GNG2101

Design Project Progress Update

GROUP A2.1

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Acronym	Definition
BOM	Bill of Materials

Table 1: Acronyms

Term	Acronym	Definition
Osteoarthritis	OA	The most usual form of arthritis. It occurs most frequently in the hands, hips, and knees. The cartilage within a joint begins to break down and the underlying bone begins to change.

Table 2: Glossary

1 Introduction

ErgoCares Innovations, at the crossroads of engineering and healthcare, presents a focused exploration into the development of an ergonomic renal clamp plier. This report delves into the project's inception, progress, and key economic considerations.

The healthcare industry often emphasizes patient well-being while inadvertently overlooking the health of caregivers. Renal care nurses, engaged in repetitive tasks like clipping renal clamps, face increased risks of musculoskeletal strain. ErgoCares Innovations responds to this challenge with a primary goal: to enhance the well-bring of healthcare practitioners.

This journey unfolds through an analysis of customer needs, benchmarking, and critical decision-making processes. The report candidly discusses trials, iterative improvements, and valuable lessons learned. Additionally, it delves into the economic landscape, providing insights into variable and fixed costs, income statements, and break-even analyses.

The economic exploration is complemented by a detailed investigation not the intellectual properties, shedding light on legal dimensions that safeguard innovation. This report offers a comprehensive view of patent databases, trademarks, and design rights, elucidating their significance and potential constraints on product development.

ErgoCares Innovations encapsulates not just a prototype but a commitment to elevating healthcare practices. This report invites stakeholders to delve into the project's depths, exploring a journey marked by technical finesse and a dedication to the well-being of healthcare professionals.

2 Business Model Canvas and DFX

This section provides a comprehensive exploration of our project's business model canvas and design for X. The main idea is to create a device that will enhance the work experience of renal care nurses, prioritizing hand comfort. Our venture will not only aspire to enhance the efficiency of healthcare operations but also to address critical issues related to ergonomics and overall well-being. This document delves into our project's business model canvas, emphasizing its alignment with the healthcare industry while acknowledging its profound economic, social, and environmental impacts. Furthermore, we explore our commitment to the DFX approach – focusing on ergonomics, reliability, compliance, maneuverability/portability, and accessibility – to understand our dedication to designing a product that transcends conventional boundaries.

2.1 Business model and sustainability report

Our product's value proposition is intricately designed to align with the market's needs and optimize the commercial potential of our ergonomic and durable blood tubing clamping device. The following key aspects make our value proposition well-suited for successful commercialization:

A. Prevention and Management of Arthritis
Our device is engineered to proactively help prevent arthritis, a prevalent concern for nurses due to the repetitive thumb movements involved in their tasks. The ergonomic design significantly reduces stress on thumb joints, promoting long term joint-health. For individuals already dealing with arthritis, our device acts as a supportive and efficient solution. It minimizes discomfort, enables smoother operations, and enhances overall efficiency and productivity in their daily tasks.

B. Alleviation of Thumb Joint Pains
Our blood tubing clamping device offers enhanced comfort and durability, making it ideal to reduce the progression of arthritis in individuals, especially for those who already have arthritis. Moreover, our product will not stifle the current efficiency in the clinics. The design is engineered to improve workflow without causing disruption, ensuring that healthcare professionals can work efficiently while using our device.

C. Encouraging Proper Hand Form
Our device actively encourages and facilitates the adoption of proper hand form and posture during clamping procedures. This design not only promotes ergonomic use of the device but also minimizes the risk of hand-related injuries over time. The strategic integration of these value propositions addresses specific pain points within the healthcare sector, positioning our product for successful commercialization.

Triple Bottom Line BMC:

<table>
<tr>
<td rowspan="2">Key Partners

- Hospitals
- Arthritis clinics
- Dialysis clinics
- Medical supply stores
- Arthritis charities</td>
<td>Key Activities

- manufacturing
- distribution</td>
<td rowspan="2">Value Proposition

- ergonomic blood tubing clamping devices that reduce thumb stress for renal care nurses
- improve efficiency and comfort while handling medical tubing
- durable and long-lasting devices that are quick and easy to sanitize</td>
<td>Customer Relationships

- staying in contact and communicating with hospitals, arthritis clinics, and medical supply stores to understand their specific needs and gather info for continuous improvement</td>
<td rowspan="2">Customer Segments

- hospitals/clinics specializing in renal care
- medical supply stores who sell to healthcare professionals requiring medical devices
- nurses</td>
</tr>
<tr>
<td>Key Resources

- manufacturing materials + equipment + facilities
- storage warehouse
- offices
- distribution network + logistics support</td>
<td>Channel

- direct sales to hospitals and arthritis clinics using sales teams
- distribution through medical supply stores via partnerships</td>
</tr>
<tr>
<td colspan="2">Cost Structure

- manufacturing: raw material, labor, equipment maintenance
- advertising
- product development: prototyping, testing</td>
<td colspan="3">Revenue Streams

- sales to both hospitals and clinics and by distributing to medical supply stores
- franchising
- individual purchasing by nurses</td>
</tr>
<tr>
<td colspan="2">Social & Environmental Cost

-cost imposed on nurses to purchase our device
-pollution associated with manufacturing, distributing our product
-disposal of product at the end of its life</td>
<td colspan="3">Social & Environmental Benefit

-Prevention of long-term debilitating condition
-long-lasting product which will reduce re-purchasing and therefore reducing waste</td>
</tr>
</table>

Table 3: Triple Bottom Line Business Model Canvas

In developing the Triple Bottom Line Business Canvas for the ergonomic and durable blood tubing clamping device business, several core assumptions have been made to structure the model effectively and evaluate its feasibility, including:

A. Assumptions about Target Market
We assume that our primary target includes hospitals specializing in renal care, arthritis clinics, and medical supply stores. These assumptions are based on the intended usage and ergonomic benefits of the clamping device in the context of renal care and arthritis treatment.

B. Assumptions about Value Proposition
The assumption is that the value proposition of ergonomic design and durability will significantly reduce thumb stress for renal care nurses and enhance efficiency in handling medical tubing. Additionally, the assumption is that the cost-effectiveness resulting from durability will be a strong selling point.

C. Assumptions about Key Partners
We assume that key partners such as hospitals, arthritis clinics, and medical supply stores will be willing to collaborate for the distribution and use of our products. This assumption is based on the perceived value the product brings to these partners and their willingness to enhance healthcare professionals' working conditions.

D. Assumptions about Cost Structure and Revenue
We assume that the main cost drivers will be manufacturing, distribution, marketing, research, and development. The revenue streams are anticipated to come from direct sales, distribution sales, maintenance services, and licensing.

E. Assumptions about Key Activities and Resources
The assumption is that our key activities will primarily involve manufacturing and distribution, and the key resources required will be skilled labour, manufacturing facilities, and distribution networks. This assumption is grounded in the nature of the product and its delivery to the market.

The following sustainability report reflects on both the positive and negative impacts of our product.

A. Social Impact
Our product will have a large positive social impact. The purpose of our device is to prevent arthritis in renal care nurses and offer relief for nurses with this condition. This device will enhance the well-being of nurses, aiding them in the workplace and in their personal lives. However, we must also explore the possible negative impact. We need to consider that the nurses could become stressed because of having to adapt to new equipment and a new procedure at work. This could be especially problematic because renal care nurses have been following the same clamping procedure for a long time.

B. Environmental Impact
We will be designing our product to be reusable, manufacturing a product that is not single use will have a positive impact on the environment. Unfortunately, there are many more negative environmental impacts. Like any product, there is pollution caused by the manufacturing and distribution processes. If this product is in high demand the resource consumption will increase since we are introducing a new medical product to the market. Even though the product is reusable, it will not last forever so there will be waste due to disposal at the end of its life.

C. Economic Impact
On a positive note, the creation of a new business comes with job creation and economic growth. With the manufacturing, distribution, and maintenance needs of our company, we will create new jobs contributing to local and regional economic growth. However, introducing a new product to the market raises the problem of affordability. We anticipate our product will be popular, as it is currently the only solution on the market. Manufacturing costs may reflect on the price of our product, and having no price-accessible options force our customers to purchase our product. Even though this is good for our revenue, it could have a negative economic impact on our consumers.

2.2 Design for X

A. Ergonomics
The definition of ergonomics is a design for efficiency and comfort in the workplace. The method the nurses are currently using to clip the clamps is not just causing discomfort but an irreversible illness which in the long-term affects their ability to work and live. Our design focuses on reducing the possibility for injuries, while also improving productivity for healthcare professionals among the workplaces.

B. Reliability
A reliable product will be beneficial in many ways. Practically speaking we want our customers to be able to use our product knowing it will not break or malfunction, this is especially important because it has been used in the healthcare industry a malfunction could be potentially dangerous. Secondly, this product’s purpose is to prevent or aid with arthritis so we want our clients to trust our product will not cause arthritis or worsen its effects. Lastly, a reliable product will have a better buy-in which will help with our business.

C. Compliance
Our device's design prioritizes both cleanliness and efficiency in clinical settings. Featuring smooth, easy-to-clean surfaces, it makes the sanitation processes user-friendly, ensuring that its sanitation aligns with the stringent healthcare hygiene standards. Moreover, healthcare professionals can save valuable time thanks to its quick and thorough sanitation capabilities. Lastly, the device is constructed using materials resistant to the cleaning agents commonly used in healthcare settings, guaranteeing durability and reliability in maintaining a sterile environment.

D. Maneuverability / Portability

Our client expressed to us that dialysis machines have many tubes and wires and can be placed in tight spaces. This raised the importance of our device to be maneuverable, compact, and lightweight. This will ensure it does not get in the way of nurses and will not catch on any of the machinery causing damage. We were also made aware that nurses would keep the device on their person transporting it from patient to patient. Therefore, we have a need for portability and maneuverable ensuring that it will be accessible in many different situations.

E. Accessibility

Our innovative device promotes universal compatibility, making it ideal for a wide range of applications, including accommodating various blood tubing diameters. Engineered with versatility in mind, it will seamlessly be integrated into existing workflows, ensuring ease of use across many different situations. Our team is eager to present this project as a meaningful change, emphasizing its adaptability and user-friendly design to potential clients and stakeholders, with a focus on its potential for widespread adoption and success.

Overall, our project revolves around the development and implementation of a business model canvas and a meticulously designed device that caters towards renal care. Through a dedicated focus on ergonomics, reliability, compliance, maneuverability, and accessibility, we envision a transformative impact on the healthcare industry. Our main goal is to improve the work experience for renal care nurses and set a new standard of efficiency and comfort within the healthcare sector. By aligning our design objectives with the discussed outlines, we are confident that our renal care product will stand as a testament to innovation, enhancing the quality of care and the overall well-being of both healthcare professionals and patients.

3 Problem Definition, Concept Development, and Project Plan

3.1 Problem definition

Introduction

This section delves into the critical phases of problem definition and concept development, fundamental to the success of our project. Beginning with an exhaustive exploration and prioritization of client needs and problems, we establish a comprehensive problem statement that clearly delineates the issue, its stakeholders, and the desired solution. Concurrently, we identify and define need-inspired metrics, using quantifiable units to enable benchmarking and evaluation. This section of the report also provides information on the concept development, where we craft prototype solutions aligned with the set target specifications. Thorough analysis and integration of these prototypes pave the way for a unified global design concept. This structured approach is fundamental in our goal to innovate pragmatic and effective solutions within the healthcare industry.

A. Client Needs and Metrics
To tailor our design to the specific needs and preferences of renal care nurses, it is imperative to first understand and prioritize their requirements. The table below outlines these needs and assigns importance levels, aiding us in creating a product that efficiently addresses their concerns.

Need	Metric	Importance (5 is high, 1 is low)
Will reduce stress on the thumb	Applied Force	5
Is easy to sanitize	Material, Shape	4
Uses whole hand motion	Shape	3
Is portable and discreet to carry around	Size, Weight	4
Can be easily maneuvered in tight spaces	Size	3
Is not a nuisance to use	Speed	5
Is small	Size, Weight	3
Is easy to use	Simplicity	3
Employs squeezing mechanism	Applied Force	5
Is durable	Lifetime, Material	4
Is cheap	Cost	2
Will not slow down the nurses	Speed	5
Can be used by either hand	Shape	3
Provides enough force to close clip	Applied Force	5

Table 4: Corresponding Client Needs and Metrics

The ideal renal tube clamp for medical use should meet several key criteria. Firstly, it should provide adequate clamping force, especially when dealing with larger tube diameters, ensuring a secure grip without damaging the tube. The design should favor a circular motion rather than a side pinch motion, leveraging the stronger and more ergonomic action of squeezing the whole hand with the wrist joint. Moreover, quick, and easy sanitization is crucial in a hospital setting dealing with biohazardous waste, blood, and body fluids. Therefore, the clamp should be easily wipeable with alcohol-based solutions and durable enough to withstand heavy-duty cleaning.

Furthermore, the clamp should excel in maneuverability within tight spaces, as hospital rooms are not always spacious. It should be compact, easy to carry, and not a nuisance to use, with the goal of benefiting the health and joints of healthcare professionals. Being easily portable allows nurses to carry it individually, either on a keychain or in their pockets, and it should operate seamlessly with one hand. The squeezing mechanism should be user-friendly and efficient.

Durability of the clamp is essential, as it is typically bought in bulk by hospitals, making durability a cost-effective consideration. It should also be suitable for quick and efficient use without impeding the workflow of healthcare workers. Currently, some nurses use braces or splints for support, but these can be bulky and inconvenient. Therefore, a compact, easy-to-remember, and easy-to-use renal tube clamp with a squeezing mechanism, like looped scissors designed for kids with fine motor difficulties, would be highly beneficial.

Ideally, the renal tube clamp should endure for at least four years, with a minimum acceptable lifespan of two years. It should be available for individual purchase by nurses and be procured in bulk by hospitals to ensure widespread availability. The clamp should facilitate efficient and ergonomic clamping of renal tubes while minimizing strain and inconvenience in a healthcare setting.

B. Problem Statement

To devise an innovative solution that alleviates thumb stress and diminishes the risk of injuries by streamlining the clamping process. The proposed device will prioritize ergonomic design, reducing the load on the thumb while ensuring efficient and safe clamping of the clips. The design will also be easy to clean, portable in tight spaces, user-friendly, and quickly accessible.

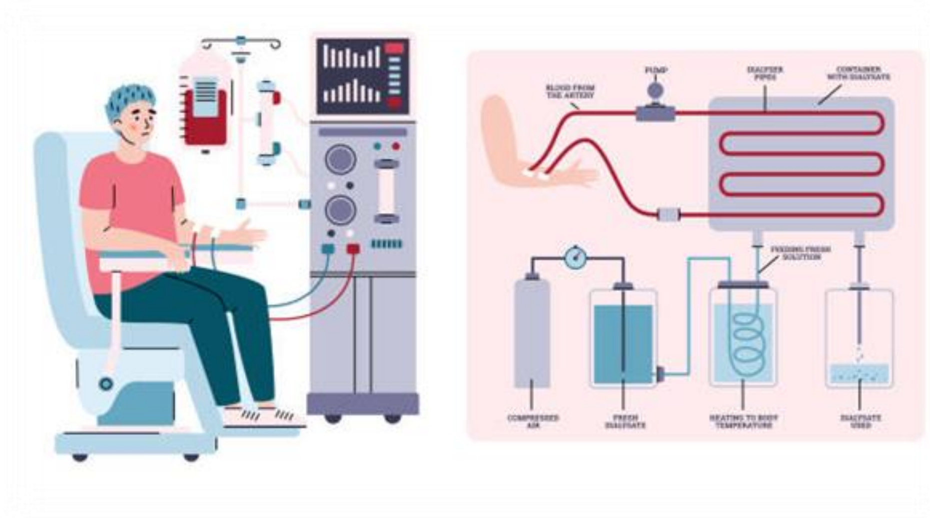

Figure 1: Hemodialysis Setup with Tubes and Clamps

Who Has the Problem?

The problem is prevalent among renal care nurses, a dedicated group of healthcare professionals responsible for the critical task of administering care to patients with renal conditions. Given the integral role of renal care in the medical field, addressing this problem directly impacts the efficiency and well-being of these nurses.

What Form Can the Solution Take?

The proposed solution takes the form of an ergonomic and ambidextrous device engineered to streamline the clamping process. This innovative device will alleviate thumb stress by minimizing the force required for clamping, ensuring a secure grip while also prioritizing the safety and comfort of the nurses. Additionally, the device will be designed for easy cleaning, making it hygienic and suitable for the healthcare environment. Its portable and compact design will facilitate usage even within confined places typically found in hospital settings.

Insights obtained from an interview with a nursing student further highlighted the importance of a multifaceted solution. The ideal device not only needs to enhance the clamping process but also address auxiliary concerns such as hygiene, portability, and ease of use. By integrating these features in the proposed solution, we aim to provide renal care nurses with a tool that not only minimizes thumb stress but also optimizes their overall work experience.

C. Similar Solutions

There is currently no product on the market that solves the specific problems proposed by our client. Our client did mention a thumb splint that some nurses use to alleviate the soreness in their thumbs. While the thumb splint does alleviate a bit of the stress, it still requires the thumb's full force and does not solve the issue of preventing arthritis. Aside from the thumb splint, there is no similar solution, however, the client did mention loop scissors. She pictured a product that would have the same motion as the loop scissors, where the full hand would be used to close the clips.

Metric	**Importance (5 is high, 1 is low)**	**Units**	**Thumb Splint** 	Loop Scissors 	Weingart Pliers 
Size	5	Centimeters (cm)	12x10x1	20.3x8.9x1.5	14
Cost	3	CAD dollars ($)	10	11	16.73
Weight	3	Grams (g)	34	45	40-60
Expected lifetime	3	Years	1	4	3
Material	3	Material type	fabric	Stainless steel + polypropylene	Medical grade stainless steel
Sanitation	4	Scale of 1-5 (5 is easily sanitized)	1	4	5
Speed	5	Seconds (s)	2	n/a	n/a
Applied Force	5	Newtons (N)	5-10	1-5	5-15
Shape	4	Scale of 1-5 (5 is most ergonomic shape)	1	2	5

Table 5: Metrics on Competitive Products

D. Target Specifications

To ensure a well-guided and effective design and development process, clear and measurable target specifications must be defined. These specifications encompass both ideal and marginally accepted values for crucial metrics, each selected based on their relevance to ensure the optimal functionality and usability of the product.

Metric	**Units**	**Marginal**	**Ideal**
Size	Centimeters (cm)	14cm	14cm
Cost	CAD dollars ($)	$10	$8
Weight	Grams (g)	100g	50g
Expected Lifetime	Years	2 years	4 years
Material	Material type	Metal	Metal + plastic
Sanitation	Scale of 1-5	4	5
Speed	Seconds (s)	3 s	1 s
Applied Force	Newtons (N)	40N	10N

Shape	Scale of 1-5 (5 is most ergonomic shape)	4	5

Table 6: Target Specifications for Optimal Renal Tube Clamp

In delineating the needs pertinent to the project, a focus on ergonomics is critical. A compact design is envisioned to deter the progression of arthritis and mitigate thumb pain. Moreover, sanitation considerations are pivotal, ensuring that the device can be effortlessly cleaned in adherence to the highest hygiene standards. Additionally, portability is a significant need, facilitating ease of movement and utilization in constrained spaces.

To measure the project's success, we will employ various metrics. These metrics will gauge factors such as the reduction in thumb strain, speed of clamping, device durability, and ease of cleaning. Furthermore, benchmarking against similar solutions in the market will provide a comparative analysis to validate our project's effectiveness and identify areas for potential improvement. In defining our target specifications, we aim to set ambitious yet achievable goals, thereby propelling the project towards optimal outcomes.

In defining our target specifications, our aim is to set ambitious yet achievable goals. By doing so, we endeavor people to propel the project towards optimal outcomes, ensuring the devised solution meets the critical needs of renal care nurses effectively.

3.2 Concept development

A. Subsystems Prototyping and System Integration

In this phase, our focus sharpens on refining prototypes for each subsystem and integrating them seamlessly into the overall system. The central goal remains creating an ergonomic, ambidextrous clamping device that adeptly handles rigid plastic tubing clips. Priority lies in reducing thumb stress and enhancing usability for nurses.

First, our design will adopt a similar structure and mechanism of a pair of pliers. The plier mechanism will be designed for ease of use and comfort. It will incorporate a handle crafted from soft, non-slip materials to ensure a secure and comfortable grip in the nurses' hands, aligning with the client's preference for the whole hand over the thumb reliance.

It will also have a handle that fits comfortably in the nurse's hand by using soft, non-slip materials for a comfortable grip. As the client requested, it is better for nurses to rely on their entire hand as opposed to just their thumbs. Moreover, implementing finger grooves in the handles can help to reduce hand fatigue. Not only that, but the mechanism will also be spring-loaded for easy clamp engagement; once the nurse releases the pliers, it will return to its open state.

Next, our device will have a secure and reliable method to clip the renal tube clamps. Our team has discussed many possibilities ranging from a chamber where the blood tubing clamps would sit for the nurse to clip for a quick and easy clipping to increasing the surface area of the head so that nurses would not have to line up the pliers to clip successfully. Furthermore, our design will be able to accommodate various clamp sizes commonly used in the clinics. This feature will be essential for nurses since blood tubes can come in different diameters all around the clinic.

In terms of the materials that will be used, the design must be manufactured with durable and easy-to-clean materials that can withstand the conditions of a healthcare setting. For example, it might be a promising idea to use stainless steel or medical-grade plastic since they are biocompatible, which means that they have a low chance of causing adverse reactions or allergies when in contact with human tissue or bodily fluids. Moreover, these materials are durable and corrosion resistant which helps them last longer in an intense environment. Not only that, but they are also easy to clean and sterilize; they can withstand a process called autoclaving, chemical sterilization, and other cleaning procedures with resistance to degradation. Lastly, these materials can be used to create a lightweight and ergonomic device, ensuring it is comfortable for nurses to handle and use regularly.

B. Concept Evaluation and Specification Analysis

In this table, we assess and compare three design concepts: the Claw Pliers, Wide Head Pliers, and Stapler designs, based on the metrics we chose. Each metric has its previously chosen priority level to reflect its significance in the overall evaluation. For each concept, a score out of 10 is assigned under each metric, representing how well it performs in that category. To prioritize metrics, we multiply the score by the assigned priority to calculate a weighted total. This approach allows us to objectively rank and compare the concepts based on their performance against the defined criteria. In short, this table helps us in decision-making and identifying the design concept that best aligns with our project's goals and requirements, while highlighting areas where further development may be needed.

Priority (5 is high, 1 is low)	**Metric**	**Claw Pliers**	**Weighted Value**	**Wide Head Pliers**	**Weighted Value**	**Stapler**	**Weighted Value**
3	Size	6	**18**	6	**18**	8	**24**
2	Cost	7	**14**	7	**14**	6	**12**
3	Weight	7	**21**	6	**18**	9	**27**
4	Expected Lifetime	8	**32**	8	**32**	7	**28**
4	Material	9	**36**	9	**32**	8	**32**
4	Sanitation	8	**32**	9	**32**	6	**24**
5	Speed	8	**40**	8	**40**	9	**45**
5	Applied Force	9	**45**	9	**45**	9	**45**
3	Shape	9	**27**	9	**27**	9	**27**

	Total Points		**265**		**258**		**264**

Table 7: Evaluating Design Concepts Against Target Specifications on a Scale of 10

C. Promising Solutions Selection

Choosing one design concept is difficult without further testing, but our team plans on advancing both the pliers' concepts further as we believe these two-hold significant promise in addressing the ergonomic challenges faced by renal nurses during their daily tasks. The pliers design, with its comfortable grip and intuitive operation, can enhance the ease and efficiency of clipping and unclipping renal tube clamps. We are eager to delve deeper into the development process, refining the design, conducting testing, and optimizing materials and mechanisms to create a device that truly caters to the needs of healthcare professionals.

D. Global Design Concept Development and Rationale

For our pliers-based device, we will pursue a modified integration approach. We recognize the strengths of our initial pliers' concept, including the comfortable grip and intuitive hand-squeezing operation. However, we also acknowledge the importance of addressing any potential shortcomings, such as its size and weight, and ensuring our device aligns closely with our target specifications.

In our approach to developing a global design concept for our pliers-based device, we are going to use the promising elements from our initial concept. These include the comfortable grip, the speed at which one can wield the device, and the easy-to-clean surfaces. Furthermore, we intend to address any identified weaknesses or limitations by opting for a modified integration approach. This might include refining the clamp connection mechanism to make clipping easier, decreasing the dimensions if possible, and optimizing materials for both durability and decreasing weight.

E. Visual Representation of the Global Concept

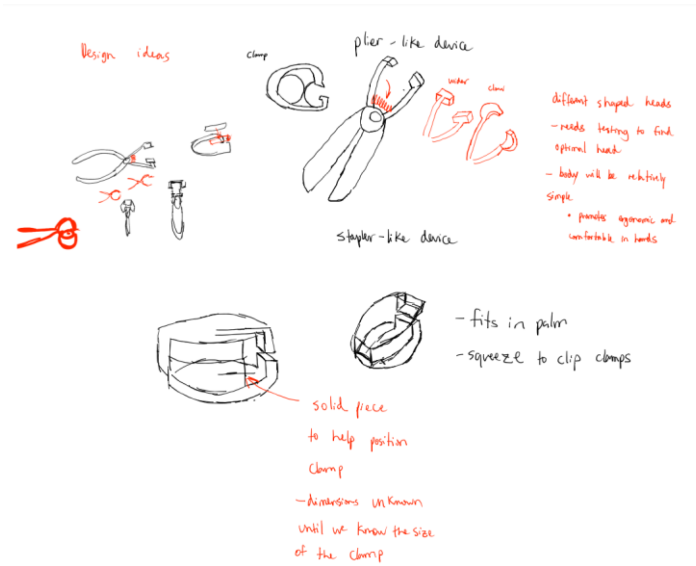

Figure 2: Visual Representation of Potential Prototypes

Considerations	Concerns
Plastic head with rubber strips to increase friction and control over clamp	Too much forced applied and the clip breaks
Metal fulcrum to strengthen the base	How to guide plier to correct position to clamp
Head possibly shaped like the clamp to help guide the device (also allows the user to clip with only one hand), or a longer head	Which parts to reinforce with metal and which to use plastic (we want to avoid having a heavy product)

Table 8: Considerations and Concerns of the Prototypes

Materials	Pros	Cons
Polypropylene	-Low cost -Excellent chemical resistance -Lightweight -Good electrical insulation -Low friction properties -Biocompatible options available -Resistance to moisture and humidity -Ease of fabrication -Recyclable	-Limited temperature resistance -Vulnerable to UV degradation without stabilization -Low mechanical strength -Permeable to certain gases and liquids -Susceptible to scratching -May require flame-retardant additives for fire resistance -Persistence in the environment -Limited aesthetic options
Polyethylene	-Low cost -Excellent chemical resistance -Lightweight -Good electrical insulation -Low friction properties -Some biocompatible options available -Resistance to moisture and humidity -Ease of fabrication -Recyclable	-Limited temperature resistance -Vulnerable to UV degradation without stabilization -Low mechanical strength -Permeable to certain gases and liquids -Susceptible to scratching -May require flame-retardant additives for fire resistance -Persistence in the environment -Limited aesthetic options
Stainless Steel (Austenitic Stainless steel300 Series, most notably 304 and 316)	-Excellent corrosion resistance -High durability and longevity -Hygienic and easy to clean -Good strength-to-weight ratio -Aesthetic appeal -Recyclable and environmentally friendly	-Higher cost compared to some materials -Heavy -Some alloys may exhibit weak magnetic properties -Can be prone to surface scratches

	-Food and medical-grade options available -Heat and fire resistance	-Requires proper maintenance to prevent staining or discoloration -Limited insulation properties -More challenging to machine than softer metals
Aluminum	-Lightweight -Good corrosion resistance -High strength-to-weight ratio -Excellent thermal conductivity -Recyclable and environmentally friendly -Modern and attractive appearance -Non-magnetic -Ease of machining and fabrication	-Lower melting point than some metals -Weaker tensile strength compared to steel -Limited ductility and formability -Susceptible to galvanic corrosion when in contact with dissimilar metals -Prone to surface scratching and abrasion -Slightly lower electrical conductivity than copper -May be more expensive than some materials, depending on the grade

Table 9: Comparison of Material Properties for Healthcare Device

F. Concept Rationale and Alignment with Target Specifications

Our design concept exhibits a range of commendable qualities and areas with potential for improvement. It is a handheld device designed for one-handed use, emphasizing cost-efficiency. The core concept centers on increasing the spacing between the clip arms by a factor of x, which, in turn, reduces the necessary force by the same factor of x to achieve equivalent torque. Implementing this concept within the integrated tool mechanism will decrease the force required by the user.

The choice of materials will play a pivotal role in determining the device's lifespan, ease of sanitization, and its capacity to withstand force without fracturing. Currently, the prototype is slated to be constructed from aluminum and polypropylene. These strengths yield various advantages, including heightened durability, cost-effectiveness, user comfort, and enhanced operational efficiency. Nevertheless, there is room for refinement, especially concerning dimensions, expenses, and weight, prompting us to reconsider and modify the design, as necessary. Overall, the concept displays substantial potential in addressing the ergonomic challenges encountered by renal nurses.

Overall, this section has laid the foundation for the comprehensive development of an ergonomic and ambidextrous clamping device, tailored to facilitate the handling of rigid plastic tubing clips in healthcare settings. By diligently analyzing and prioritizing client needs and defining relevant metrics, we have established a clear problem statement and a set of target specifications that serve as guiding principles for the design process. Furthermore, our exploration of various materials has provided insights into potential choices for constructing the device, considering their respective advantages and disadvantages. As we move forward into the concept development phase, we are equipped with a deep understanding of the user's requirements and a well-defined path toward creating a solution that prioritizes usability, durability, and efficiency.

3.2 Project plan

Below is the link that contains our project plan and timeline:

https://www.wrike.com/frontend/ganttchart/index.html?snapshotId=BNKgVcd62voy0Npusjc1MF9cAaUAEwS3%7CIE2DSNZVHA2DELSTGIYA

4 Detailed Design and BOM

Introduction

This section delves into the critical phase of design refinement and consolidation, building upon the invaluable insights provided by our client. We have carefully incorporated the feedback and suggestions from our client, ensuring that our design aligns seamlessly with the needs and expectation of the end-users. With a focus on enhancing usability and addressing concerns such as slippage during usage, our updated design reflects a deeper understanding of the practical aspects involved in clamping rigid plastic blood tubing. Additionally, we explore the feasibility and practicality of translating our design into a physical prototype, aiming to optimize the design for efficient fabrication and assembly. Furthermore, we present a comprehensive Bill of Materials (BOM) for our final prototype, underscoring the materials and components essential to the realization of our envisioned solution. This section encapsulates the evolution of our concept, emphasizing a meticulous approach to design and material selection, getting us closer to the realization of a functional and user-centric prototype.

4.1 Detailed design

A. Client Feedback
During our second client meeting with our client, she expressed her approval for our plier-like design and encouraged us to continue with the design prototype, affirming that we are on the right track. To further improve our design, we will go ahead with rubber tips to prevent slippage as the client agreed this would be a beneficial aspect of our design. Moreover, the client clarified a key operational detail: nurses typically hold the tubing with one hand while using the other hand to apply the clip. This insight guides us in refining the design to accommodate this ergonomic aspect, eliminating the need for a feature to hold the tube in place. These details will be pivotal in advancing our design and creating a more user-friendly and efficient clamping device.

B. Detailed Design Development and Visualization

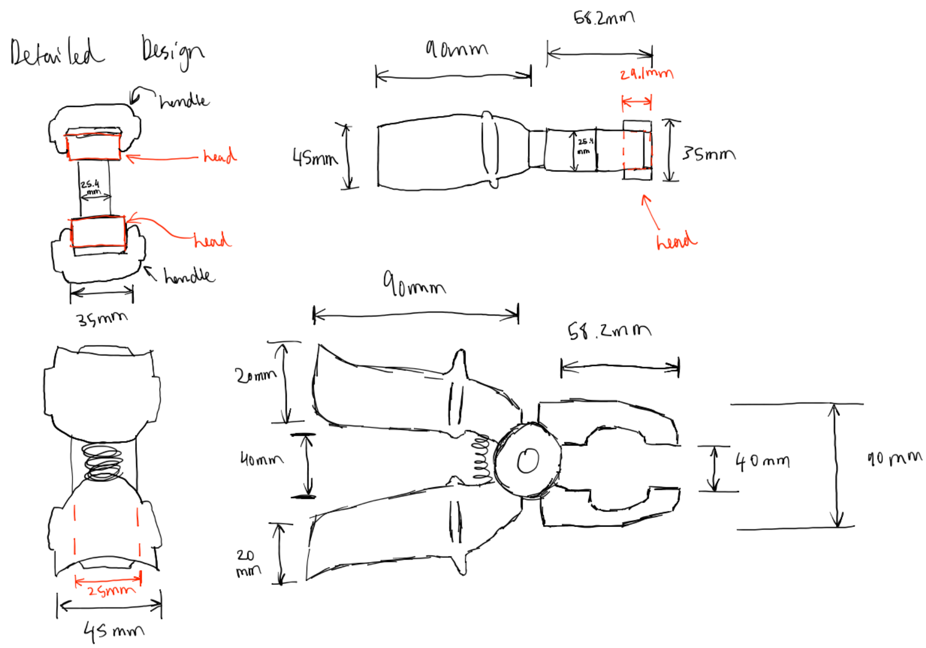

Figure 3: Detailed Design of the Clamp

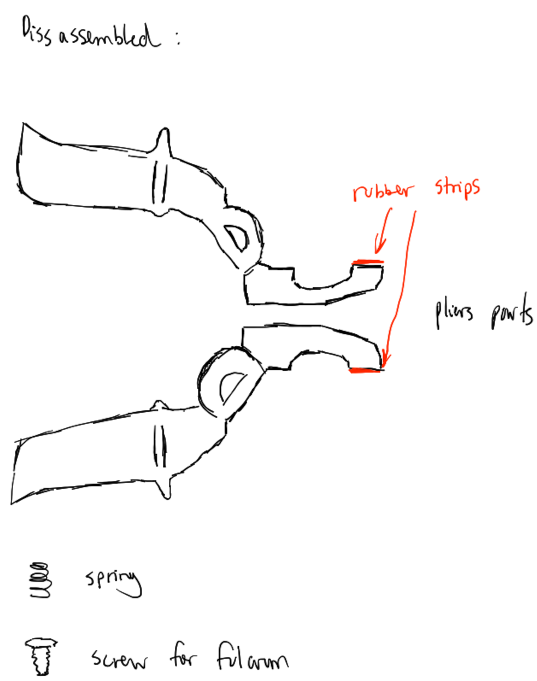

Figure 4: Disassembled Model of the Clamp

Based on valuable feedback, stainless steel will be used for both the head and fulcrum due to their durability, ease of cleaning, and low maintenance requirements. Additionally, silicone lubricants will be applied to the fulcrum to reduce wear. The subsystems consist of the upper and lower handle, spring, and screw. The upper and lower handle will be placed one on top of the other in a way where both parts will lock at the fulcrum. Then, a screw will be fastened tightly to prevent the two plier parts from separating. A spring will be fastened to both legs of the pliers so that it constantly applies a slight force to separate the two legs away from each other, ultimately keeping the pliers in an open state. This force will not be very strong; it is only enough to keep the pliers open.

C. Skills and Resources for Design Realization

Our ability to bring our design to actualization relies significantly on the skills and resources at our disposal. Our team benefits from access to uOttawa facilities, including the makerspace and Brunsfield, providing us with the necessary infrastructure for prototyping and fabrication. Additionally, our team possesses basic mechanical skills, notably in 3D printing, a crucial tool in our prototyping toolkit. This proficiency enables us to craft and iterate on our design concepts efficiently. However, we acknowledge certain skill gaps and resource deficiencies, particularly in materials engineering, biocompatibility and medical standards, and human-centric design. Addressing these gaps is a priority as we strategically plan to augment our capabilities and ensure seamless execution of our design.

D. Time Assessment and Allocation for Implementation

In evaluating the timeline required for the implementation of our design, we estimate dedicating approximately two to four days for the 3D printing process to produce our prototype. Subsequently, an additional day is allocated for the assembly and thorough testing of the design.

Realistically, the time commitment from our group members will revolve around the availability of hours within our schedules. Each member plans to spend several hours in the makerspace, making use of the time gaps between classes or other commitments. As a collective, we anticipate pooling our efforts, with each member contributing a few dedicated hours to the project. This collaborative approach ensures efficient utilization of the available time and maximizes productivity.

E. Critical Product Assumptions

In the process of conceptualizing our design for an ergonomic, user-friendly renal tube clamp, we have identified and considered several critical assumptions that influence our approach and expectations regarding the functionality and practicality of our prototype. Firstly, we are assuming that the operation of the tubing clips is relatively easy to close and does not require a lot of force. Since we do not have access to a physical version of the clips, we are assuming that it requires a similar amount of force as a hair clip.

Moreover, we are also assuming the accessibility of necessary materials critical to our design. We assume that essential components like rubber for grip enhancement and a spring for the clamping mechanism will be readily available for incorporation into our prototype. These components are foundational to the functionality and ergonomics of our device. Assuming their availability allows us to strategize our design, ensuring that the necessary elements are in place to create an effective, user-friendly renal tube clamp that addresses the ergonomic challenges faced by healthcare professionals during clamping procedures. These assumptions guide our decision-making and enable us to work within practical constraints while aiming for an optimal, realizable solution.

4.2 BOM

The BOM below outlines the key components and their associated costs for the development of our renal plier device designed to address the challenges of clamping rigid plastic tubing clips. This BOM serves as a critical tool for guiding us through the development process while ensuring alignment with our project's constraints and objectives. Notably, our team has made a creative effort to maximize funds, making cost effective choices without compromising on quality and functionality.

Materials	**Cost (per unit)**	**Description**	**Link**
Stainless steel	$23.99 for **"2-1/2" x "2-1/2" x "7/8"**	Main body and handles	https://www.amazon.ca/Oudtinx-Steel-Jewelers-Jewelry-Staing/dp/B08DFSQGJS/ref=asc_df_B08DF78G9W/?tag=googleshopc0c-20&linkCode=df0&hvadid=490980298990&hvpos=&hvnetw=g&hvrand=2650392304496256167&hvpone=&hvptwo=&hvqmt=&hvdev=c&hvdvcmdl=&hvlocint=&hvlocphy=9000684&hvtargid=pla-989461487894&th=1
Spring mechanism	$17.99 (for 300 with 30 different compression spring)	Internal spring for efficient clamping action. Different spring sizes gives us more to test with.	https://www.amazon.ca/Compression-Assortment-Stainless-Different-Individual/dp/B09VZH6NS1/ref=asc_df_B09VZH6NS1/?tag=googlemobshop-20&linkCode=df0&hvadid=579230276817&hvpos=&hvnetw=g&hvrand=16995267981314377935&hvpone=&hvptwo=&hvqmt=&hvdev=m&hvdvcmdl=&hvlocint=&hvlocphy=9000684&hvtargid=pla-1675152284052&psc=1
Rubber grip	$10 - $27	Rubber band on the head to help with gripping onto clip	https://www.amazon.ca/uxcell-Solid-Rectangle-Rubber-Strip/dp/B07ZKPK4K1/ref=sr_1_21?keywords=rubber+strip&qid=1696966665&sr=8-21 https://www.amazon.ca/NABOWAN-Rubber-Sheets-Strips-Neoprene/dp/B08G4CX7SW/ref=sr_1_4?crid=13Q1HBXHCS

			JN6&keywords=rubber%2Bstrip&qid=1696966718&sprefix=rubber%2Bstrip%2Caps%2C82&sr=8-4&th=1 https://www.walmart.ca/en/ip/Dip-and-Grip-Rubberized-Plastic-Coating-Black-8-fl-oz/PRD79UQ0XYY0EFZ?skuId=79UQ0XYY0EFZ&offerId=1070AD48DFB64A4D8DF332E6E4479E40&cmpid=SEM_CA_32609_5D6BYGWY03&utm_id=SEM_CA_32609_5D6BYGWY03&utm_medium=paid_search&utm_source=google&utm_campaign=always_on&gbraid=0AAAAADv6L0RPKZNHAluP_9Iy5h8hjZx6K&gclid=Cj0KCQjwsp6pBhCfARIsAD3GZuaadY9CzRz7zZw1frhLCv9iY2N6JHMZAif5I8K5Qhh_Jf_W55WRoaIaAn18EALw_wcB&gclsrc=aw.ds https://www.amazon.ca/Performix-11601-06-Plasti-Dip-14-5/dp/B0006SL0VO/ref=asc_df_B0006SL0VO/?tag=googlemobshop-20&linkCode=df0&hvadid=341851042496&hvpos=&hvnetw=g&hvrand=2909740794961603572&hvpone=&hvptwo=&hvqmt=&hvdev=m&hvdvcmdl=&hvlocint=&hvlocphy=9000684&hvtargid=pla-309519410776&psc=1
Screws and Fasteners	up to $0.67 per piece	For assembly	Home Depot
Plastic components	Free. The university lets us 3D – print materials	Various plastic parts for lightweight construction	

Table 10: Bill of Materials

Our team has been diligent in identifying cost-effective sources for materials and components. By considering alternatives and making efficient choices, such as looking for free materials that we may already own, we aim to maximize the utilization of available funds. This approach demonstrates our commitment to cost-effectiveness and ensuring that the project remains within the budgetary constraints. The selection of materials and sources has been made with careful consideration to achieve a balance between cost-efficiency and the quality and functionality of our clamping device. This creative effort will contribute to the successful realization of our prototype while staying within financial boundaries.

In conclusion, our decision to pursue the plier-like design as our final prototype stems from its alignment with our client's feedback and its potential to effectively address the challenges of clamping rigid plastic tubing clips. The endorsement from our client instilled confidence in our chosen path. However, we are of the challenges and skills gaps within our team, particularly in the biomechanical realm. Addressing these gaps will demand collaborative efforts and efficient utilization of the resources at our disposal. Looking ahead, the successful realization of our prototype hinges on a dedicated investment of time and a united application of our combined expertise, optimized by our access to crucial facilities. Crafting a comprehensive and accurate BOM will serve as our compass, guiding us through the development process while aligning with our project's constraints and objectives.

4.3 Project plan update

Below is the link that contains our project plan and timeline:

https://www.wrike.com/frontend/ganttchart/index.html?snapshotId=VJioLWJXKJOoIL5kwNeu2CIjBqfE0JQV%7CIE2DSNZVHA2DELSTGIYA

5 Prototype 1, Project Progress Presentation, Peer Feedback and Team Dynamics

Introduction

This section delves into the critical stage of prototyping, a pivotal step in our project's progression. Our first prototype stands as a significant milestone, allowing us to validate assumptions made about our final product. Through careful testing and documentation, we pe to analyze performance against our target specifications. Additionally, we emphasize the importance of purposeful prototypes, ensuring each serve to verify specific product assumptions.

5.1 Prototype 1

In our previous deliverables, we made a set of assumptions that played a crucial role in guiding our approach to designing our product. Among these assumptions, those were about the behavior of the clamps and the availability of springs.

First, we assumed that the clamps do not require a significant amount of force to close. This assumption was pivotal in defining the ergonomic and user-friendly nature of our device. By presuming that minimal force is needed for clamping, we aimed to create a tool that would not only be efficient but also comfortable for renal care nurses to use over extended periods. This assumption helped drive our design decisions, such as the selection of appropriate materials and the optimization of the mechanical structure to ensure that the clamps are easy to operate, reducing the risk of hand strain and fatigue.

Figure 5: Prototype 1

Secondly, we assumed that suitable springs would be available for us to use in the design of our product. Springs are crucial components in ensuring the smooth operation of the clamps and, consequently, the overall functionality of our device.

Metric	**Units**	**Marginal**	**Ideal**
Size	Centimeters (cm)	17cm	10cm
Cost	CAD dollars ($)	$10	$5
Weight	Grams (g)	100g	50g
Expected Lifetime	Years	2 years	4 years
Material	Material type	Metal	Metal + plastic
Sanitation	Scale of 1-5	4	5
Speed	Seconds (s)	3 s	1 s
Applied Force	Newtons (N)	50N	20N
Shape	Scale of 1-5	3	5

Table 11: Prototype 1 Metrics

To ensure that every prototype has a well-defined purpose, we have identified specific assumptions for each prototype. In our initial prototype, we created a global proof of concept, and our design works as intended, although still not perfect. Since its job is to validate that our concept is technically feasible and demonstrate that it works as envisioned, it turned out to be a success. Future prototypes will be used to improve efficiency, ergonomics, and ease of sanitation.

In conclusion, our first prototype has served as a valuable tool for testing and validation. It has allowed us to confirm our assumptions, providing us with a solid foundation for further iterations. The information gained from this prototype will inform and guide the evolution of our design, ensuring a refined and effective final product. Through rigorous testing and analysis, we are better positioned to make informed design decisions as we progress toward realizing an optimized solution for our intended users.

5.2 Project Progress Presentation

Below is the link that contains our project plan and timeline:

https://docs.google.com/presentation/d/10uZdTlowfpA5-Xzh6AcWgREeXfEUg_-NhmKn0n-HXaw/edit?usp=sharing

5.3 Project plan update

https://www.wrike.com/frontend/ganttchart/index.html?snapshotId=VJioLWJXKJOoIL5kwNeu2CIjBqfE0JQV%7CIE2DSNZVHA2DELSTGIYA

https://www.wrike.com/workspace.htm?acc=4975842#/folder/1214411344/timeline3?viewId=202193499

6 Design Constraints and Prototype 2

This section of the report marks an important phase in the ongoing development of our innovative renal care pliers. Our team has been steadfastly committed to refining a solution aimed at significantly improving the challenges faced by nurses in handling renal tube clamps. As we proceed, our focus lies not only on the functionality of the device, but also in addressing the ergonomic stressors that medical staff encounter. This report encompasses our exploration of non-functional design constraints and the application of the DFX methodology. These methodologies and constraints play an integral role in driving our iterative design approach, ensuring that the resulting prototypes align with stringent quality benchmarks and serve the practical needs of medical practitioners.

6.1 Design constraints

1. Identify two non-functional design constraints that play an important role in the development of your prototypes. Justify your reasoning.

Two non-functional design constraints that we encountered are the limitation with 3D printing and material selection. 3D printing technology has specific limitations that can significantly impact the development of prototypes. These limitations include different nozzle sizes, limited availability of 3D printers, and the time-consuming nature of the 3D printing process. Nozzle size affects the level of detail and precision that can be achieved in a print, and it can impact the speed of printing. Due to the limited 3D printers available, we had to use .6mm for half the prototype and .8mm for the other half which caused the parts to not fit together as expected. Limited access to 3D printers and their availability in the makerspace led to delays in the prototyping process. Furthermore, 3D printing is a layer-by-layer process that can be time-consuming.

Material properties are a fundamental non-functional design constraint for 3D printing prototypes. The choice of material directly affects the physical characteristics, strength, durability, and suitability of the prototype for its intended purpose. Different materials have unique properties, including strength, flexibility, thermal resistance, and color options. Material properties can also influence factors like weight, cost, and post-processing requirements. In the makerspace, we are limited to the available PLA. The constraint of material properties is vital because it impacts the functionality and aesthetics of the prototype.

2. For each design constraint, explain in detail what changes would need to be made to your design to satisfy the constraint.

To satisfy the design constraints related to 3D printing limitations and material properties, it is crucial to adapt the design both in terms of its geometry and the choice of materials. The design should be flexible and compatible with the specific capabilities and limitations of the 3D printers and materials available, ensuring that the final prototype meets the desired objectives and requirements. Now that we are aware of how the 3D printers work, we will allocate more time to

3D printing as well as arriving as early as possible to ensure we get a printer with the desired nozzle. For the material selection, our design can be modified with supports (such as inserting steel in the handle) so that the available PLA in the makerspace is strong enough.

3. Provide proof (e.g., analysis, simple calculations and/or simulations, research) to demonstrate the effectiveness of your changes in satisfying the constraints. Justify the process and methods you used.

Now that we are more familiar with the 3D printing process, we have been able to create a prototype that is to our desired design. This last prototype was printed with only one nozzle size which allowed for optimal movement between the parts. In terms of material, we kept it the same PLA as before because we still do not have a physical renal clamp that we can test the strength of our product on. If it turns out that our product is not durable enough, then we will investigate reinforcing the PLA with other materials.

6.2 Prototype 2

A. Prototype Testing and Design Requirements

Our latest rounds of prototype testing have led to important insights crucial for enhancing our device's design. Notably, these tests have highlighted the imperative need to address the limitations in the first plier prototype, which successfully tackled the handle ergonomics and weight but fell short in accommodating the required head size for efficient clamping of the renal tube clips. Specifically, recent testing involving the evaluation of clip-holding capacity has underlined the inadequacy of the head design. The findings emphasize the necessity to extend the head size while preserving the established ergonomic handle and optimal weight. These revisions are pivotal to aligning our prototype's functionality with our target specifications. The identified upcoming improvements will be addressed in our upcoming design phase to refine the device's overall performance.

B. Critical Product Assumptions

1. Durability of 3D Printing Materials:
This critical untested assumption pertains to the durability of the 3D printing materials utilized in our prototypes. The assumption suggests that the plastics obtained from the 3D printing process possess the required durability, strength, and longevity necessary for continual use in a clinical setting. The unverified durability of these materials is crucial in ensuring they can withstand repetitive usage, maintain structural integrity, and resist wear and tear over extended periods of time. Testing the longevity and resilience of the materials used in the pliers under conditions replicating real-world usage will provide valuable insights into their sustainability for the final device.

2. Material and Design Compatibility:
Assumptions were also made regarding the compatibility of materials and the overall design of the device. Although we have integrated rubber grips and a spring mechanism into the design concept, we have not tested the compatibility of these materials and mechanisms over prolonged use and under different environmental conditions. An unverified assumption remains on the exact resilience of these materials when exposed to constant usage, diverse clinical settings, sterilization procedures, and potential chemical interactions, which could impact the overall functionality and durability of the device.

1. **C. Second Iteration Prototyping and Assumption Testing**

Prototype 2 serves as a significant advancement from our initial design iteration. It specifically focuses on rectifying the inadequacies found in Prototype 1, notably concerning the head size and its compatibility with renal tube clips. The modifications made in Prototype 2 primarily revolve around extending the head size, a crucial adjustment to ensure the effective clamping of various clip sizes, addressing the key challenge faced in the previous prototype. The enhanced dimensions aim to enhance the device's usability and functionality, particularly in securely holding and operating the renal tube clips. Additionally, these design changes work towards refining the ergonomics, with a keen focus on ensuring user comfort and operational ease for medical professionals during extended usage. Ultimately, prototype 2 reflects our commitment to addressing the essential product assumptions and serves as a pivotal step toward the creation of our final prototype.

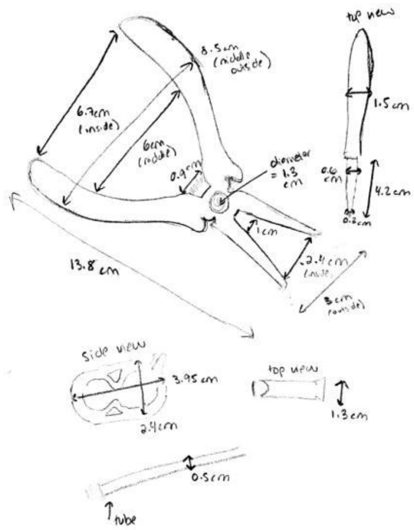

Figure 5: Detailed Dimensions of Prototype 1 and Clip

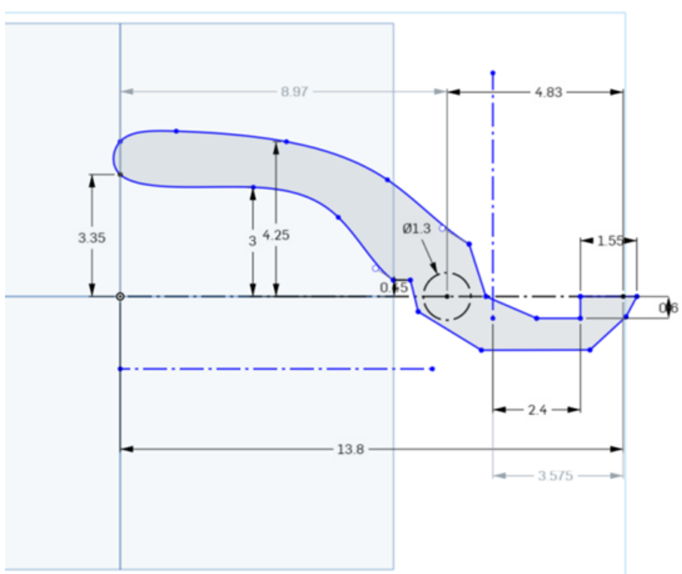

Figure 6: Handle Design Dimensions (cm) of Prototype 2

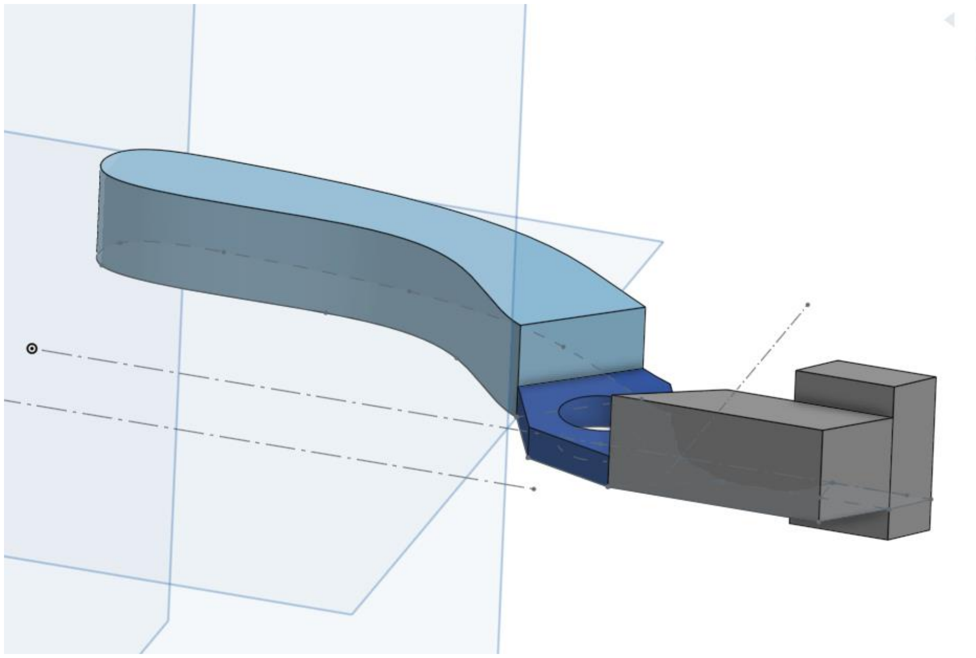

Figure 7: 3D Design of Prototype 2

Figure 8: Prototype 2

D. Prototype Performance Evaluation and Comparison to Target Specifications
Carry out prototype testing, analyze and evaluate performance compared to the updated target specifications first developed in Project Deliverable C and document all your testing results and prototype specifications. Present your testing in an organized, tabular format that shows expected

versus actual results (i.e., compare your measured prototype specifications to your target specifications by including both in a similar table to the one your developed for Project Deliverable C).

Prototype 2:

Metric	Units	Prototype 2	Ideal
Size	Centimeters (cm)	14cm	14cm
Cost	CAD dollars ($)	$0	$8
Weight	Grams (g)	40g	50g
Expected Lifetime	Years	2 months	4 years
Material	Material type	PLA	Metal + plastic
Sanitation	Scale of 1-5	4	5
Speed	Seconds (s)	2 s	1 s
Applied Force	Newtons (N)	40N	10N
Shape	Scale of 1-5 (5 is most ergonomic shape)	1	5

Table 12: Target Specifications for Prototype 2

Next steps:

- The head has trouble opening wide enough. We remodel the head to allow for wider opening.
- The two plier parts were not aligned symmetrically. We will remodel it to fit symmetrically.
- The pliers' handles are too far apart in the closed position, which hinders its performance and ease of use. We will improve the design of the legs so that they are less curved.
- The design is uncomfortable to hold since the legs have rough edges. We will improve the design of the legs by rounding the handles.

E. Prototype Specifics and Client Feedback

1. Initial Prototype Assessment: Discuss the client's options on the initial plier prototype, focusing on the performance of the pliers regarding ease of use, comfort, and functionality. Ask specifically about her opinion on the small and long head size and how it aligns with her expectations, as well as how easily the device can be sanitized.

2. Size and Head Design: Present the proposed changes for the plier's rounder head shape and gather the client's thoughts on this alteration. Specifically ask about the preferred material and ideal head shape, aiming to align with the client's needs and ergonomics.

3. Testing and Performance Feedback: Request feedback on the tests and their resonance with the tasks that are performed by renal care nurses. Understand the insights on the force required, overall handling, and any other challenges faced during our testing.

4. Improvement Preferences: Ask the client about any specific features, functionalities, or modifications the client wishes to see in the revised prototype. Request for a priority list if anything stands out as more critical for the device's functionality.

In conclusion, the iterative development process in this deliverable has been instrumental in addressing critical limitations found in the initial prototype. The extensive testing and analysis of Prototype 1 provided vital insights into the specific challenges faced, notably in head size and clip functionality. Prototype 2, developed in response to these insights, represents a significant advancement. The enhanced head dimensions promise to rectify prior issues and cater to the varying sizes of renal tube clips, ensuring improved clamping efficiency. The modifications not only aim to refine functionality but also emphasize ergonomic design, enhancing user experience. The series of tests performed have provided valuable feedback, guiding our design toward a more efficient and effective final prototype. As we continue the development of our renal care device, each prototype iteration serves as a learning opportunity, progressively refining our design in response to critical assumptions and constraints.

6.3 Project plan update

https://www.wrike.com/frontend/ganttchart/index.html?snapshotId=Ee8Iqw1xECTX0xDacEo2NQbhvW21BkS0%7CIE2DSNZVHA2DELSTGIYA

7 Other Considerations

Introduction

As our innovative renal pliers advance from prototype to a market-ready product, this phase of our project marks a significant milestone. With full-scale production underway and the assumption of establishing a company for commercialization, our focus shifts towards the economic viability of our venture and potential legal constraints. In this deliverable, we delve into two vital aspects: a comprehensive economics report detailing costs, income statements, and break-even analyses, and an exploration of intellectual properties, understanding their significance and legal implications in the development of our renal care device. These considerations are pivotal as we bring our product to market and ensure its sustainability beyond the prototyping phase.

7.1 Economics report

In steering ErgoCares Innovations from prototyping to full-scale production, our economic analysis delves into the financial landscape of manufacturing and selling our renal care pliers. The following breakdown of variable, fixed, direct, and indirect costs provide a nuanced understanding of the economic considerations associated with our venture.

	Material	**Labour**	**Expenses**
Direct	Production Materials **($4 / plier)**	Salaries **($40,000 / person)**	Patent Maintenance Fee **($400 / year)** Staff Training **($750 / person)** 3D Printer **($250 / printer)**
Indirect			Marketing **($1000 / year)** Electricity **($400 / month)** Rent **($30,000 / year)** Shipping (**$3 / unit**)
Fixed			Marketing Electricity Rent Shipping
Variable	Production Materials	Salaries	Staff Training

Table 13: ErgoCares Innovations Cost Classification Table

Material Cost:

General Assumptions:

- There are 40,891 nurses in British Columbia as of 2022.
    - Retrieved from https://www.statista.com/statistics/496935/total-registered-nursing-canadian-workforce-by-province/
- 24% market share in the first year, 29% market share in the second year, 35% market share in the third year.

Number of units sold:

40,891 * 0.24 = approximately 10,000 units sold first year

40,891 * 0.29 = approximately 12,000 units sold second year

40,891 * 0.35 = approximately 14,400 units sold third year

If each pliers cost $4 to produce, there will be a material cost of $40,000 in the first year, $48,000 in the second year, and $57,600 in the third year.

For machinery, we will be using a 3D printer to produce our product. According to https://www.fusion3design.com/how-much-does-a-3d-printer-cost/, we can acquire 3D printers for around $250 each.

For electricity, according to https://hydroottawa.com/en/accounts-services/accounts/rates-conditions/residential-rates, electricity costs 18.2 ¢/kWh. After calculating the power used by basic appliances and the machinery we use, the bill becomes around $400 per month.

Labor:

We will have 4 employees, and each of their salaries will be $40,000 per year.

Shipping:

There are many shipping services that deliver products for $10.85 per pound which is around 450g across Canada. We will be shipping all our products. Every set of pliers weighs 27g, so we can fit 16 pliers in one box. In the first year, it will cost us 10,000/16 *$10.85 = approximately $6781.25. In the second year, it will cost 12,000/16 * $10.85 = approximately $8137.5. In the third year, it will cost 14,400/16 * $10.85 = $9765.

Marketing:

According to https://www.bdc.ca/en/articles-tools/marketing-sales-export/marketing/what-average-marketing-budget-for-small-business#:~:text=A%20common%20rule%20of%20thumb,to%20reach%20various%20customer%20segments, it is common for small companies to spend around 2 – 5% of their revenue on marketing.

10,000 * $20/pliers * 5% = $10,000 for marketing in first year

12,000 * $20/pliers * 5% = $12,000 for marketing in second year

14,400 * $20/pliers * 5% = $14,400 for marketing in third year

Assumptions:

- The operating expenses remain constant throughout the years (first year is an exception due to the initial start up costs)
- Each year, we sell 20% more products than the year before
- We are given a starting balance of $300,000
- We will show 5 years to show when we break even

Year	2023	2024	2025	2026	2027
Starting Balance	**300,000**	**160,000**	**152,000**	**182,400**	**258,880**
Gross Profit					
Total Revenue	200,000	240,000	288,000	345,600	414,720
Costs Of Goods Sold	40,000	48,000	57,600	69,120	82,944
Total	**160,000**	**192,000**	**230,400**	**276,480**	**331,776**
Operating Expenses					
Start Up costs	100,000	0	0	0	0
Rent	30,000	30,000	30,000	30,000	30,000
Salaries	160,000	160,000	160,000	160,000	160,000
Overhead	20,000	20,000	20,000	20,000	20,000
Total	**300,000**	**200,000**	**200,000**	**200,000**	**200,000**
Operating Income	**-140,000**	**-8,000**	**30,400**	**76,480**	**131,776**
Closing Balance	**160,000**	**152,000**	**182,400**	**258,880**	**390,656**

Table 14: 5-year income statement

Revenue:

In the first year, we will make a revenue of 10,000 * $20 = 200,000. In the second year, 12,000 * $20 = $240,000. In the third year, 14,400 * $20 = $288,000. In the fourth year, 17,280 * $20 = $345,600. In the fifth year, 20,736 * $20 = $414,720.

Rent:

According to https://www.realtor.ca/on/ottawa/real-estate-for-rent, a large enough base of operations cost around $2,500 a month, which adds up to $30,000 a year.

Assumptions for NPV analysis:

Discount rate: 8%

$$NPV = \sum_{t=1}^{n} \frac{(Cash\ Flow)}{(1 + Discount\ Rate)^{Time\ Period}}$$

The cash flow is the operating income. The break-even point occurs when the total NPV = 0.

$$NPV_{one\ year} = -\frac{114{,}000}{1.08} = -129629.6296$$

We get this value after selling 10,000 products.

$$NPV_{two\ years} = NPV_{one\ year} - \frac{8{,}000}{1.08^2} = -136488.3402$$

We get this value after selling $10{,}000 + 1.2 \times 10{,}000 = 22{,}000$ products.

$$NPV_{three\ years} = NPV_{two\ years} + \frac{30{,}400}{1.08^3} = -112355.8401$$

We get this value after selling $22{,}000 + 1.2 \times 22{,}000 = 48{,}400$ products.

$$NPV_{fourth\ year} = NPV_{three\ years} + \frac{76{,}480}{1.08^4} = -44404.35064$$

We get this value after selling $48{,}400 + 1.2 \times 48{,}400 = 106480$ products.

$$NPV_{five\ years} = NPV_{four\ years} + \frac{131{,}776}{1.08^5} = 69266.78453$$

We get this value after selling $106{,}480 + 1.2 \times 106{,}480 = 234256$ products.

It takes us five years to break-even. With that knowledge, we need to sell enough products on the fifth year to get an NPV of at least 44404.35064 to break even. Therefore we can say

$$44404.35064 = \frac{(Net\ Income_{fifth\ year})}{1.08^5} \rightarrow Net\ Income_{fifth\ year} = 44404.35064 \times 1.08^5$$

Where the $Net\ Income_{fifth\ year} = 30220.85492$. The Net Income is defined as

$$Net\ Income_{fifth\ year} = Gross\ Profit - Operating\ Expenses$$
$$= (20 - 4) \times p_{break\ even} - 200{,}000$$

$$\rightarrow$$

$$p_{break\ even} = \frac{Net\ Income_{fifth\ year} + 200{,}000}{16},$$

Where the $p_{break\ even} = 16577.78495$. So, we need 16578 products in the fifth year to break even. Adding the number of products needed in the fifth year with the previous year, we get 123058. We need to sell 123058 products to break even.

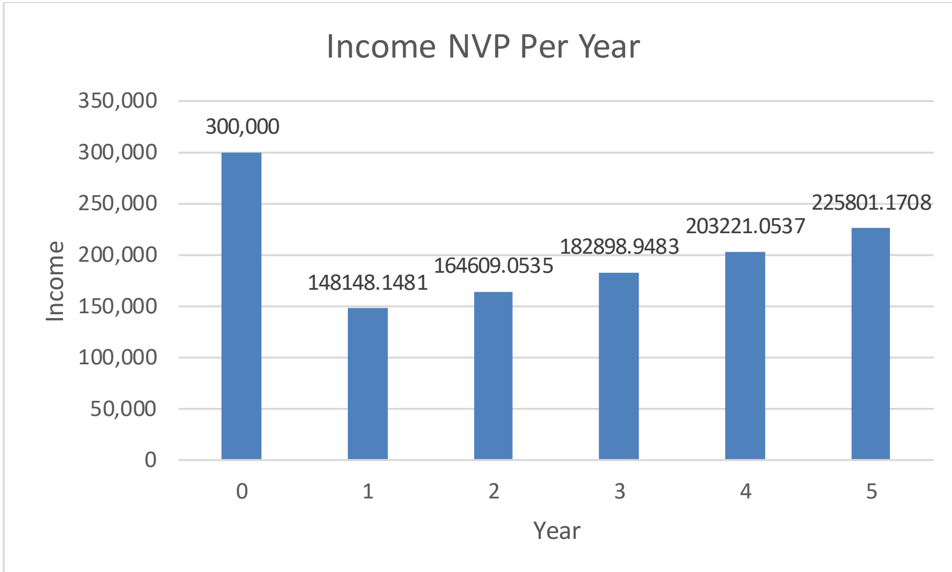

Figure 9: Income NVP Per Year

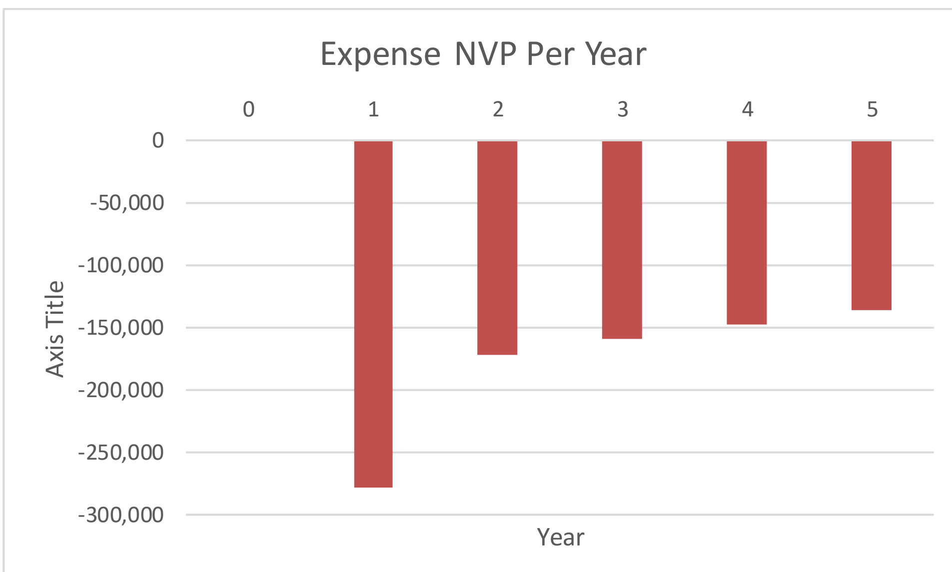

Figure 10: Expense NVP Per Year

Justifications for Assumptions

In formulating our financial projections for the ergonomic plier's business, several key assumptions have been made to guide our estimations. First and foremost, we assume a unit price of $20 for our product, reflecting a balance between market competitiveness and maintaining a reasonable profit margin. This pricing strategy is grounded in our understanding of the perceived value in the market, with the variable cost per unit estimated at $8. This variable cost encompasses materials, labor, and other direct expenses associated with production.

Next, our sales projections are based on a carefully crafted estimate, starting with 10,000 units in the first year and projecting a 20% annual increase in subsequent years. These projections are informed by our preliminary market research, which indicates a growing demand for ergonomic tools and a strategic positioning in the target market.

Fixed costs, estimated at $200,000 annually, represent a comprehensive assessment of our operational needs. These include expenses such as rent, salaries, and other fixed overhead costs. This estimate is derived from our analysis of industry standards and our findings align with realistic financial decisions required to sustain our business.

Lastly, in the NPV analysis, we have applied a discount rate of 8%. This rate represents our opportunity cost of capital, and it aligns with realistic interest rates.

7.2 Intellectual property report

The significance of intellectual property, specifically patents and design rights, is crucial in safeguarding innovation and fostering investment in research and development. In the case of our product—an ergonomic hand-held clipping device versus similar pliers. Patents, providing exclusive rights for a set duration, encourage inventors by granting temporary monopolies on their inventions. If someone holds a patent for pliers, legal constraints may arise for our business in producing a similar product without permission. Similarly, design rights protect the visual aspects of a product, preventing others from copying distinctive features. Legal constraints may emerge if our pliers' design closely resembles an existing design under protection. Navigating these constraints involves avoiding infringement through thorough searches, considering licensing agreements, and strategically leveraging intellectual property for a competitive edge and market exclusivity. Ultimately, understanding and adhering to intellectual property laws are imperative for the success and sustainability of our business.

Currently, there are a few patents out there that are similar to our product and what we have in mind for future variations. Firstly, Patent CA 2768119, PLIERS WITH ADJUSTABLE JAW SPAN; this patent impedes on our design because it holds the rights to having an adjustable jaw span which we had considered implementing into our product so that it could be more universal to different sized clips. Luckily for our company, this patent is deemed expired. Another intellectual property that may hinder our design is the Trademark 1682959, REDUCES WRIST STRAIN & Design. This trademark protects the rights to a plier with a 62° angled head which aims to reduce wrist strain. This trademark has a similar goal to our product, reducing pain in the thumb/hand, and has a similar idea to use pliers to offset the load. This trademark specifically hinders our product from being 62° but otherwise, we are free to design our head as desired.

In conclusion, the journey from prototype to market-ready product for ErgoCares Innovations' renal care pliers represents a significant milestone. As we transition into full-scale production and establish our company, economic viability and legal considerations take the focus. In this deliverable, we have meticulously examined two critical aspects: an in-depth economics report detailing costs, income statements, and break-even analyses, and an exploration of intellectual properties, understanding their significance and legal implications in the development of our renal care device. These considerations are pivotal as we bring our product to market, ensuring its sustainability beyond the prototyping phase.

7.3 Project plan update

https://www.wrike.com/frontend/ganttchart/index.html?snapshotId=D7NQWHM7qcmeC5x8bYkkXLkP6zL5bJg1%7CIE2DSNZVHA2DELSTGIYA

8 Design Day Pitch and Final Prototype Evaluation

A. Short Project Summary

ErgoCares Innovations addresses the ergonomic challenges faced by renal care nurses, offering a user-friendly solution for handling kidney tube clamps. Our innovative design prioritizes caregiver health and well-being in healthcare practices involving tubes and dialysis machines.

B. Design Day Pitch

Welcome to the ErgoCares presentation, where we tackle a real-world problem in renal care. Through our collaboration with a nursing professional, we identified a common problem issue: the strain renal care nurses endure while handling kidney tube clamps. It is a problem that impacts not just the nurses but also the efficiency of healthcare procedures involving tubes and dialysis machines.

Why does this matter? Because healthcare prioritizes patient well-being, but often overlooks caregiver health. ErgoCares is our solution, designed to make the lives of renal care practitioners easier and healthier. Our project focuses on creating a user-friendly, efficient, and accessible device – one that addresses ergonomic challenges and improves the overall standard of care in renal health.

As you go through our presentation, you will see the evolution of our design, the consideration of user needs, and the unique features that make ErgoCares stand out. Our functional final prototype is ready for a demonstration, showcasing our commitment to innovation and user-centric design.

Thank you for joining us on this journey. Here is our presentation to learn more about ErgoCares Renal Clamp Pliers – where practical solutions meet healthcare challenges.

C. Presentation Materials

https://docs.google.com/presentation/d/10uZdTlowfpA5-Xzh6AcWgREeXfEUg_-NhmKn0n-HXaw/edit?usp=sharing

9 Video and User Manual

Video pitch

https://drive.google.com/file/d/1t61rIeq1trcKXD1TNdI6tZlWTYedAQxm/view?usp=drivesdk

User manual

See User Manual document.

10 Conclusions

The completion of this comprehensive project marks a significant milestone in the journey from conceptualization to realization. Our endeavor to design and develop ergonomic renal care pliers has been a collective exploration to design and develop ergonomic renal care pliers has been a collective exploration of innovation, problem-solving, and interdisciplinary collaborations. As a team, we embarked on this venture with the shared goal of addressing the occupational health challenges faced by renal care nurses in their daily tasks.

Throughout the project, we navigated the intricate landscape of user needs, technical constraints, and economic considerations. The iterative process allowed us to incorporate valuable feedback, refine our prototypes, and ultimately arrive at a functional and user-friendly solution. The journey was not without its challenges, as we encountered unforeseen obstacles, made critical decisions, and learned valuable lessons along the way.

The importance of prioritizing caregiver health in the healthcare sector became evident as we delved into the ergonomic intricacies of renal care procedures. Our client, a medical student connected with an arthritis clinic in BC, provided essential insights into the real-world implications of our design. The significance of developing a cost-effective, easy to use, and durable device to enhance the well-being of renal nurses became a driving force throughout our project.

In our exploration of the economic landscape, we ventured into the complexities of manufacturing, costs, and income projections. The examination of intellectual property added another layer of understanding highlighting the legal constraint and protective measures necessary for bringing a medical device to market.

As we reflect on this journey, we acknowledge the growth and dedication that fueled our progress. The insights gained from this project extend beyond the realm of product design, reaching into the realms of business strategy, ethics, and legal considerations. This experience has equipped us with a better understanding of the intricacies of involved in developing and bringing a medical innovation to fruition.

While the project has reached its conclusion, the lessons learned, and the skills honed will resonate as ensuring assets. The renal care pliers we designed stand not only as a tangible solution to a specific problem, but also as a testament to the potential of interdisciplinary collaboration in addressing real-world challenges.

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