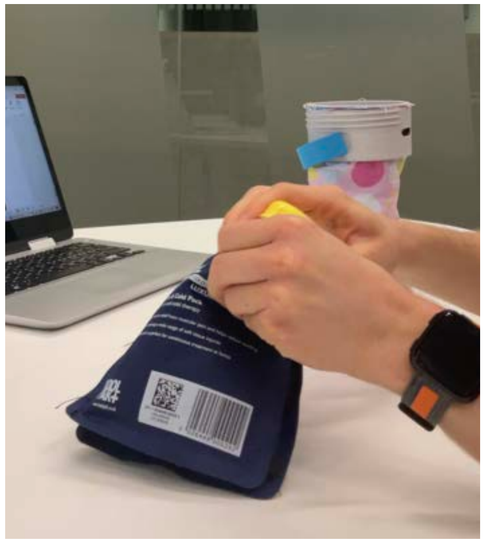
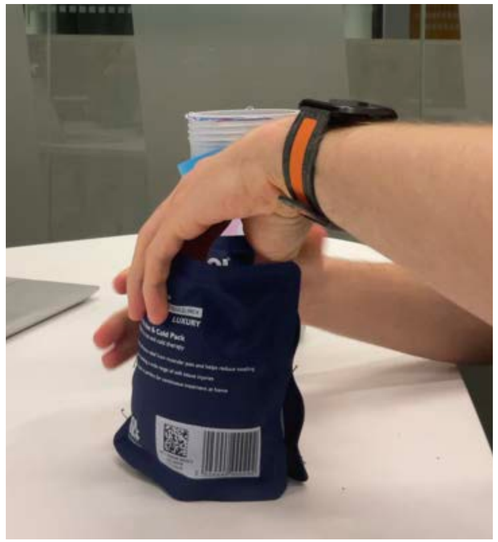
This produced a cost of 123.286 pence (£12.32) per product.

For the less common processes/materials used in my design I approximated the cost by finding quotes for materials on Alibaba. This produced a figure of 92 pence (£0.92) per product.

The total cost estimate, therefore, is £13.25

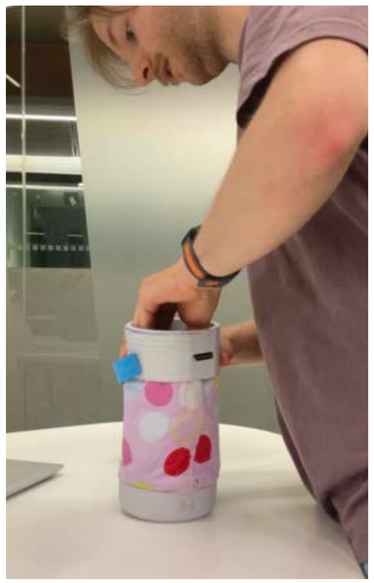
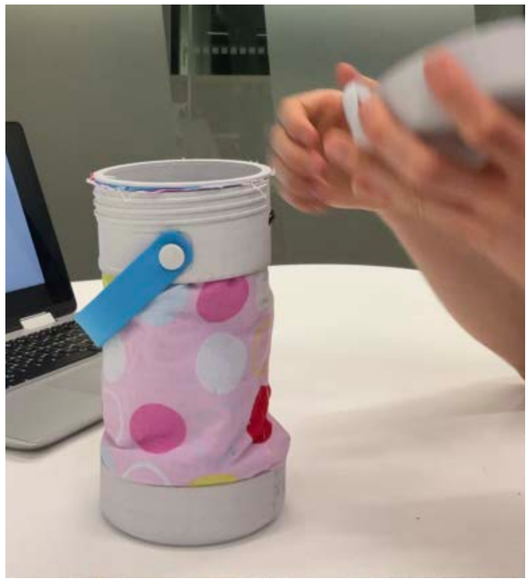
Interaction Results - Participant 1

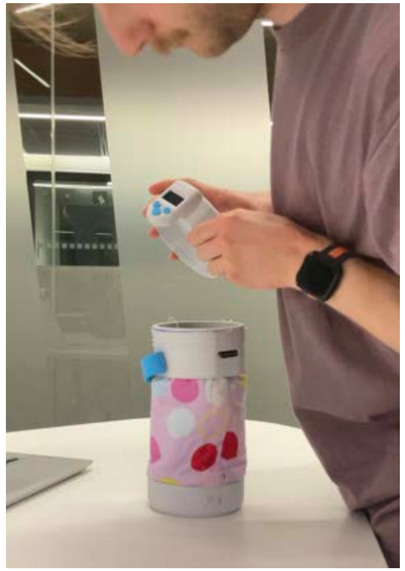
User Testing

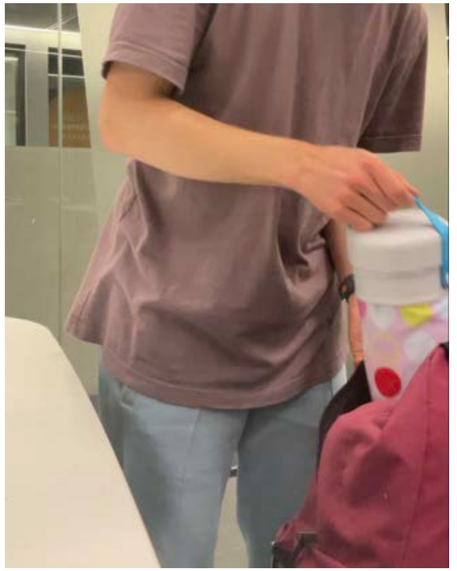


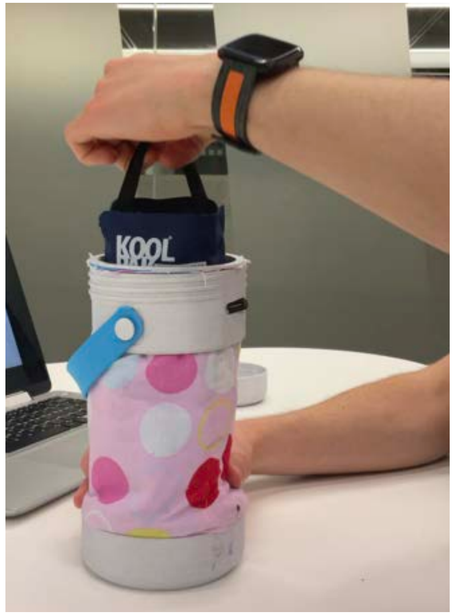




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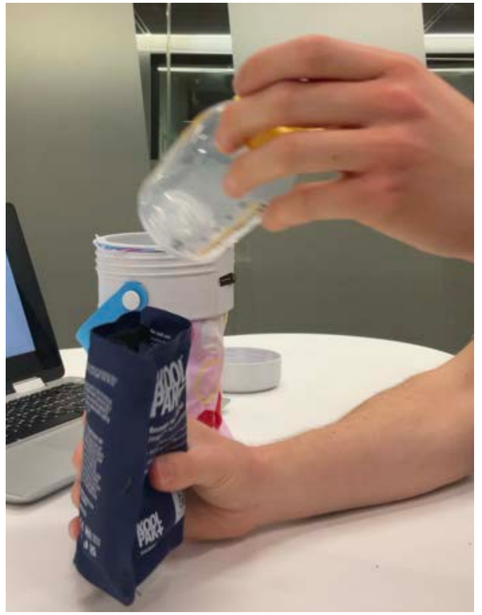
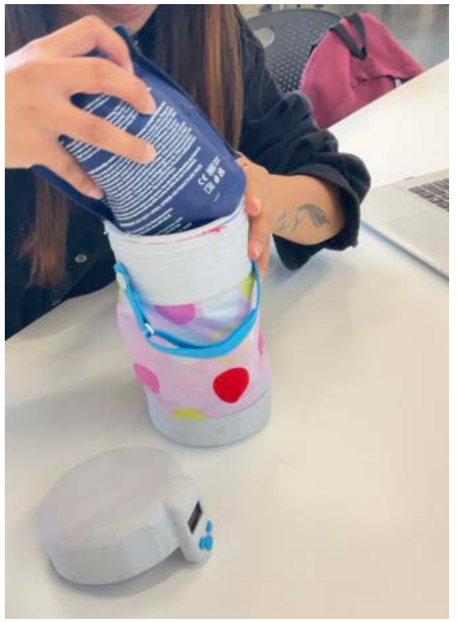


Interaction Results - Participant 2

User Testing







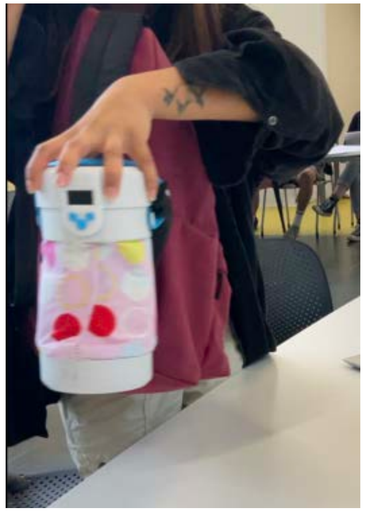
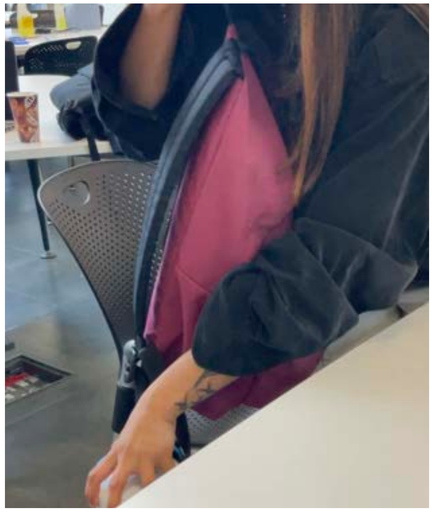






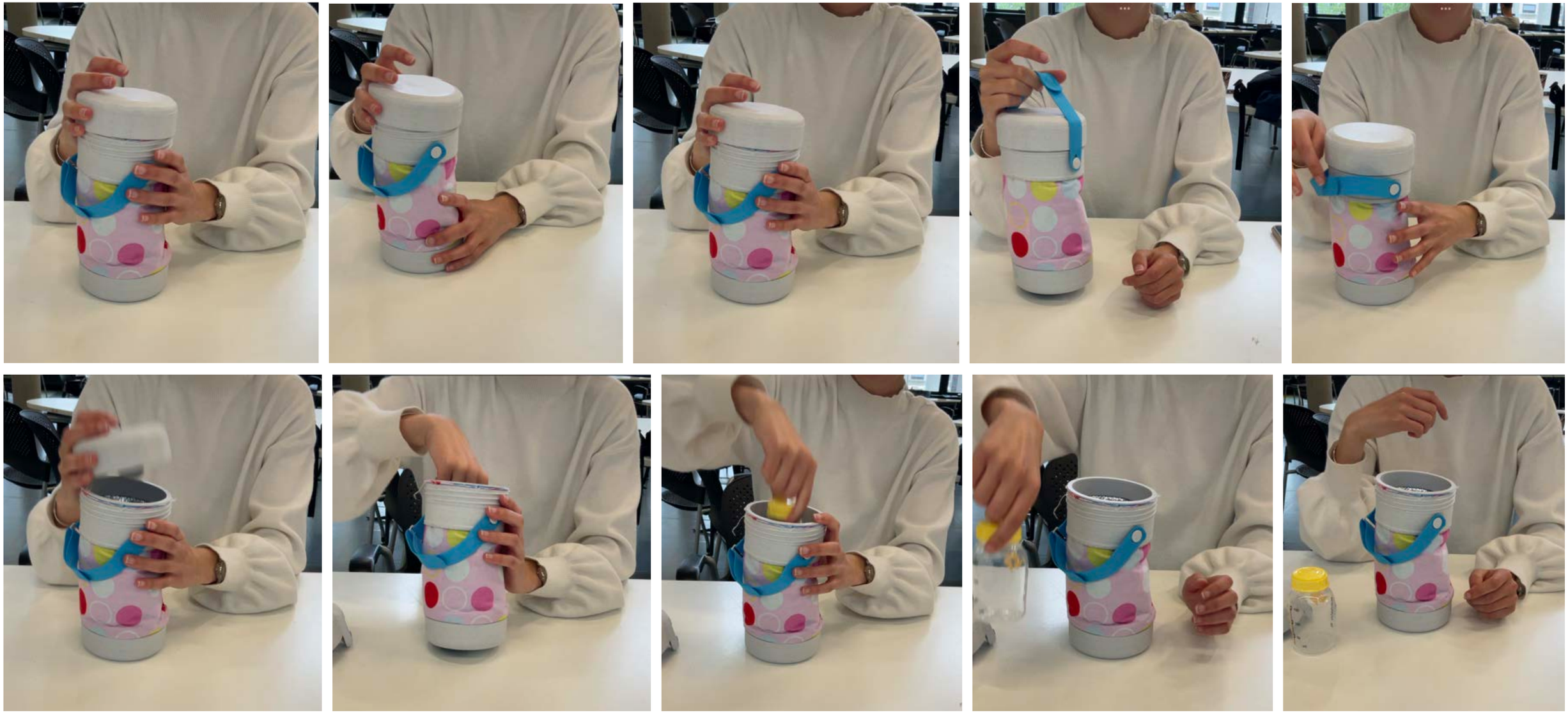




Interaction Results - Participant 3

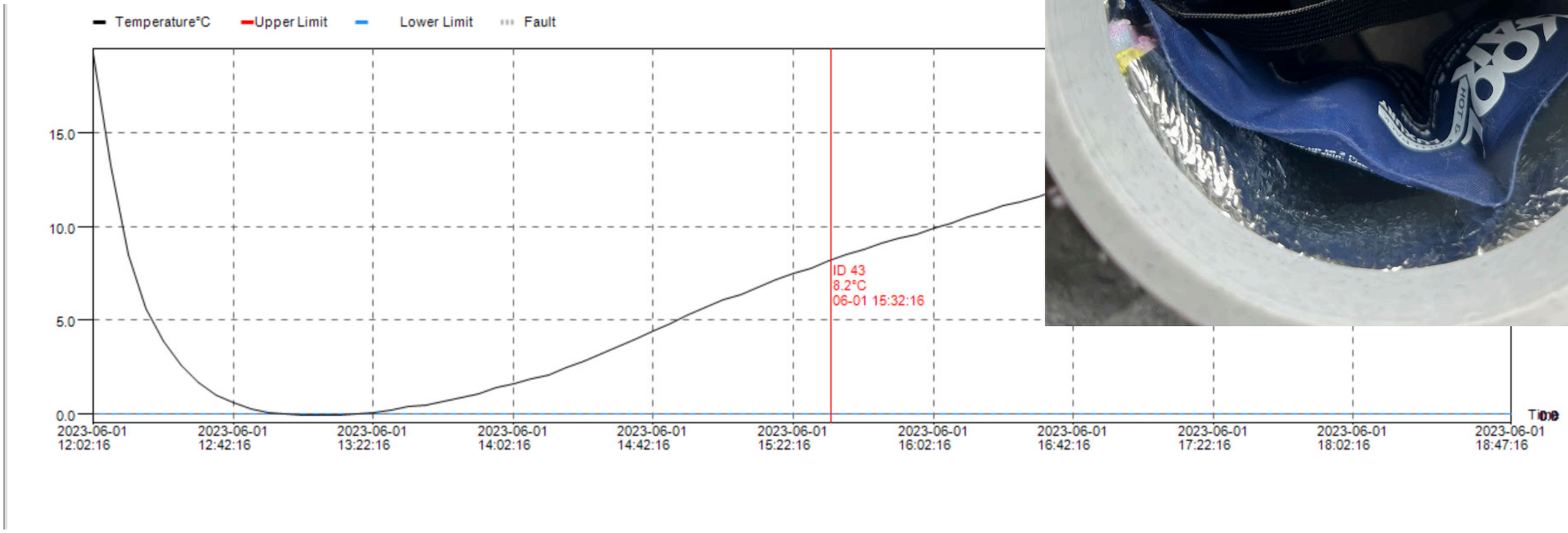
User Testing



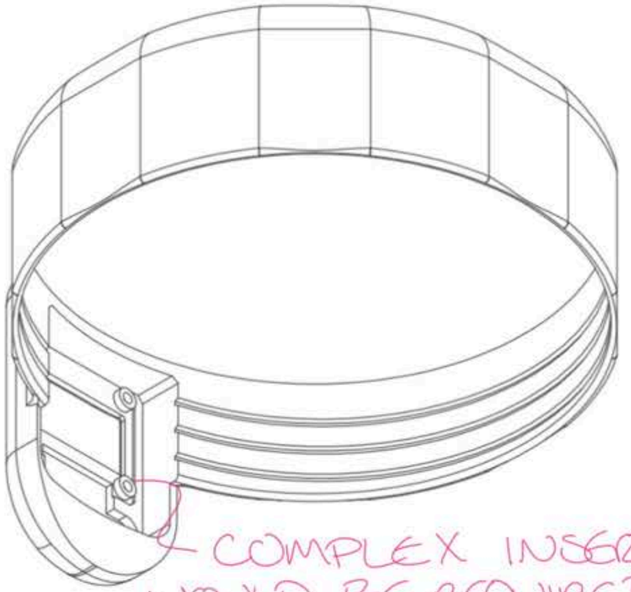
Interaction Results Summary
User Testing

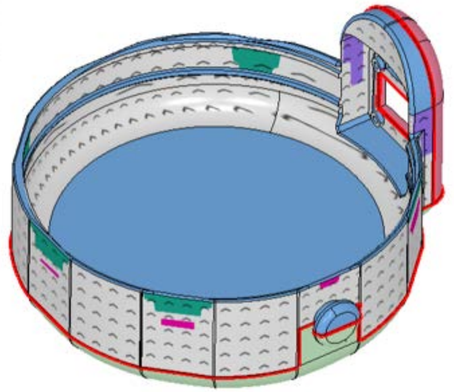
	Participant 1 (Male, 22)	Participant 2 (Female, 22)	Participant 3 (Female, 22)	Summary
Placing sleeve on bottle	Started to put the bottle in, then removed it and reinserted. Stood the sleeve on the table and pushed bottle in correctly.	Peered in sleeve before correctly placing bottle in.	Identified and inserted in cooling sleeve correctly and quickly	
Placing the bottle in the casing	Stood up to place bottle inside. Tapped container on table to push bottle downwards.	Looked inside it first, pushed bottle all the way down	Had to use thumb to push the base of the cooling sleeve in first. Pushed bottle in.	
Inflating to secure bottle	Did not interact with buttons	Did not interact with buttons	Did not interact with buttons	Inflating function needs to be communicated better
Securing the lid	Lined up screen panel with pogo pins and pushed down (but not all the way). Pulled strap up over the lid. Reached to push the big button after securing lid.	Looked at inside of lid before placing on, carefully twisted, examined from different angles and pushed down to check it was on. Pulled strap up over the lid	Kept turning the lid, wasn't sure it was on correctly.	Would be good if the screen came on once the lid was on to confirm it's on securely. Or a 'click', some kind of feedback is needed.
Carrying/ transporting home	Picked up by strap. Pushed lid down all the way before placing in backpack. Mentioned a carabiner would be good if he wanted to attach it to the bag rather than in. Said if the bag was full he'd carry it by the handle, and wouldn't want to use a carabiner to attach it as it would dangle and swing around. Intuitively would've clipped it onto the zip pull on the pocket of the backpack.	Stopped to think, then attached to arm strap of backpack by unhooking the strap from the knob (didn't realise strap was adjustable/ could be undone). Instinctively tried to hook end of strap onto screen section Lifted backpack with product very tentatively, was scared of it falling off	Would carry it by the strap in her hand.	Function and properties of strap were not clear to users (probably because it doesn't look like velcro)
Taking off the lid	Unscrewed lid to remove (despite not having screwed it on)	Unscrewed lid.	Unscrewed lid.	
Removing bottle	Used the elastic as a strap to pull out the bottle and sleeve	Pulled out by the cooling sleeve.	Removed bottle without sleeve	
Deflating the outer	Had to be reminded of the inflating function. Pressed the power button to deflate/release bottle.	Was confused by the interface, thought + button cooled the bottle. Said she'd press the power button to release the bottle.	Correctly stated she'd press the - button to deflate.	Inflating function needs to be communicated better
Comments	Mentioned that he wouldn't be able to see the screen if it was in his backpack and that a sound alert could work (but also acknowledged that having a beep going off in a backpack isn't ideal).	Mentioned limitations with where the container could be attached to a bag, that it wouldn't work with all bags. Said it was comfortable to carry by the strap and doesn't make it obvious it contains breast milk.	Mentioned that size was offputting; is significantly larger than just the bottle. Asked if it was collapsible.	

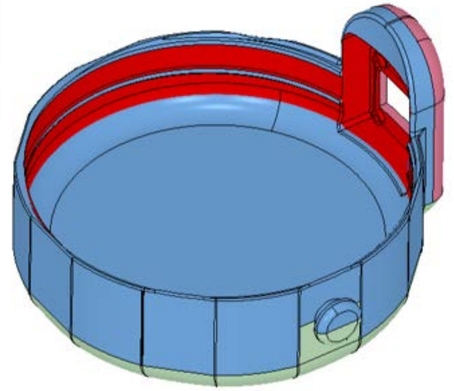
Insulation Testing
PDS Testing



Product Structure and Part Design
Feasibility + Design for Manufacture

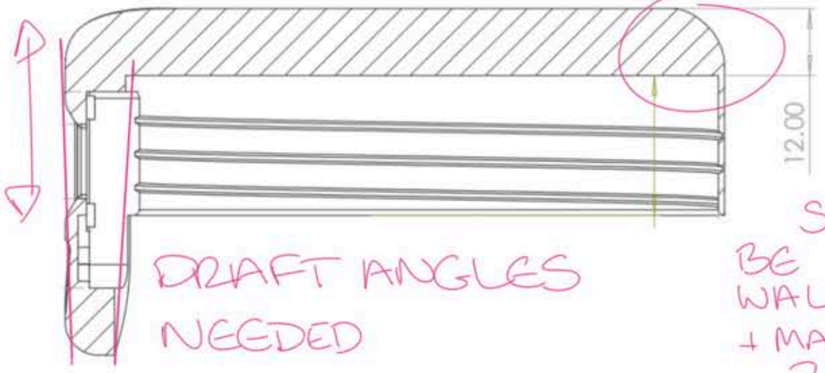




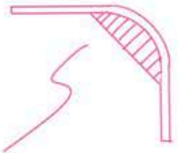


DEEP PARALLEL SIDES

RADICAL DIFFERENCE IN WALL THICKNESS



DRAFT ANGLES NEEDED



SHOULD JUST BE HOLLOW BC WALL THICKNESS + MATERIAL EFFICIENCY ?

RIBBING NEEDED?

COMPLEX INSERT WOULD BE REQUIRED FOR THIS BIT ?

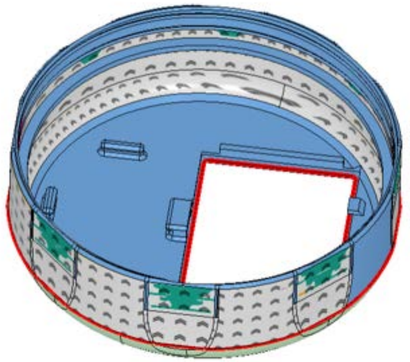
SCREEN COULD INSTEAD BE HELD BY A LIP ALTHOUGH THIS IS ALSO AN UNDERCUT

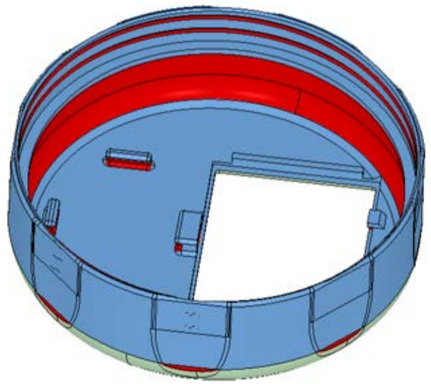
COMPLEX UNDERCUT ? ESP W/ CURVE BEHIND SCREEN ?

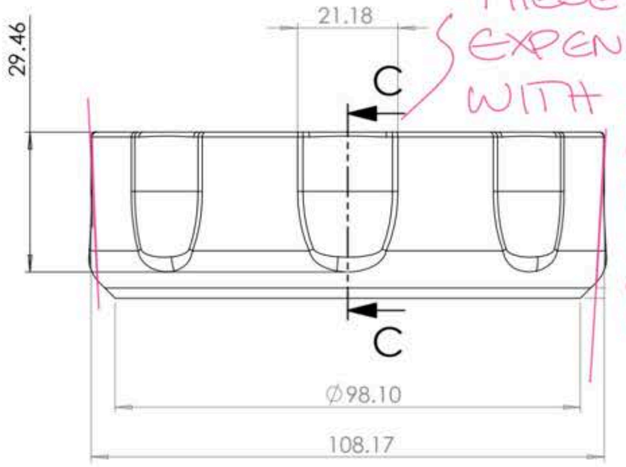
BEST OPTION IS PROBABLY TO HAVE AN INDENT IN THE PART THAT SCREWS IN TO COVER BACK OF SCREEN — COULD BE MADE WITH A SIMPLE TWO-PART MOULD TOOL

Product Structure and Part Design

Feasibility + Design for Manufacture



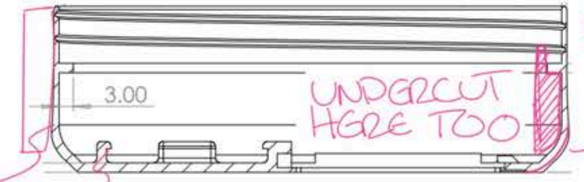




TOOLS USED TO MAKE MOULD FOR THESE RIDGES WOULD BE EXPENSIVE – NOT POSSIBLE WITH 2.5D MACHINING

MAY NEED TO SIMPLIFY AS SLIGHT UNDERCUT

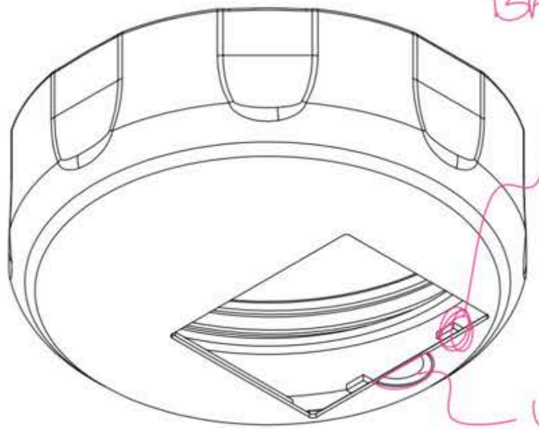
POTENTIALLY COULD BE DONE W/ A LARGE BALL-NOSE CUTTER



SIMPLE FILLET INSTEAD OF CHAMFER

BITS THAT SECURE PCB HAVE UNDERCUTS
- SAME WITH CUTOUT FOR BATTERY REPLACEMENT

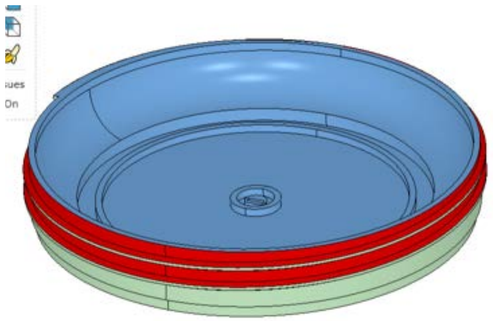
THREADED MOULD PART WOULD BE EXPENSIVE TO REMOVE

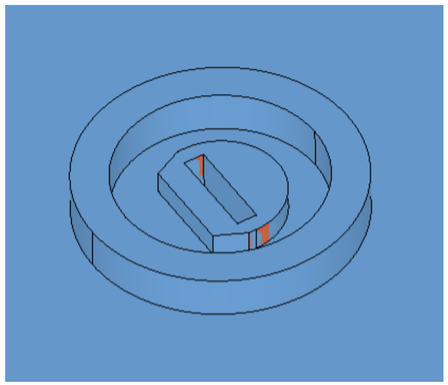


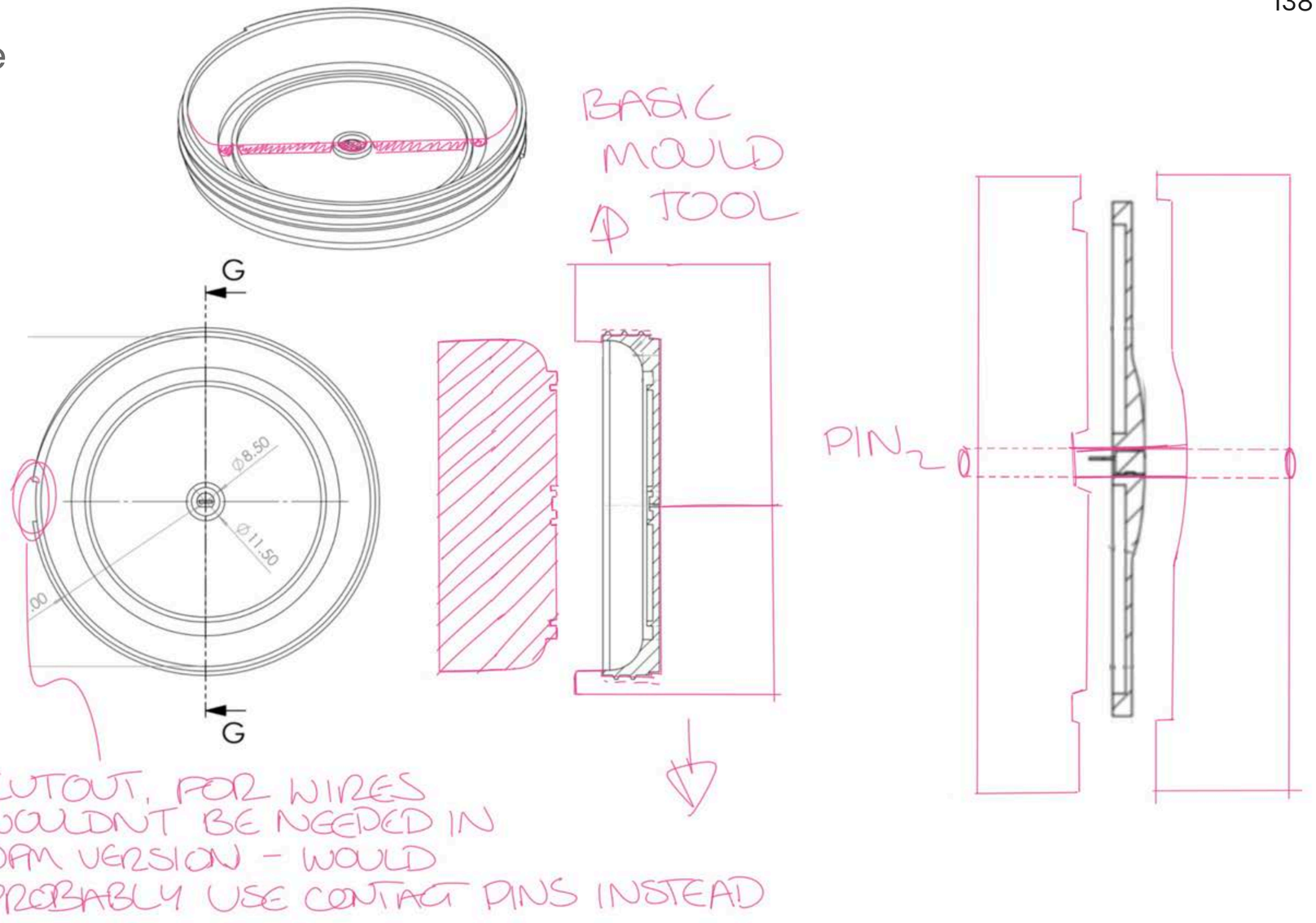
BUT THESE FORMS ARE VERY COMMON IN CHEAP ELECTRONICS SO MUST BE POSSIBLE

WOULD NEED A RADIUS CUTTING END MILL TO MAKE MOULD FOR THIS

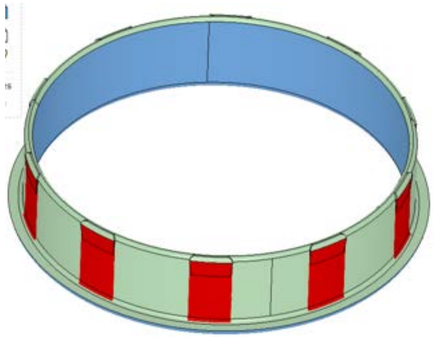
Product Structure and Part Design
Feasibility + Design for Manufacture

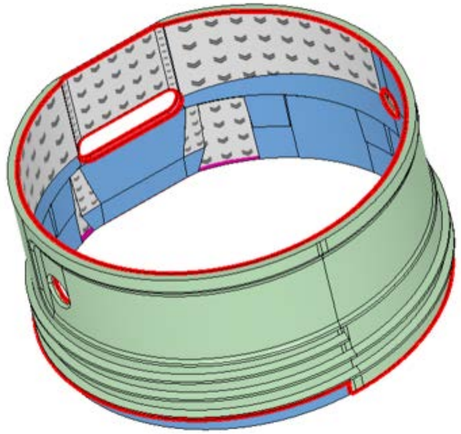


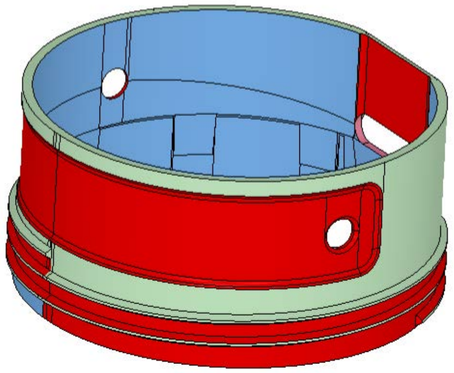




ProtoLabs Analysis
Feasibility + DfM







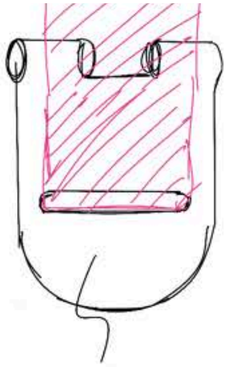
Summary of key findings

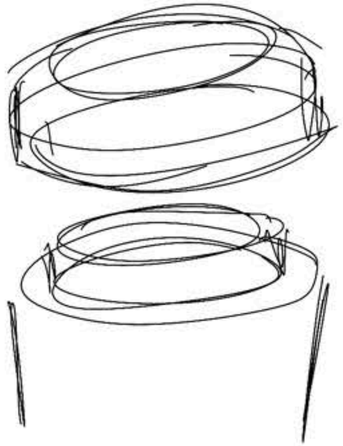
The ProtoLabs analysis helped identify some points I hadn't considered, such as the scope of the draft angles needed, and the number of sections they consider to be undercuts.

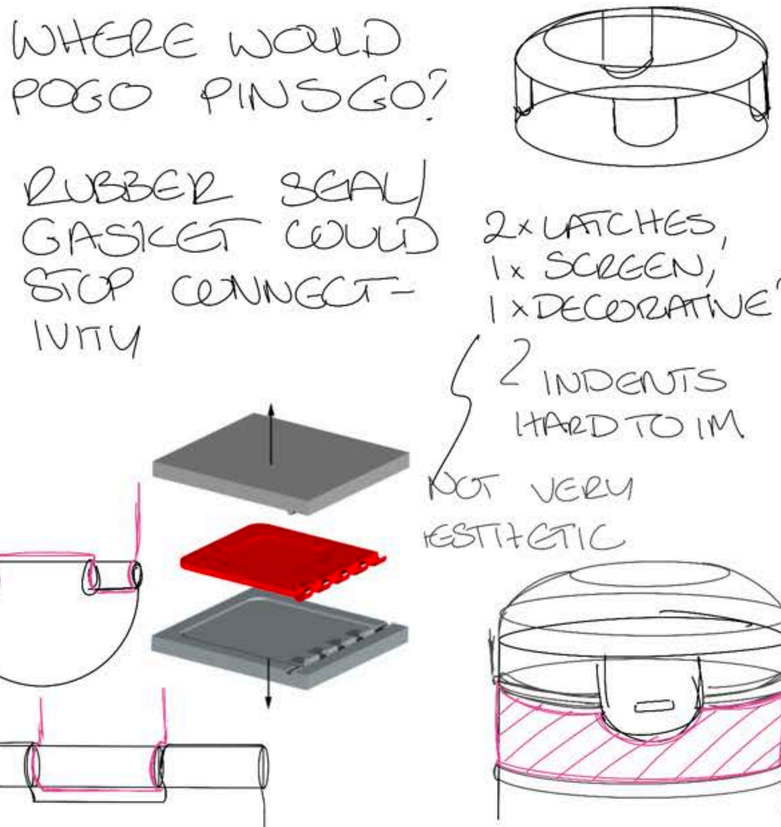
I knew I had a number of undercuts but thought most of them could be manageable with clever mould tool design, however ProtoLabs seemed to disagree.

The designs definitely need to be simplified and thought out more cleverly for optimised injection moulding.

Proposed Design Changes
Response to Evaluation & DFM







STRAP COULD LOOP THROUGH LATCH? MAY BE ANNOYING WHEN SECURING LID

DOES A STRAP OR A LATCH NEED MORE SUPPORT FROM HINGE?

STRAP SUBJECT TO GREATER FORCE WHEN CARRYING

Summary of key findings

Redesigning the lid to consider the insights from user testing, as well as DfM issues identified with the existing design has been challenging.

The updated design should:
- clip on rather than screw on
- allow the lid to fit on without the screen getting in the way
- avoid undercuts
- be aesthetically pleasing and straightforward to use