



## Team Fresnel - Documentation

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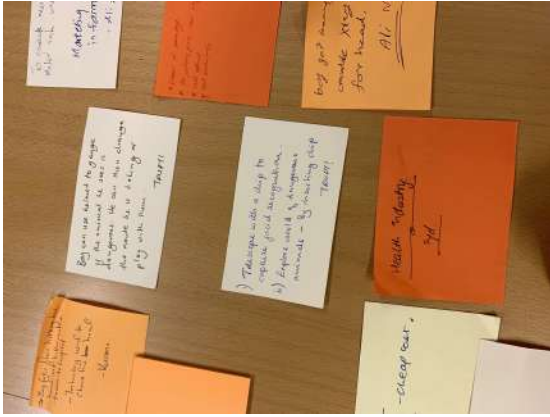
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# # The Team



# # WEEK 2 - Jobs to be done & Benchmarking

## **META HiLIGHT: *Metamaterials - Lenses for miniature devices.***

This is technology that uses metamaterial properties to manipulate light wave control in a lens which overcomes the limitations of refraction. Metamaterials are contrived materials that possess electromagnetic properties which otherwise were absent in a given material. A Russian scientist, Victor Veselago, was the pioneer of theoretical works concerning the properties of metamaterial in 1968 where he talked about permeability<sup>1</sup> and permittivity<sup>2</sup> that changes the properties in an object.

Metamaterials are 'artificial electromagnetic media' constructed on the sub-wavelength which 'provide optical properties that can be reproducibly shaped on length scales below the wavelength of light' (Adams & Barabantseva, 2015, p. 269).

This is an invention in the lenses industry. Currently, unlike silicon material, glass surfaces are used in the optical sensor. The use of this surface is to convert and direct the light rays on to the specific object or target for which evaluation/ identification is needed.

### **Q1. How are the jobs from week one currently being done?**

Identification of what customer or market need or expect from the product or service or what kind of product or service customer is looking for to satisfy their need, requirement, or leisure, in short, by whatever name it is called, co-relation of that need to our product or service is what is called job to be done (Christensen et. al, 2016).

The novel technology proposed by META HiLight is the incorporation of flat metasurfaces in optical lenses. META HiLight aims to make use of adaptive Metamaterials for smart standalone Histopathology with Polarized Light. Metamaterials refer to artificially structured materials used to control and manipulate light in optical space. These materials are useful to make lightweight optical devices and drastically reduce the cost related to making bulky optical instruments. The innovation of this technology lies in how existing technologies are integrated. It combines technologies from Nano photonics and metamaterials, Micro-electromechanical systems (MEMS), and bio-photonics.

The jobs that can be done with the Meta HiLight have been categorized according to industry in the following text. This is not an exhaustive list but outlines the main jobs that the technology potentially

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<sup>1</sup> **Permeability** is the ability of a material in supporting the creation of a magnetic field.

<sup>2</sup> **Permittivity** is the ability of a material in storing energy.

could do. Comparison is also drawn with how the stated jobs are currently being done.

<b>Job 1</b>	<b>Adaptive optical metamaterial waveplate for polarization state control</b>
Current technology	Polarization control is dependent on a material's optical properties. This has an impact on what response is observed as the polarization of the incident light will vary from material to material
Meta Highlight	The metamaterial waveplate is characteristically adaptive, thereby removing dependency on material properties.
<b>Job 2</b>	<b>On-chip system integrated metamaterial-based spectroscopic polarimeter</b>
Current technology	Polarization state and spectrum information is collected separately which is costly and time consuming. Further, the instruments to achieve this are bulky and due to size expensive to produce.
Meta Highlight	The technology can determine polarization control and spectrum simultaneously. Additionally, it offers the possibility of significantly reducing the size of instruments and delivering similar and faster output in smaller-sized instruments.
<b>Job 3</b>	<b>Data processing through machine/deep learning</b>
Current technology	Optical biopsy are a type of medical diagnosis that employ the use of light when conducting endoscopy. They allow for instant diagnosis. Current techniques offer improved image resolution, contrast, and tissue penetration and provide biochemical and molecular information about mucosal disease.
Meta Highlight	Supersedes this as it offers potential to develop algorithms and data processing for optical biopsy systems.
<b>Job 4</b>	<b>Enabling portable stand-alone - digital histopathology system for medical diagnostics</b>
Current technology	Digital histopathology as a subset of pathology focuses on managing data on information generated from digitized specimen slides. Integration to lab information systems, IT dependency and equipment are common in how some current digital pathology systems are organized.
Meta Highlight	Enable the implementation of personalized medicine more widely by combining nano photonics, Microelectromechanical systems, and medical imaging diagnostics by simplifying barrier to entry through a stand-alone system.

References:

<https://pubmed.ncbi.nlm.nih.gov/24121732/>

<https://ui.adsabs.harvard.edu/abs/2018SPIE10489E..0TW/abstract>

<https://pubmed.ncbi.nlm.nih.gov/15354274/> <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7698715/>

<https://www.leicabiosystems.com/en-se/knowledge-pathway/digital-pathology/>

<https://www.virtual-microscopy.net/>

<https://translational-medicine.biomedcentral.com/articles/10.1186/s12967-020-02316-w>

## **Q2. How have other existing products tried to solve the problem that you have identified?**

The focus market of MetaHiLight is in the diagnostics area with the health industry. Currently, the equipment used in the health industry for diagnosis is giving results which are even though not real time but, still, identification of cellular changes in the body is still possible. However, the equipment currently used for this is bulky in size, heavy to weigh at, complicated to work with since Opticals and focus that is needed to work on are needed to adjust according to the requirement of the focus.

Currently, technology is developed to use light polarization such as circular and angular momentum of light to diagnose advanced cell cultures and tissue samples with optical biopsy.

This will help to identify dangerous diseases like cancer at an incredibly early stage.

(Reference:

<https://phase1.attract-eu.com/showroom/project/smart-optical-biopsy-withpolarized-light-smartopsy/> )

Currently, mass spectrometers are used for this purpose. Also, mass spectrometers have been developed to address a wide variety of scientific research such as to facilitate DNA sequencing and analyze intact viruses. They are used in environmental science labs, forensic labs, drug manufacturing facilities, and cosmetic research.

(Reference: <https://www.excedr.com/blog/mass-spectrometer-function/>)

## **Q3. How has the technology of these jobs evolved?**



The technology used for these jobs keeps improving. These technologies have become part of our daily lives now. The usual method of going into the hospital to use technologies to get diagnosis for any problems has been minimized. Now, diagnosis can be given using small devices like watches and even the conventional way of using blood samples to test for causes has been improved to just scanning of the body. Just as mentioned above, a device used for diagnosis like the mass spectrometer has evolved into a device that can analyze more diseases unlike the previous years.

(Reference: [What Is a Spectrometer? - Types and Function of Spectrometer \(toppr.com\)](#))

#### **Q4. What are available solutions on the market?**

1. One of the available solutions is free-form lenses which are digitally manufactured to provide light frames with adjustable lenses accounting for individual prescriptions. For example, this work to improve efficiency and performance multiple tasks such as:
  - Improve color vision by applying these technology lenses will be able to show brighter and more intense colors.
  - Exceptional night/low light vision these glasses can reduce the glare and halo effect created by light in night, for example car headlights.
2. Lawrence Berkeley National Labs build a microscope which can help to make image of half the width of a hydrogen atom which make it highly effective equipment. But on the other hand, it is expensive.
3. NIL Technology already exists in the market and provides the solution, manufacturing, and custom-made Optical Meta Element. The company claims to have innovative optical technology which is cost-efficient. The following are some advantages:
  - i. Lowering the consumption power in these devices gives the battery longer life
  - ii. Thinner devices and more compact
  - iii. Accurate 3D mapping
  - iv. Advance and better image quality
  - v. Low optical loss
  - vi. High diffraction efficiency
  - vii. Stray light suppression
  - viii. High output suppression and better intensity uniformity

#### **Q5. What are their strengths and weaknesses?**

**a) Weaknesses towards optical number glasses:**

Lenses in general are priced exorbitantly which makes other patients fail to afford them. This, therefore, makes them stick to the glasses with the traditional lenses that they can afford.

Dry eyes, though rare, can be brought up using ill-fitting pairs, wrong prescriptions, or wrong design which can all contribute to down grade in the quality of the lenses.

After prescription, there is no possibility of testing them before production which may be challenging later in case of wrong prescriptions.

In the case of the free-form lens, there is a challenge of blurry vision in the periphery of the lens especially when one turns around.

Some of the existing technology have a design flaw where straight lines appear as though bent.

**b) Strengths:**

Some of the solutions in the market offer prescriptions that are highly customized/personalized to a specific individual and a specific defect that it corrects. This in turn increases customer satisfaction.

With modern technology, users get to experience clarity of sight brought about by the new lenses. This improves customer experience and hence satisfaction. Case in point, high-definition glasses.

It is also possible to have all prescriptions easily accommodated. This innovative technology allows the lenses to be freely fitted since they do not necessarily conform to the properties of the traditional lens.

References:

<https://www.optometrytimes.com/view/understanding-strengths-and-weaknesses-differentsolutions>

<https://progressive-glasses.com/15-disadvantages-of-progressive-lenses/>

<https://www.relfeyecare.com/lens-technology/>

## **Q6. How do they compare to our companies?**

If we compare the solution which is mentioned above so the main comparison between META highlight lenses which are used in the health industry, but other companies like NIL technology focusing on 3D mapping which can help in navigation.

Lawrence Berkeley National Labs manufactures microscopes which are beneficial in the following fields.

- In computing science networking, data analysis, Applied math and computing.
- In biosciences this microscope helps researchers in environmental and health care issues.
- In Earth & environmental sciences we can detect climate changes and eco system.
- In physical sciences Berkeley National lab researchers consider astronomy, biological compositions, and physics.

(Ref: <https://www.lbl.gov/research-areas/>)

## **Ideas and exploration about the possible alternatives.**

### **1. Do we see any nonconsumption?**

Current market target of the MetaHilight is diagnostic area in the health industry. Using standalone sensing and quantitative characterization, project aims at diagnosing biological tissues in real time for detection of cancer, Alzheimer, and other chronic diseases (Ref: META-HILIGHT Application from documents provided by company for reference). Even though the current technology is sufficiently carried out these tasks and those are rapid and non-destructive, still that equipment is bulky in size and heavy.

The objectives of this invention are:

- a) To overcome the limitations of existing lenses such as liquid crystals and tunable or nonlinear waveplates for optical metamaterials, MetaHiLight invented tunable optical metamaterials for adaptive, versatile, pocket friendly and portable use.
- b) Further, it is developed on chips. In short, its compact, fast multifunctional and data processing is possible through this invented chip.
- c) Reduce costs and increase efficiency.

The targeted markets are:

- 1. Digital and personalized medicine through digital histopathology.
- 2. Optical systems requiring rapid and compact polarization control.
- 3. Digital and personalized medicine.

(Reference: META-HILIGHT Application, document provided in company profile: Meta Highlight Packages)

With this background MetaHiLight currently focuses on diagnostic areas in the health industry. However, considering the compact, portable, and light-weight nature of the chips/ surfaces developed by the company, we may expand the industrial exposure for the usage of this product line.

## **2. What work arounds have people invented?**

Workarounds are invented when both consumers and employees try to employ different alternatives to achieving a task. This can in a way bring out new ways of solving a problem. But a heavy reliance on workarounds in an organization or with products can provide a deceitful effect.

This is because the main issue causing the work around is not dealt with.

(Reference: [The Danger of "Work-Around" Cultures - CBS News.](#) )

Christensen et al (2016) expresses that work arounds only exist because people are not content with the available choice. In place of costly and timely medical checkups, some customers result in the use of apple watches to keep in check their heart rate and heart pressure. Even though research shows the absorption of radiation from it when used for longer periods. The habit of selfprescription has also grown in people. People consider usual symptoms and self-medicate to avoid the ordinary processes where these technologies take care of.

### **3. What surprising uses have users invented for existing products:**

#### **a. Optical number lenses industry:**

Around two thirds of the population is required to wear eye wear with optical numbers. This percentage increases with the senior citizen or old aged people

(Reference:

<https://www.cbs.nl/engb/news/2013/38/more-than-6-in-10-people-wear-glasses-orcontact-lenses>,

Exploration Week 1 Sanum Noor and Trupti Daga)

In general terms, it is recommended to undergo an eye check-up every six months to make sure that existing lenses are still valid and there is no change in the optical lenses number. However, most of the people, irrespective of the fact, avoid these regular check-ups due to the cost involved.

The eyewear market for optical numbers has matured. However, those are considered as one of the expensive affairs due to several reasons including monopoly in the market (As discussed in the column: “Why are glasses so Expensive? The eyewear industry prefers to keep that blurry” of Los Angeles Times (Link:<https://www.latimes.com/business/lazarus/la-fi-lazarus-why-areeyeglasses-soexpensive-20190122-story.html>)).

Hence, still, eye wear is out of reach for a reasonable percentage of the population. Hence, if combination is made for: innovative technology, reduced cost through mass production, tie-up with eye-wear frame manufacturers and may be synchronization with ophthalmologist, may help to capture the opportunity for the market need due to the excessive cost involved.

(Reference: Exploration Week 1 Sanum Noor and Trupti Daga)

#### **b. Space technology**

Within aeronautics space, big players such as NASA and Space X make use of optical technology and related instruments such as imaging systems for the exploration of space. Rovers equipped with mast cameras, spectrometers and imagers are used to acquire information about the geology, atmosphere, environmental conditions, and potential biosignatures on planets.

These are often bulky and carried by geologists into the field. Incorporating Meta Hilight into these instruments could help improve efficiency using metamaterials. Additionally, benefit from cost saving and smaller sized devices are possible.

(Reference: <https://mars.nasa.gov/msl/spacecraft/instruments/summary/> )

**c. Farming and forest: Forest entomology:**

Various insects including insects with the size 1/16th inches kills trees, or hamper growth of the trees.

(Reference: [https://www.ncforests.com/forest\\_health/pdf/FHH/FHH\\_Entomology.pdf](https://www.ncforests.com/forest_health/pdf/FHH/FHH_Entomology.pdf))

Equipment with reduced size, compact, lighter weighted is easier to carry in the amazon world.

Further, this may help to protect thousands of trees from diminishing their life or deteriorating at an early stage.

(Reference: Exploration Week 1 Sanum Noor and Trupti Daga)

**d. Health industry:**

Used in the electromagnetic field and to reduce the cells of cancers, artificial intelligence, and material science.

(Reference: <https://www.nature.com/articles/s41928-021-00589-7>). Also, it has been also useful for the purpose of the closed heart surgery such as angioplasty to set the stent with Balloon they used the nano camera as they used the thin tube to pass through the vessel at the area of heart artery for the purpose of creating the space for the more blood flow. If the company makes more efforts towards the production of nano-size cameras and offers reduced prices it will certainly increase the demand as it is useful in cardiac surgeries

(Reference: Exploration Week 1 Sanum Noor and Trupti Daga).

**e. Educational labs:**

For future research in the laboratory in the university or educational institutions. Even though this is an established market, students are charged additional bulky fees to access the facilities of the laboratories and carry out the research. Reduced cost of equipment installed at the university and educational institutions may lead to reduced cost and eventually access to many students to explore and trial and

error multiple times which increases the possibilities of better innovations and who can be the future innovations.

**f. Nano projectors for household usage:**

The current market for projector is under consumed with a specific reason that the projectors are costly affair. If lenses are used to reduce the cost and make projectors portable, then it may become a household necessity and a replacement for a television. For example, if portable projector paired with smart phones, can be used to project videos/ movies anywhere on the wall. This helps to reduce the usage of smart phones on small screens and eventually damage the eyes.

**g. Digital chips for medical issues:**

One exploited idea we also went into was in the health sector. Different ideas came together considering situations in different countries. We proposed the creation of a small digital chip with this technology for patients with Alzheimer to help keep track of them. Many developing countries do not have the facilities to control these situations.

Dissolvable chips

Another wild idea is the production of a temporal chip or visual device that can be used to analyze the internal system of a person by ingesting it through the mouth. It is then connected to a mobile application or a computer giving a live video of what is currently happening in the person's organs, which we project could help solve health issues.

Scan glasses

These are going to be glasses that can provide immediate or real time scans to medical practitioners in enhancing instant feedback and reduce processing time and cost involved in the conventional methods. For example, the MRI machine reduced into a pair of glasses.

**h. Anna Missskam and Natalie:**

1. Measure the status of the blood e.g., different blood levels or blood sugar
2. Supporting blind people
3. Food-safety & hygiene-safety

4. Completely new forms of the detection of individuals
5. Screen what is behind walls
6. Finding victims of disasters
7. Detecting resources more efficiently and effectively

**From Siyu and Chen:**

- Solar Panel

**I. Combination of Smart watches with mobile application:**

By using this advanced technology in a way to combine with smart watches and create a chip which can identify the medical condition of person and will automatically send report or alerts to medical authorities and relatives. For example, heart pension, medically challenged and old people who live alone.



## **Reference list**

Adams, S., Barbante, C. 2015. Comprehensive Analytical Chemistry. *Elsevier*, vol (69)

Christensen, C. M., Hall, T., Dillon, K., & Duncan, D. S. (2021, December 3). Know Your Customers' "Jobs to Be Done." Harvard Business Review. Retrieved April 7, 2022, from <https://hbr.org/2016/09/know-your-customers-jobs-to-be-done>

# **#WEEK 3 - Need finding, User and Hands-on exploration**

## Education Industry:

### Laboratories with an example of the use of the microscope for studying/researching

Introduction:

From Week 2 report of Team Fresnel:

*“For future research in the laboratory in the university or educational institutions. Even though this is an established market, students are charged additional bulky fees to access the facilities of the laboratories and carry out the research. Reduced cost of equipment installed at the university and educational institutions may lead to reduced cost and eventually access to many students to explore and trial and error multiple times which increases the possibilities of better innovations and who can be the future innovations.*

### Armchair research

Japan International Cooperation Agency (JICA) is a government agency of Japan. It is chartered with assisting economic and social growth in developing countries, and the promotion of international cooperation.

(Reference: [https://en.wikipedia.org/wiki/Japan\\_International\\_Cooperation\\_Agency](https://en.wikipedia.org/wiki/Japan_International_Cooperation_Agency).)

In one of JICA’s brochure, it has published the following:

#### Expansion of higher education in developing countries and challenges of engineering education

Higher education in developing countries has largely expanded quantitatively in the past 10 years – in terms of both the number of enrolled students and the enrollment rate. The causes of the expansion are growing demand for advanced human resources corresponding to the advancement of industrialization and the knowledge-based society; and growing number of applicants to higher education due to the expansion of primary and secondary education.

On the other hand, the quantitative expansion of higher education is not necessarily leading to the quantitative and qualitative expansion of engineering education. In many developing countries, the development of human resources in engineering field is prioritized as a means to

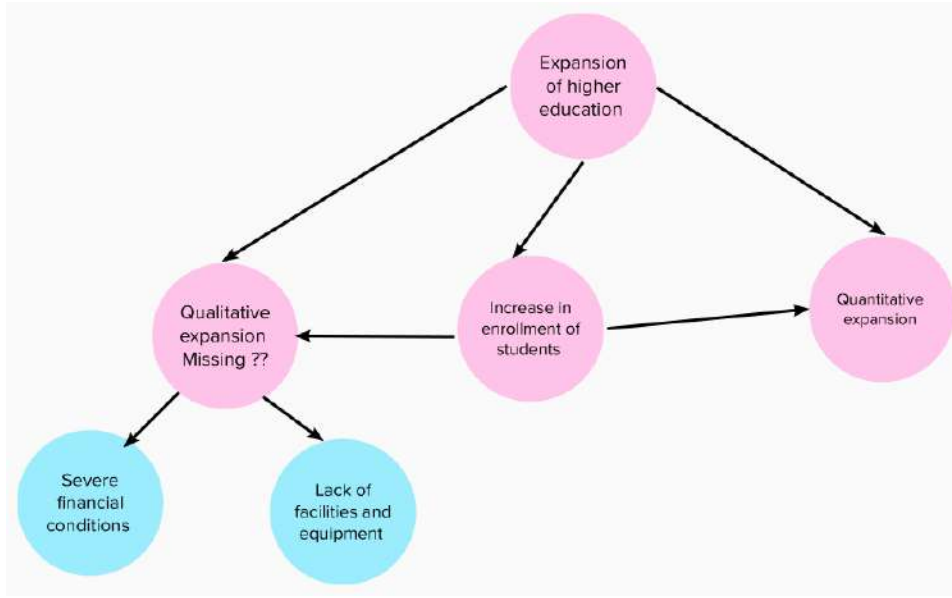
leading economic growth, however, quantitative expansion has been carried out mainly in humanities and social sciences because of severe financial conditions. In addition, the deterioration of education and research quality has become a challenge since faculty staff, facilities and equipment, and research funding, which are indispensable to secure/improve the quality of engineering education, are insufficient.

In developing countries, due to the lack of experiments, training equipment, and research funds, education centered on classroom lecture and memorization is often carried out, and makes it difficult to develop human resources with practical skills and application ability required by industry.

Source: Development of Human Resources in the Engineering Field with practical skills through research activities in a team

([https://www.jica.go.jp/english/publications/brochures/c8h0vm000avs7w2-att/japan\\_brand\\_06.pdf](https://www.jica.go.jp/english/publications/brochures/c8h0vm000avs7w2-att/japan_brand_06.pdf))

In summary, JICA in its brochure highlights the following cycle:



Further, the following screenshot is the sneak peek from the article dated 11 August 2013 “the role of research universities in developing countries” published in University World News - the global window on higher education – an online publication that reports news and developments from Global perspective.



<p>the global knowledge economy.”</p> <p><b>Research universities and academic systems</b></p> <p>Research universities are a very small and specialised but crucial part of any academic system, Altbach argued. In America there were around 220 research universities in a system of more than 4,000 post-secondary institutions. In the UK, there were just 25 research universities among 100 universities and 300 post-secondary institutions.</p> <p>“Smaller developing countries have perhaps one research university, and many have none.” China was developing around 100 research universities – out of more than 3,000 institutions countrywide – as part of its efforts to build world-class institutions.</p> <p>A clearly differentiated academic system was needed for research universities to flourish, Altbach wrote.</p> <p>A good example was the three-tier California public higher education system, established by the California Master Plan, which has at its pinnacle 10 campuses of the research-oriented University of California, the 23-campus California State University system with around 433,000 students, and a community college system with three million students.</p> <p>Funding patterns, missions and governance differ across the three tiers and state regulation maintained their different missions. “By</p>
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(Reference: <https://www.universityworldnews.com/post.php?story=20130811091502202>)

In summary, the above-mentioned articles reflect that research universities or department is a crucial part of an academic structure of developing countries to stand in the que with developed countries, to participate in globalized environment of higher education and for modern knowledge economy based i.e. for economic growth and development of youth to stand with the rest of the world.

Also, an article published in October 2010 ‘Does science education in developing countries really counts’ identified the need of the research institutions in the developing countries to stand in the trend of globalization.

(Reference: <https://esajournals.onlinelibrary.wiley.com/doi/pdf/10.1890/0012-9623-91.4.432>)

Last but not least, research made by the UNESCO in December 2006 in the field of education presented the paper called ‘Research capacity of higher education sector in developing countries’ where the conclusions are:

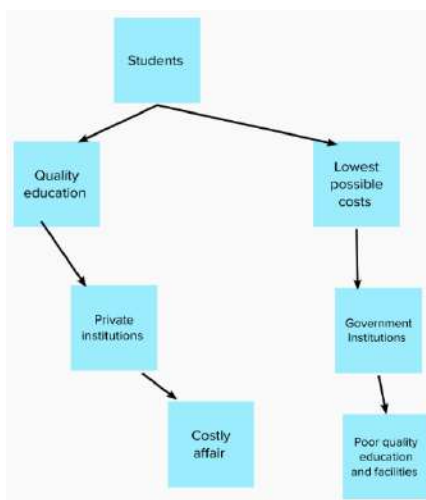
- a. Developing countries do not use the updated technology from time to time and somewhat use outdated technology in the field of research in educational institutions/schools / universities due to lack of both financial and human resources in the R&D.
- b. (Reference: <https://unesdoc.unesco.org/ark:/48223/pf0000153116>)

knowledge economy places greater value and stronger emphasis on the production and distribution of knowledge – R&D. Knowledge production used to be an activity coordinated by the public authorities and public universities played an important role in R&D activities. At present, knowledge production in many developed countries is critical for industrial production and has become an important corporate concern.

Based on the available sources of information, this paper argues that the knowledge divide is deep and is heavily tilted in favor of developed countries. Developing countries suffer from a lack of both financial and human resources in R&D. They need to improve their capacity to produce knowledge domestically and absorb the knowledge produced elsewhere. This can happen when allocation of financial resources to R&D activities increases, human resources are trained in adequate numbers and an institutional framework to carry out R&D activities is created.

While universities play a less significant role in funding and carrying out research, their role remains unchallenged in the area of research training. Changes in the investment priorities in education during the structural adjustment regime paved the way for a decline of higher education and research in public institutions of higher education in developing countries. There is a need for reviving and strengthening the university system in developing countries to strengthen their research capacities. This change should be reflected in resource allocation to higher education and research, and in the provision of opportunities to expand graduate programmes and improve female participation rates. The experience of developed countries shows that the private sector investment in R&D increases when the research environment and facilities improve in the country. Therefore, the initial investments to strengthen research capacity in developing countries have to come from public sources.

Processes involved in this journey:



Users/ Challenges / Problems / Difficulties:

Users are pushed to resolve some other options to make up for these situations. Due to the costly nature of this equipment, schools limit themselves to a small quantity to help at least make available these tools for students to be able to get experience of the equipment (instead of use those equipment) and know their way around these tools. Some schools result in the adoption of lower quality or the second-hand of this equipment to make it available. The challenges in sticking to these kinds of solutions are that they do not give students enough time with the tools in relation to the small quantity, they do not give better results as the quality devices would and these challenges would limit the knowledge acquired by the students.

The issue of low-quality lenses and insufficient equipment further spreads into the health sector. Some developing countries are forced to use some of these devices which are not highly effective due to the costly nature of acquiring them. (Ref: [Accessing medical equipment in developing countries through remanufacturing | SpringerLink](#))

## **Research mode 2**

### **Questions asked to the relevant person for further information:**

Since people contacted were friends and/or relatives, the communication was carried out in a more informal way through what-up chats or voice calls rather than formal mails and messages.

#### **A. Questions asked to a school management team:**

“Currently I am, with my team doing research in educational laboratory equipment in the area as to following:

1. What are the current problems you as a school / educational institution face when you purchase laboratory equipment for your science department?
2. What improvements do you expect to be carried out in the equipment when you buy them next?
3. Any specific problems you face pertaining to lenses attached to the said equipment?
4. Do you think, if we can reduce the size and weight of the lenses attached, it will make any difference?
5. Does lens cost is significant in the whole cost of equipment?
6. Which equipment with which heavy lenses you would be happy if it will be available at lower rates with lower weight of the equipment.

#### **B. Questions asked to a doctor who recently completed his MBBS and now pursuing his MD and student who is pursuing post-graduation in Gynecology (Received reply and inputs)**

Currently, During my masters, we are doing research in the educational lab equipment with main focus on the lenses used in that equipment. The basis of research is how we can reduce the cost of the costly equipment by reducing the size and weight of the equipment so that more and more students can access the laboratory. In this regard, you being a medical student, I have few questions and I would appreciate if you can provide feedback for those:

- a. While using the lab equipment during your studies as a medical student, what problems did you face with that equipment which you want to see improved for future students?
- b. Any specific problems you face pertaining to lenses attached to the said equipment?
- c. Do you think, if we can reduce the size and weight of the lenses attached, it will make any difference?
- d. As a medical student, which equipment with which heavy lenses you would be happy if it will be available at lower rates with lower weight of the equipment.
- e. And which are the most commonly used equipment in the college / university labs for the research of the students

**Summary of reply received from the student who is pursuing post-graduation in Gynecology:**

- a. People affected: medical students
- b. Area: Government Medical college (Karachi, Pakistan)
- c. Equipment focused: Microscope used for research and studies
- d. Problem identified:
  - i. Second hand microscopes are purchased from foreign universities
  - ii. Lenses of the original microscope are replaced with the local lenses which are not producing the desired results like more zoom – better results – current replacement of lenses lacks this facility and also difficulty in identifying color of the cells like either blue or red and hence difficult to diagnose
  - iii. Microscope is the basic device needed for every research in the medical field
  - iv. In short the ratio of microscope to students need to be 1:1 whereas in reality it is 1:33

**About stakeholders, users, interdependency etc:**

We identified our main users to be students, learners, explorers, universities and schools.

Currently, we focused on medical students and stakeholders around them. And microscope equipment since it's a very basic need for the medical student. What drives the main users and how they influence one another are highlighted through the journey map and stakeholders' map.



## Industry: Forestry & Farming

### Armchair Research

Forests and farms are being attacked and destroyed not only by humans and animals but also by other tiny living organisms or insects not visible to the human eye. They destroy flora and fauna, and they need to be gotten rid of. Man has tried many ways to get rid of these organisms and has even invented technological solutions for that.





*Cankers can be caused either by living organisms, including fungi and bacteria or by nonliving things such as excessive low or high temperature or hail.*

The main stakeholders are forest researchers, farmers, and students. Researchers carry out their duty, which enables them to monitor the forests and farmlands, farmers cultivate the land, and the students do their studies. Both the farmers and students rely on results produced by the researchers to do their jobs well.

However, some of the researchers use rudimentary methods in the collection of data, analyzing the data, and interpreting. They physically walk into a forest or a farm, collect hundreds of samples, transport them to a laboratory, start the analysis then wait for results before interpreting them. These methods are tiresome, time-consuming, expensive, use bulky machinery, and are highly prone to errors.

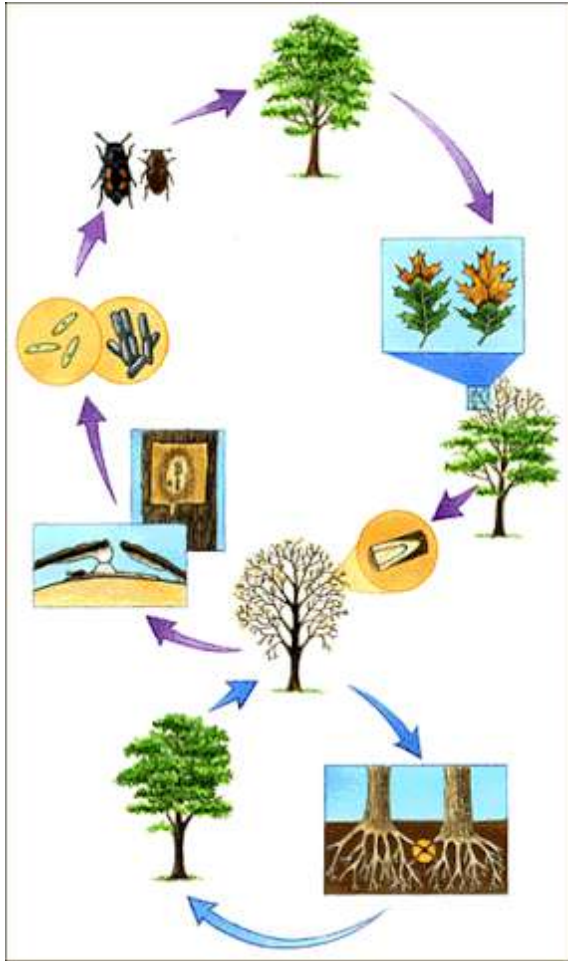
#### **Some Diseases in Trees faced by stakeholders.**

**Canker** can be caused either by living organisms, including fungi and bacteria, or by nonliving things such as excessive low or high temperature or hail





**Rust is a plant** disease caused by pathogenic fungi of the order Pucciniales (previously known as Uredinales). An estimated 168 rust genera and approximately 7,000 species, more than half of which belong to the genus *Puccinia*, are currently accepted.





Forests need attention to save ecosystems. And to save forests from different diseases mostly occurring by insects and fungi researchers went to forest and collected samples from each tree. That process is time-consuming and requires more human resources. If there is a device which can be equipped in trees to monitor surrounding it will be efficient.

### Farmers problem with mango tree



Mango disease.

Reff

>[https://www.researchgate.net/figure/Mango-Sudden-Dcline-disease-A-Eggs-larvae-and-adult-female-of-the-vector-mango-bark\\_fig1\\_305345936](https://www.researchgate.net/figure/Mango-Sudden-Dcline-disease-A-Eggs-larvae-and-adult-female-of-the-vector-mango-bark_fig1_305345936)

(A) Eggs, larvae and adult female of the vector mango bark beetle, *Hypocryphalus mangiferae*, in an open gallery. Inset shows an enlarged picture of the adult beetle,

(B) Hyphae and perithecia with sticky ascospore masses of *Ceratocystis fimbriata*,

(C) Section of a mango trunk showing the typical xylem discoloration caused by the fungal infection; entry and exit holes made by beetles on the surface of the bark (enlarged image in bottom left corner)

(D) A mango tree killed by Mango Sudden Decline disease.

farmers also face the same problem of diagnosing each tree specially mango tree in Pakistan, India, Brazil and Oman. Due to harmful insects, farmers lost their trees because of late response in treatment and

these trees took eight to ten years to become mature for producing fruits. Other crops were also infected by many insects due to late treatment.

- What kind of processes are involved?

Forest researcher >>>> Strat from lab – take equipment – go to forest- take help from human resource- diagnose the tree -collect data-preserve sample-take sample to lab safely - work on sample -note down the details of sample-and find the result.

Farmers >>>> Identify the need - buy equipment - hire Arborists – go to field - diagnose the tree - collect data-preserve sample-take sample to lab – work on sample - note down the details of sample-and find the result.

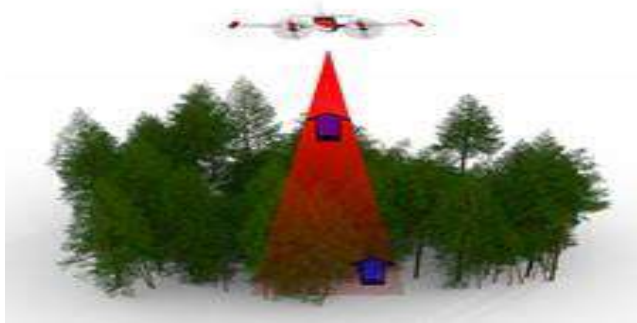
Students>>>> Course requirements – University, field, and forest authority permission - go to field or forest - diagnose the tree - collect sample - preserve sample - take sample to lab – work on sample - note down the details of sample - and find the result.

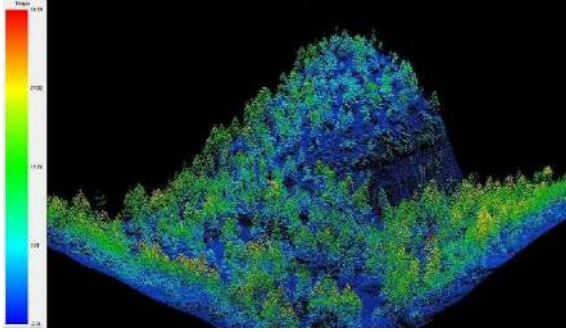
### **Current available technology**

New technology like the smart forest and Lindar are currently in use and have made the researchers' work easier and more accurate to a certain level, but they do not tackle the problem of pests and disease-causing organisms. However, they can be improved upon. The equipment is numerous, bulky, and expensive.

#### **Lidar** (Aerial Light Detection and Ranging):

Planes or drones are used to send light wave pulses from a laser to the ground which bounce back to the sensor from the trees. The sensor then calculates the distance covered by the light pulses and comes up with data used to formulate accurate information about the height of trees, density, etc. This technology cannot be used to tell which tree has been affected by what disease or how to deal with the disease.





*Illustration of Lidar the syst*

**Smart Forest** is where equipment like sensors, cameras, and other devices are placed in the forests that will be used in mapping, optimizing, and monitoring forests and animals. This eases the researchers' work. This technology looks at the tree population and density, it can sense motion like if a tree falls, etc.



## The Wired Woodlands

In the San Jacinto Mountains in California, scientists are using networks of miniature sensors, robots, cameras and computers to gather unparalleled information on the ecology of forests.

**SOLAR PANELS**  
Provide power to wired sensors. The woodland projects run on solar power and batteries.

**TREEBOT**  
Robotic array of sensors and cameras moves along cables attached to trees. The sensors, which can measure subtle changes in temperature, humidity or sunlight, can be lowered and raised to collect information at different levels of the forest canopy.

**OBSERVATION TOWERS**  
Full-motion cameras track wildlife and measure plant growth changes.

**NESTBOX**  
Contains cameras that collect time-lapse images to document nesting activity and sensors that measure temperature and humidity inside and outside the box.

**MICROCLIMATE ARRAY**  
Collects climate-related data above and below ground. Tells treebot when and where to take measurements.

Sources: Dr. Michael P. Hamilton, James San Jacinto Mountains Reserve, University of California, Center for Embedded Networked Sensing

**CRANE**  
Used to help maintain the sensors in the tree canopy. Sensors along the tower collect meteorological data.

**WIRELESS NOTES**  
Located throughout forest, they collect signals from the sensors on such things as temperature, humidity, light, soil moisture, rainfall, leaf wetness and wind speed, then relay them to a central server.

**VIDEO CAMERAS**  
Collect time-lapse images to document plant growth and wildlife activity. Cameras pictured are collecting images of insect growth and bird activity at a feeder.

**SOIL SENSOR**  
Measures soil temperature, moisture and carbon dioxide production. Small camera monitors root growth.

Illustration by Frank Toppen

However, existing solutions do not solve the problem of pest and organism menace. They also involve the use of many pieces of equipment that are bulky, expensive, and complicated to use.

Page Break



## Research Mode 2

### Interview

The questions and answers with a researcher in the Indian forest Mr. Siddhart Miniwale currently work as an observational study on birds.

- What kind of problems do you face in the forest to accomplish that job?

The answer was from a forest researcher that he faces a lot of difficulties to reach the spot and they cannot work alone so they need to work in groups in the forest i.e., guide, rangers, drivers, chef, and other staff. And at the same time, they need to walk, and a single project can take months to years to complete.

- What equipment do you use? Which is the most used equipment in the forest for research or identifying problems? ---- if any device with electronic chips and lens

1. Binocular Camera = image quality and range

2. Range finder = the limited range no use in an open forest.

3. Voice Recorder = Not efficient, mostly fails to work in rain.

4. Camera traps = due to its weight it becomes hard to fix in the forest as he mentions that in forest vehicles it does not work so staff need to walk and pick heavy camera traps. Further said the quality is also not so good and the betrayals need to be improved.

- While using the equipment in the forest, what problems do you face with that equipment which you want to see improved?

Transport and fixing the equipment and then protect from weather and animals.

- Which equipment do you wish to have more lightweight and more efficient functions as compared to existing equipment?

Voice recorder and camera trap.

- Any other information if you want to add.

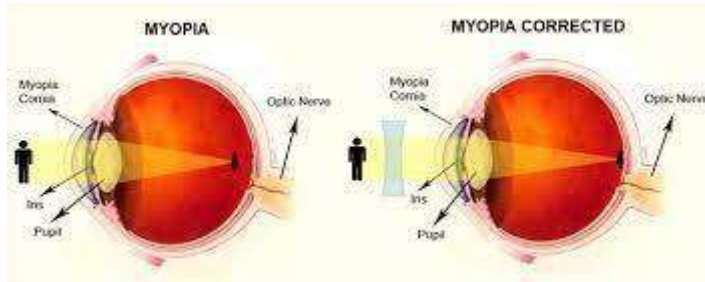
In Kerala and Maharashtra there are cashew trees that are common due to their weather, and they are in forests and farms which take 5 years to mature. In 20 years trees will die due to a limited period of fruit harvesting farmers suffer if any diseases are attacked on trees. To protect trees from pests, farmers use poison on every tree which can be harmful for trees and humans who will eat the fruit. And in farming, because all areas are covered with the same kind of tree there is more chances to grow insect infection.

## Optical Industry: Optical solutions for the visually impaired

### Armchair research

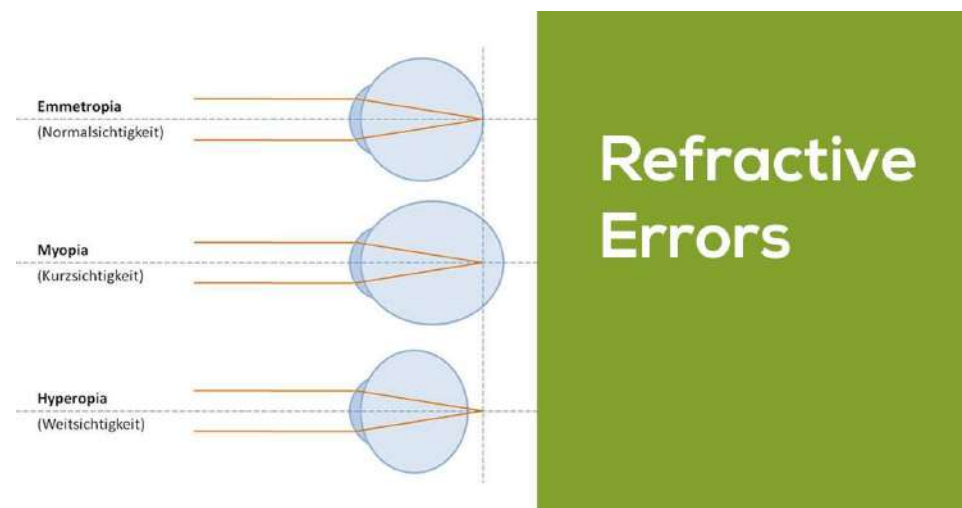
1. Find out as much as possible about the jobs and people that inhabit your problem area(s).

Ans: The main components of the eye are cornea, Iris, Lens, Retina, optic nerve connection with brain.

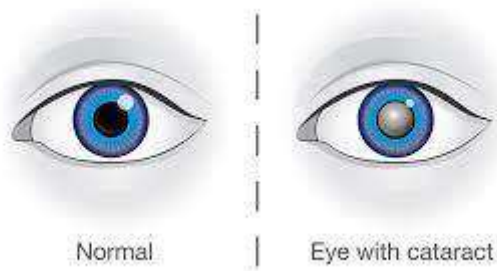


The most common problems people may face are:

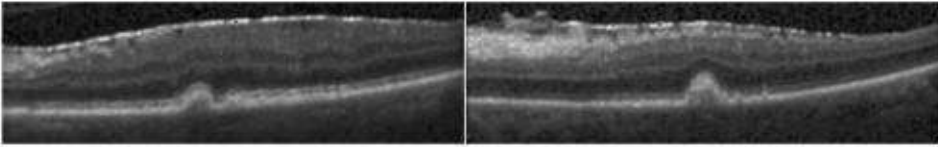
A) Refractive Errors. If you are nearsighted, farsighted or have astigmatism, you have what is called a refractive error.



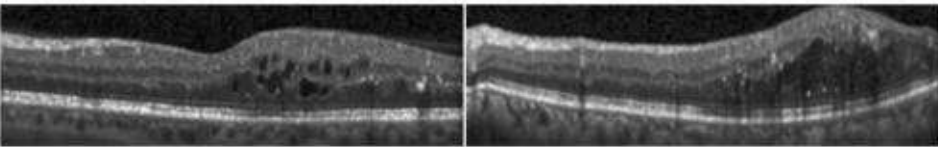
B) Cataracts. If you've noticed your vision has become blurry or hazy as you've gotten older, it could be cataracts.



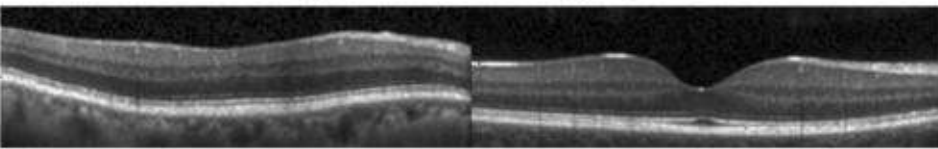
C) Age-related Macular Degeneration.



(a) Dry Age-related Macular Degeneration (AMD)

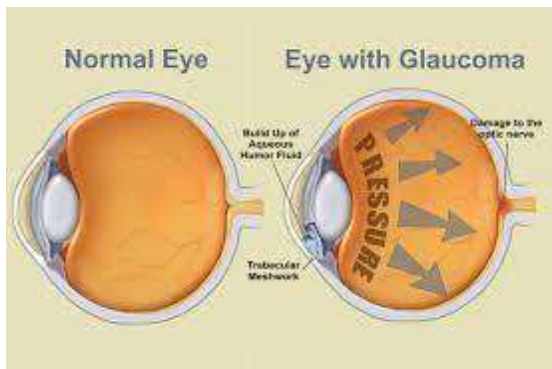


(b) Diabetic Macular Edema (DME)



(c) Normal Macula

D) Glaucoma.



2. Who are the main users?

- Medical sector - People of all ages with sight challenges. The biggest market share is an aging population as sight deteriorates. Within this market there is a preference for contact lenses over the traditional spectacle.
- Industrial use in laboratories – For example, microscopes and laser machines
- Other industries where optical lenses are used include – The automotive sector and mining equipment

Reference: <https://www.verifiedmarketresearch.com/product/optical-lens-market/>

3. What drives them and how do they influence one another?

Key influences (study in the US)

- Doctor recommendations (Endorsements from the doctors are trusted by consumers)
- Optician recommendations (End users feel opticians are more knowledgeable in eye care)
- Price
- Insurance (Users of visual aids actively seek out solutions that can be insured and have low cost)
- Product features

References:

<https://www.statista.com/statistics/257288/perceived-influences-on-consumer-purchasing-of-eyewear-in-the-us/>

[https://cms.gz.com/wp-content/uploads/2015/04/9481c-luxottica\\_presentation\\_sm.pdf](https://cms.gz.com/wp-content/uploads/2015/04/9481c-luxottica_presentation_sm.pdf)

4. What kind of processes are involved?

Opticals and focus are needed to adjust according to the requirement of focus. Opticians are using 3 alternatives for eye patients.

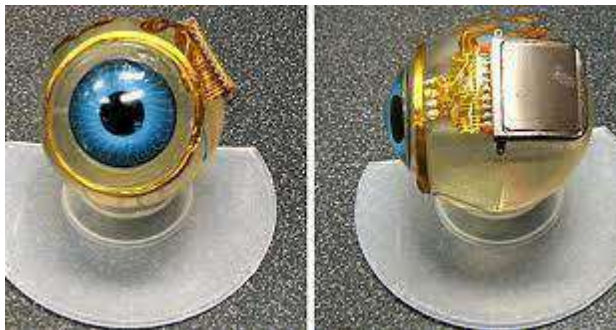
1) Optical lens /glasses



2) Contact lenses



### 3) Bionic eye



Currently, technology is developed to use light polarization such as circular and angular the momentum of light to diagnose advanced cell cultures and tissue samples with optical biopsy. (Reference: <https://phase1.attract-eu.com/showroom/project/smart-optical-biopsy-with-polarized-light-smartopsy/> )

#### 5. What do people do, what kind of tools and technology do they use?

- With modern technology, users get to experience clarity of sight brought about by new lenses. This improves customer experience and hence satisfaction. Case in point, high-definition glasses.
- It is also possible to have all prescriptions easily accommodated. This innovative technology allows the lenses to be freely fitted since they do not necessarily conform to the properties of the traditional lens.
- New contact lenses are launched all the time but one of the most exciting advances in contact lens technology in recent years has been the development of overnight vision correction. This treatment uses specially designed overnight contact lenses to alter the shape of the eye while sleeping.

### Implantable technology

With the help of a special pair of glasses and electronic data, the electrodes on the implants stimulate the retinal cells and transmit visual information to the brain. While it doesn't restore normal vision, it helps people who are completely blind perceive light and reflections of light.

6. What are the main challenges, problems, and pains that these users experience in existing solutions and processes (i.e., in what way do they do a poor job?)?

- Lenses, in general, are priced exorbitantly which makes other patients fail to afford them. This, therefore, makes them stick to the glasses with the traditional lenses that they can afford.
- Dry eyes, though rare, can be brought up using ill-fitting pairs, wrong prescriptions, or the wrong design which can all contribute to downgrading in the quality of the lenses.
- After prescription, there is no possibility of testing them before production which may be challenging later in case of wrong prescriptions.
- In the case of the free-form lens, there is a challenge of blurry vision in the periphery of the lens especially when one turns around.
- Some of the existing technology has a design flaw where straight lines appear as though bent.
- Some of the solutions in the market offer prescriptions that are highly customized/personalized to a specific individual and a specific defect that it corrects. This in turn increases customer satisfaction.
- Inserting a Lens in the eye may cause damage to the eye. Dryness bacterial infections

7. What is difficult to do?

- From a manufacturing perspective – Achieving efficiency and quality in end consumer products as the lens is usually only as good as the material it is made from. For example, the optical quality and light lost during transmission will depend on the material of the lens

- 

Reference:

[https://www.globalspec.com/learnmore/optical\\_components\\_optics/optical\\_components/optical\\_lenses](https://www.globalspec.com/learnmore/optical_components_optics/optical_components/optical_lenses)

- From the user's perspective
  - Can cause cornea hypoxia which results in blurred vision as oxygen supply is limited to the cornea
  - Interfere with the eye's natural hydration process
  - The process of putting the lenses on and off is not comfortable. The possibility that bacteria and viruses can be introduced to the eye
  - Glasses do not improve worsening eyesight and conditions like presbyopia

Reference:

<https://www.optometrists.org/general-practice-optometry/optical/guide-to-contact-lenses/com-mon-contact-lens-problems/top-8-contact-lens-problems/>  
<https://liu.se/en/news-item/postcovid-i-ogat-ska-utforskas>

## Research mode 2

We approached people within the problem area to dig deeper in our research of optical solutions. We formulated the below questions as a basis to engage in conversation and adapted them for a written response or interview.

1. **Dr. xx** – Malegaon India
  - Optician
2. **Professor xx**
  - Department of Biomedical and Clinical Sciences at Linköping University
  - Research papers and visits (if possible) to the department will be scheduled

Findings regarding current jobs and areas that can be improved

- Patients, Doctors (Hospitals), and Industries have a host of jobs that need to be done. They are highlighted in the journey and stakeholder maps below. These also make up our main stakeholders
- Current solutions are costly
- The solutions on the market are not defect-free. End-users still experience side effects such as irritation, discomfort, and blindness. Daily activities remain uncomfortable to perform. Additionally, some solutions worsen existing conditions.
- Patients are usually skeptical of the current solutions as they are expensive, and sometimes risky but offer no real solution.
- Available lenses on the market are foldable but there is a need for more flexibility. This allows for improved optical quality.
- Challenges are still experienced with current solutions when it comes to night vision and fast-moving objects.

# # WEEK 4 - Need finding, User and Hands-on exploration (contd)



## Application of Meta Hilights' novel adaptive lens technology for use within the Education Industry



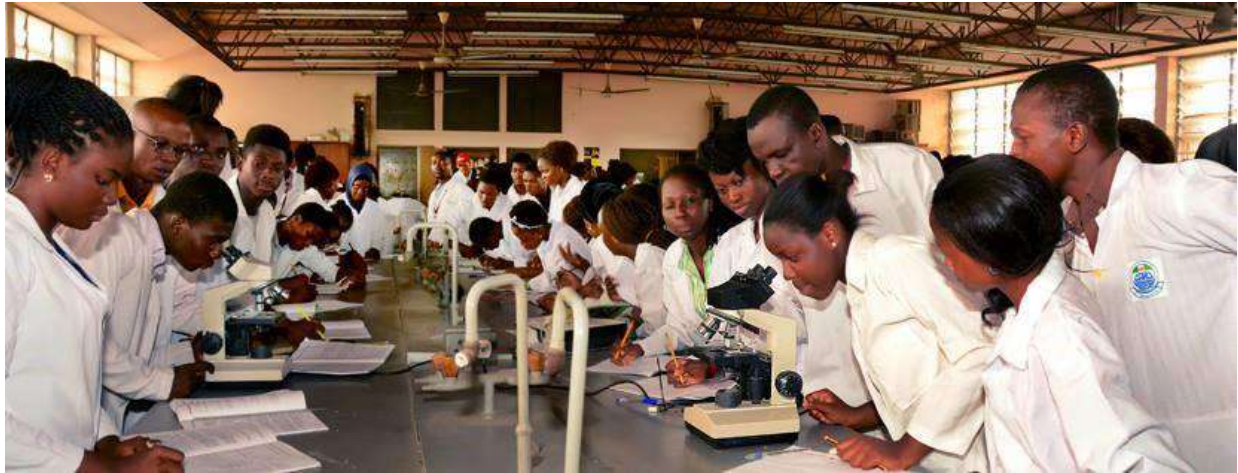
## Education Industry

### Personas

A description of our user(s) and their journey through the problem space

#### Persona 1

Ahmed: First year medical student

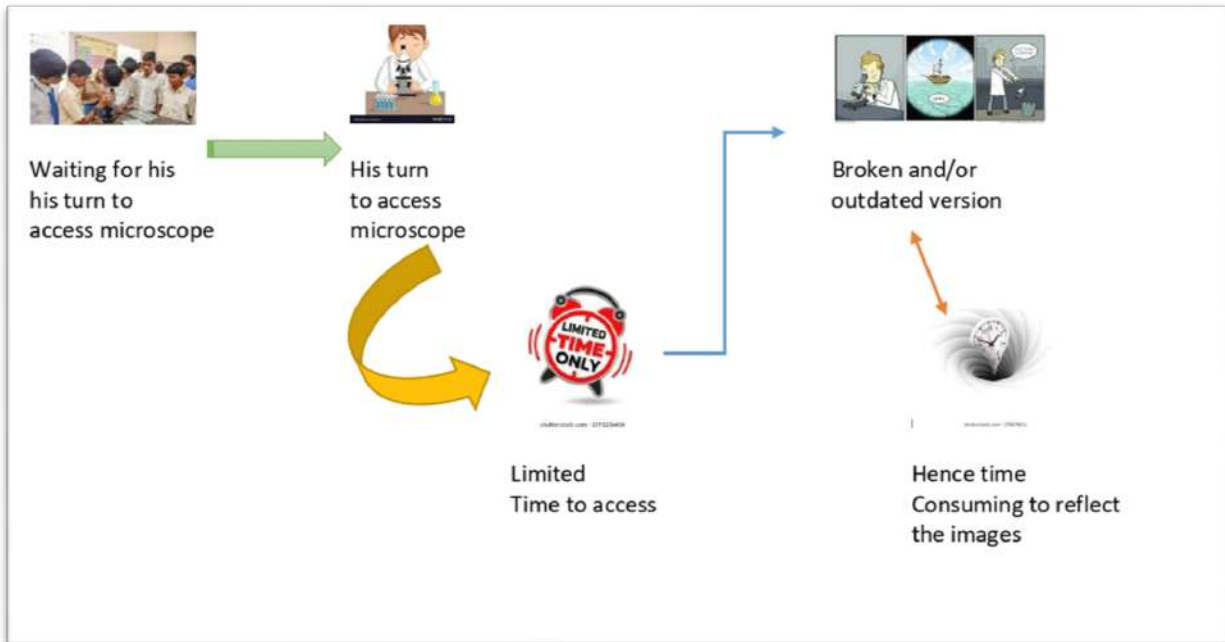


#### Story:

Ahmed is a first-year medical student in Ghana, He needs to wait for his turn to use a microscope 33 other students share. When it is his turn, he faces two difficulties, first, the microscope is outdated with poor-quality lenses. Consequently, the results are not visible as expected or needed. Moreover, it takes a

more extended period to generate the results. On the contrary, *the second issue faced is* that Ahmed's timeframe to use the microscope is limited because of other students waiting for their turns. This leads to a loss of opportunity to try his hands on the microscope to research the theoretical concepts he is learning in the classroom sessions and explore further, and hence lack of practical knowledge and ultimately his motto of being graduated with quality knowledge is hampered.

**Journey through the problem space:**



**Synthesize and Define for Persona 1:**

A collation of the discovery process, jobs to be done, and discoveries from deeper exploration

User	Need	Insight
Ahmed is a first-year medical student in Ghana's Government College where laboratory access time is limited. However, on the contrary, outdated (with poor quality lenses) microscopes available in the laboratory take more time to produce the desired results through analysis of slides	He needs at least the compound microscope (basic microscope with latest technology and quality lenses) and additional access time to the laboratory to get more practical knowledge and do more detailed analysis with his samples to get detailed understanding. Further, to try his hands on theories he studied in classroom sessions.	<p>Because if he doesn't get reasonable quality and access to the microscope then</p> <ul style="list-style-type: none"> <li>• He won't be able to finish his degree in the stipulated time due to lack of specified practical hours' completion at the laboratory</li> </ul>

		<ul style="list-style-type: none"><li>• Cannot do more research for his exam</li><li>• Cannot explore some theories or interesting facts he has read about</li></ul>
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## Persona 2

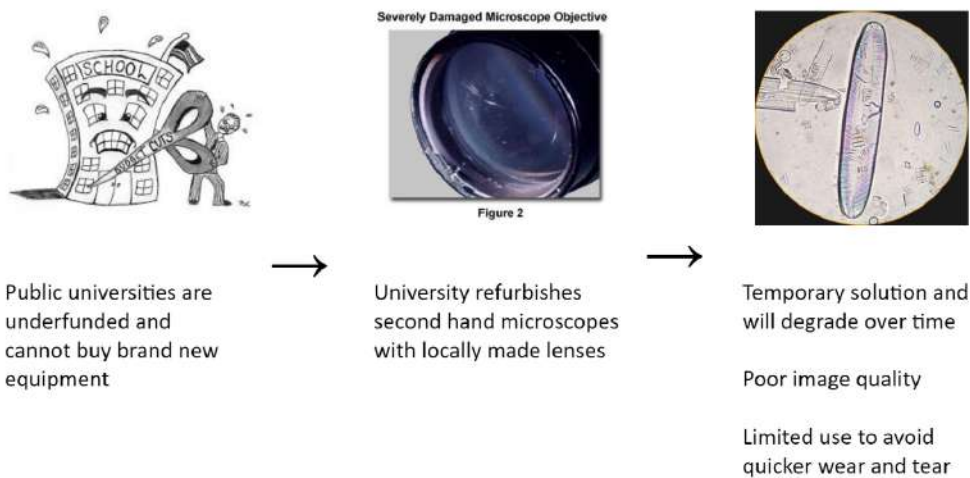
Education institution: University



**Story:**

Khairpur Medical Public College representatives highlight that in 2021, approximately 200 000 candidates appeared for the MBBS entrance exam for only 30 000 available seats in Pakistan which reflects the willingness to pursue medial education. However, there is a discrepancy in seats available for the public college and private college programs. In addition, there are limitations on fees that can be received from students by public colleges (average fees per student 210 \$) as compared the private college (average fees per student 6000 \$). This restriction of fees imposed by the Government directly affects the facilities and quality of education the college provides. To elaborate, the college purchases second-hand microscopes from foreign universities and refurbishes them with locally manufactured low-quality lenses. This alternative ultimately reduces the quality of the microscope, increases its output production time and doesn't serve the desired purpose expected of clear picture of the histological slides.

**Journey through the problem space:**



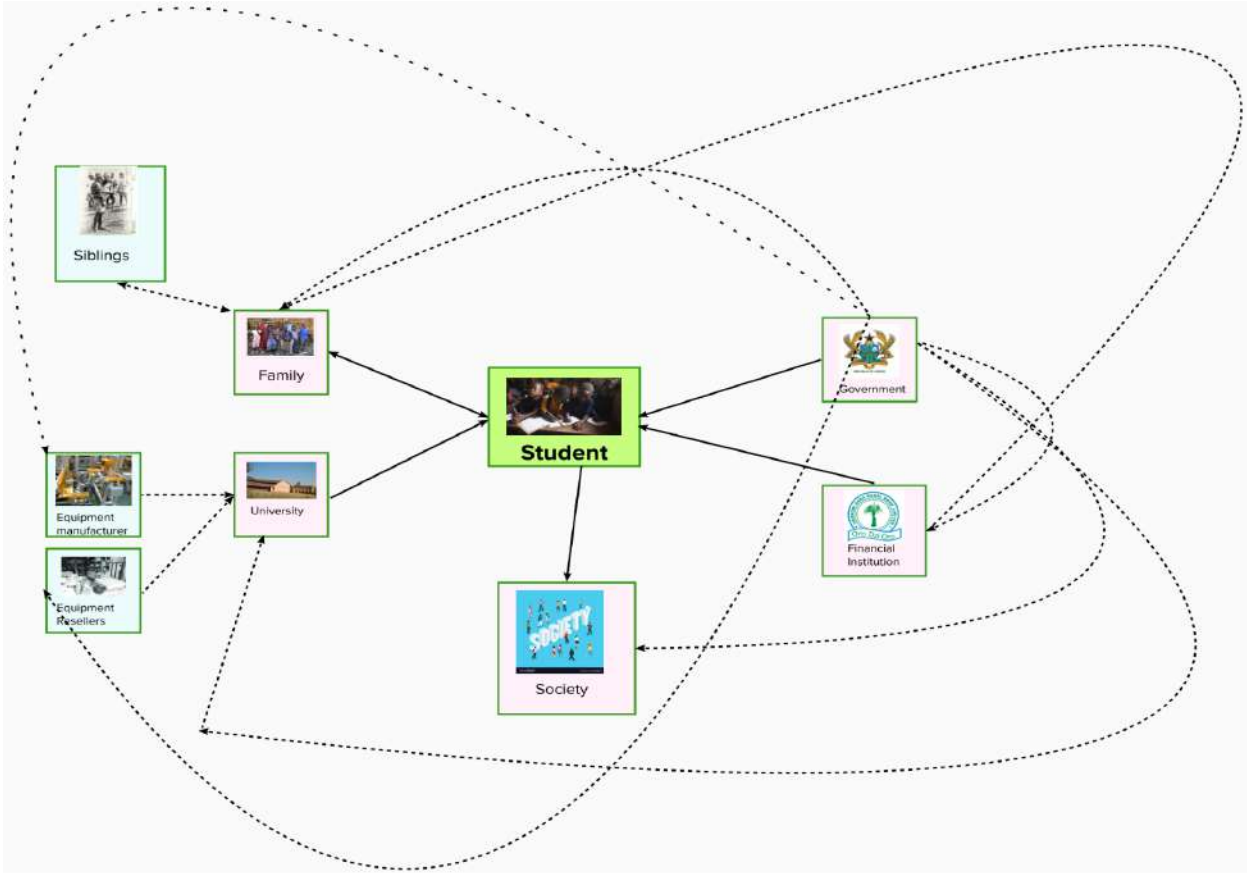
## Synthesize and Define for Persona 2:

A collation of the discovery process, jobs to be done, and discoveries from deeper exploration.

User	Need	Insight
Khairpur Medical Public College is a government college in Pakistan where Government limits the fees chargeable from students at 210 \$ (fees chargeable by private college is 6000 \$). This restriction directly affects the infrastructure provided by the college such as college is forced to buy lower quantity than required. Further, colleges buy secondhand equipment and refurbish it at the local level with lower quality products like lenses.	Need better quality equipment at lower cost to provide effective practical tutorials to the students.	Because <ul style="list-style-type: none"><li>• Lack of practical tutorials will lead to lower quality of education for the students. And lower quality of education will affect the reputation of the university</li><li>• Lower quality equipment is time consuming since it takes time to produce results and hence professors' time is not utilized efficiently</li></ul>



Stakeholders' Map:



**Summary of interviews carried out and findings:**

Details / Questions	Case study 1	Case study 2	Case study 3	Case study 4
Name and qualification	Farah, Pursuing specialization in gynecology, Pakistan	Dr Diptesh, Dentist and lecturer, India  Dr Deepa Sarda, Pathologist, India	Dhruv, First year medical student, India	Dr Deepa, Pathologist, India
Being a business student, how would you define uses of microscope in common people's language?		It is used to observe / enlarge, zoom-in and zoom-out. i.e. it is used to keep shifting focus and for lateral movement to study histological slides (study of tissues and cells)		
Whether Microscope is the necessity or option?	Necessity	Necessity	Necessity	Necessity
If functions of microscope are inbuilt in phones, then is it sufficient?	Cannot say	It may serve the basic purpose but more the nano objects, more the difficulty in identifying and hence need superior version	For first year student, compound microscope is sufficient and also more preferable option than a facilities via phone	It may serve the purpose but it will increase the cost of the phones + may make it heavy + may not be useful to common people
Facts relating to equipment with main focus on microscope while studying in respective	Lower quality microscopes, poor quality lenses and hence more time consuming. Insufficient	Basic requirement to form a college or university. Hence ratio of student to microscope is 1:1.	Satisfied with the facilities provided in the university	Outdated microscopes, cheaper, slow processing of data, not so clear images, or no

universities	quantities,	Basic microscopes are purchased without looking for latest technology to fulfil the requirement since latest such as digital or electric microscopes are costly affair.		additional facilities provided with the latest one.
How does lower quality affect students?	Lesser practical knowledge			
How does lower time access to equipment affect students?	Lower experience since lower slides to analyze, hence lower practical knowledge, hence cannot perform practical exams and ultimately affects the end result		Lower experience since lower slides to analyze, hence lower practical knowledge, hence cannot perform practical exams and ultimately affects the end result	
Fees break-up regarding equipment, coaching and other infrastructure		1:2:1		
Costs of basic microscopes		\$ 600		
Cost of latest microscopes		Average \$ 6700		
If photos of cells at various stages are provided for studies than microscope, what	It will be like to learn driving images are given for what is clutch and how to use it	Even pictures sometimes fail to capture nano things which can be observed	The more slides you evaluate through microscope, the more variation	

is your opinion?	instead of actual usage of clutch and so on	through microscopes Eg: while analyzing root canal treatment, the microscope is needed to identify the infected pulp to identify its severity	you can identify and gain knowledge. For example, blood cells are best analyzed through microscopes than the pictures	
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# Forestry and Farming

## Personas:

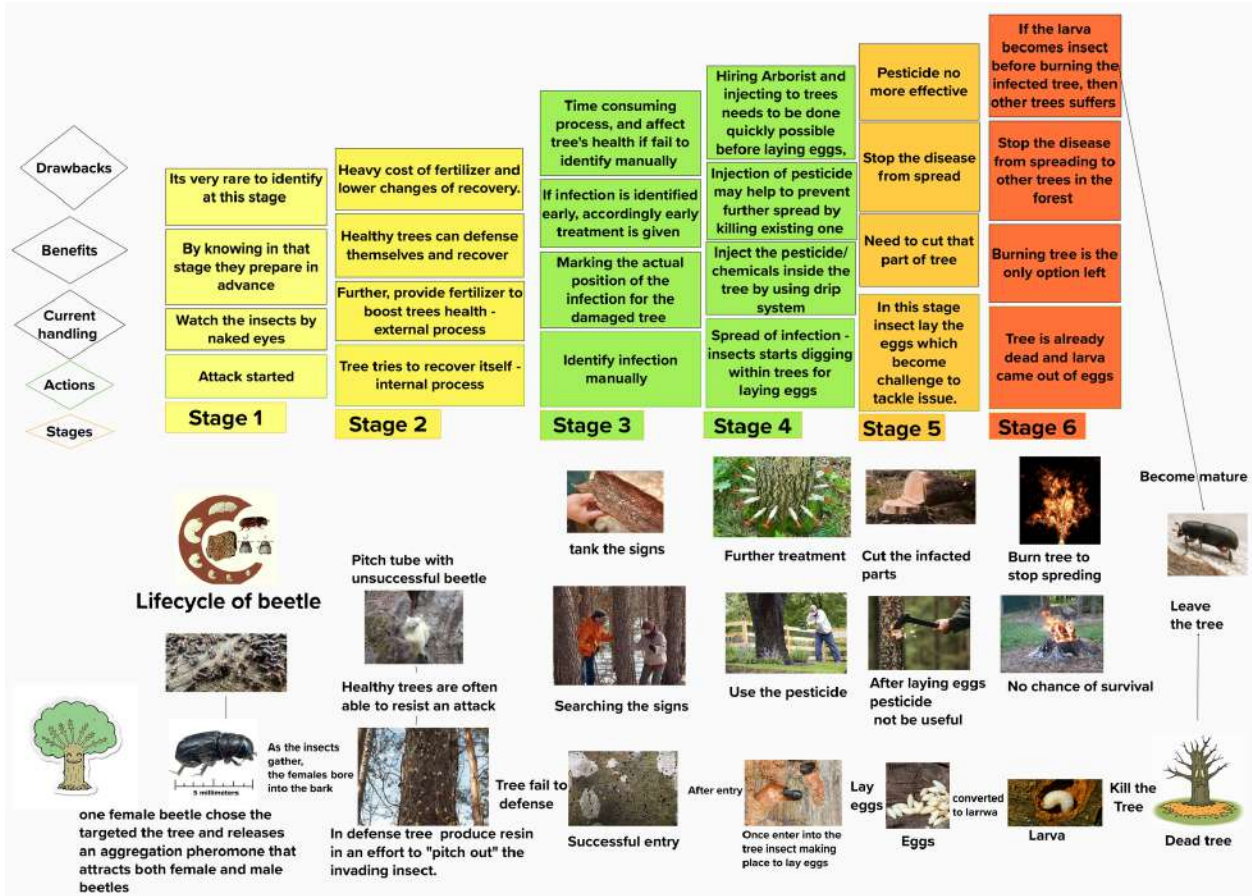
### Persona 1

#### Zaman, Farmer in Pakistan.

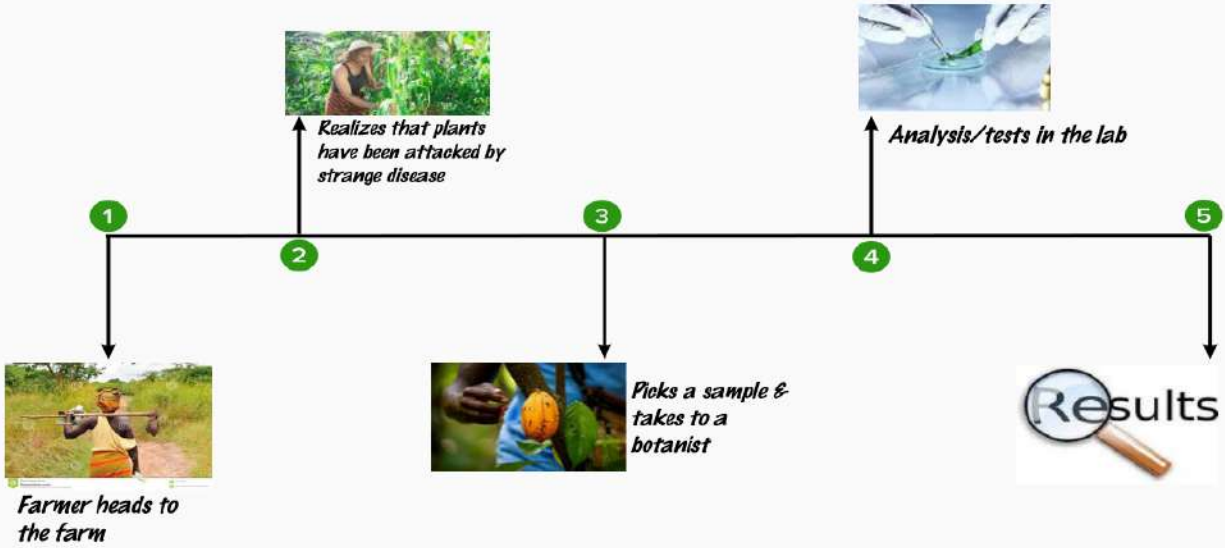
“I was standing with a group of six people, our eyes filled with tears, and complete silence as we pondered upon the losses we were staring at. One of the mango trees planted by my grandfather had died” lamented Zaman Shah, a mango farmer in the Sindh province of Pakistan who owns more than 200 mango trees. This is his and the other four families’ only source of income.

Last year, he found around 20 of his mango tree's leaves had changed color to yellow. He sought the advice of an arborist (a professional that cares for trees) who recommended expensive treatments by using pesticides. There was no change even after spending a handsome amount of money to treat the trees and also found that other trees had been affected by the same. He was then between a hard place and a rock as he had to choose to either cut down the trees or apply pesticides to all of them. Both options would eventually cost him, but he chose to fumigate his farm to avoid further infections. He, however, had to sell off some assets to afford the cost of fumigation.

His biggest challenge is getting to know that there is an infection in the initial stages. If he fails to know then the damage has been done which costs him financially and he loses the tree. Shah needs a way to catch infections the moment they start happening or the moment pests attack his plants since the naked eye cannot do this job.



# A FARMER'S JOURNEY MAP





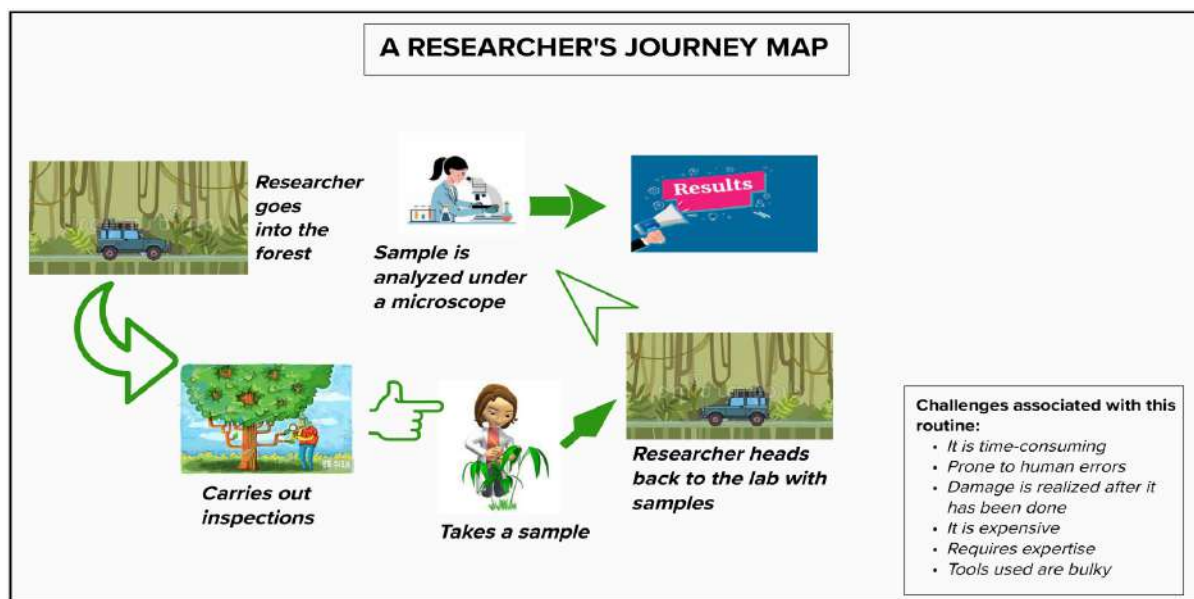
## Synthesize and Define for Persona 1:

User	Need	Insight
<p>Zaman from Pakistan uses farm of his ancestors as source of income for him and his family. He had to cut his ancestor's planted trees to prevent the spread of infection within other trees of the farm, since the infection was no longer curable with the use of even costly pesticides.</p>	<ul style="list-style-type: none"> <li>● He needs to identify the infection at an early stage.</li> <li>● He needs some affordable equipment which will help him to detect insects which are not visible to the naked eye.</li> </ul>	<p>Because,</p> <ul style="list-style-type: none"> <li>● Observing the tree from the outside does not show the extent of the damage</li> <li>● Infestation in one tree can affect the entire farm</li> <li>● By waiting for natural signals from the tree, it can be too late to act</li> <li>● He may end up cutting or burning the infected tree/s.</li> </ul>

## Persona 2

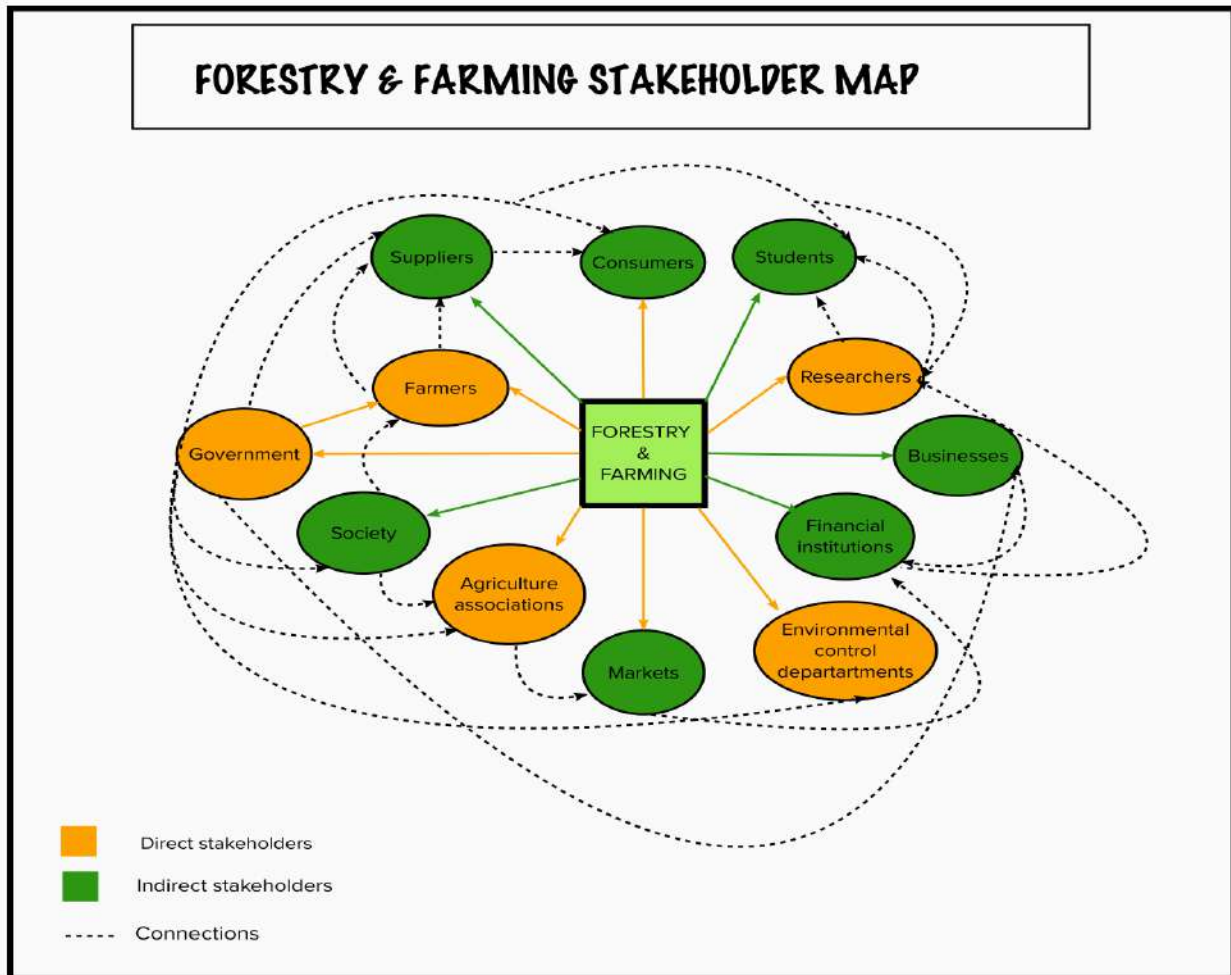
### ***Sidarth Beniwal, forest researcher in India.***

Sidarth Beniwal is a forest researcher in India who faces difficulties occurring by old traditional equipment and methods. He has to physically inspect each tree among hundreds or thousands to find the infected ones. After this backbreaking work, he finds a few trees and has to cut off parts of the infected areas then transport them back to the laboratory for tests and analysis. This step also takes longer to be accomplished hence delayed results. The whole process is also prone to human errors where the sample can be contaminated hence false results. Sidarth requires an easier and quicker way to identify infected trees, diagnose them, and release his findings.



## Synthesize and Define for Persona 2:

A collation of the discovery process, jobs to be done, and discoveries from deeper exploration



User	Need	Insight
Researcher Sidarth Binewale from India needs to walk through forest with heavy equipment carried on hands to analyze each tree manually for	He needs equipment to observe trees and /or identify changes in trees' trunks or leaves for efficient and detailed research. Further, it may help in	Because, <ul style="list-style-type: none"> <li>• Current heavy equipment is not user friendly and time</li> </ul>

<p>collecting samples or identifying infections. He is accompanied by a team of helpers to perform various day-to-day jobs, as once they have entered the jungle, they are their own due to lack of connectivity via phone or internet.</p>	<p>identifying infections at a very early stage and can help to take preventive actions.</p>	<p>consuming</p> <ul style="list-style-type: none"> <li>● Manual procedure for findings could result in human error and incorrect detection of disease.</li> <li>● Lack of connectivity delays the communication of urgent information in a timely manner.</li> <li>● Delay in identifying infected trees delays treatment time and leads to costly affairs or permanent loss</li> </ul>
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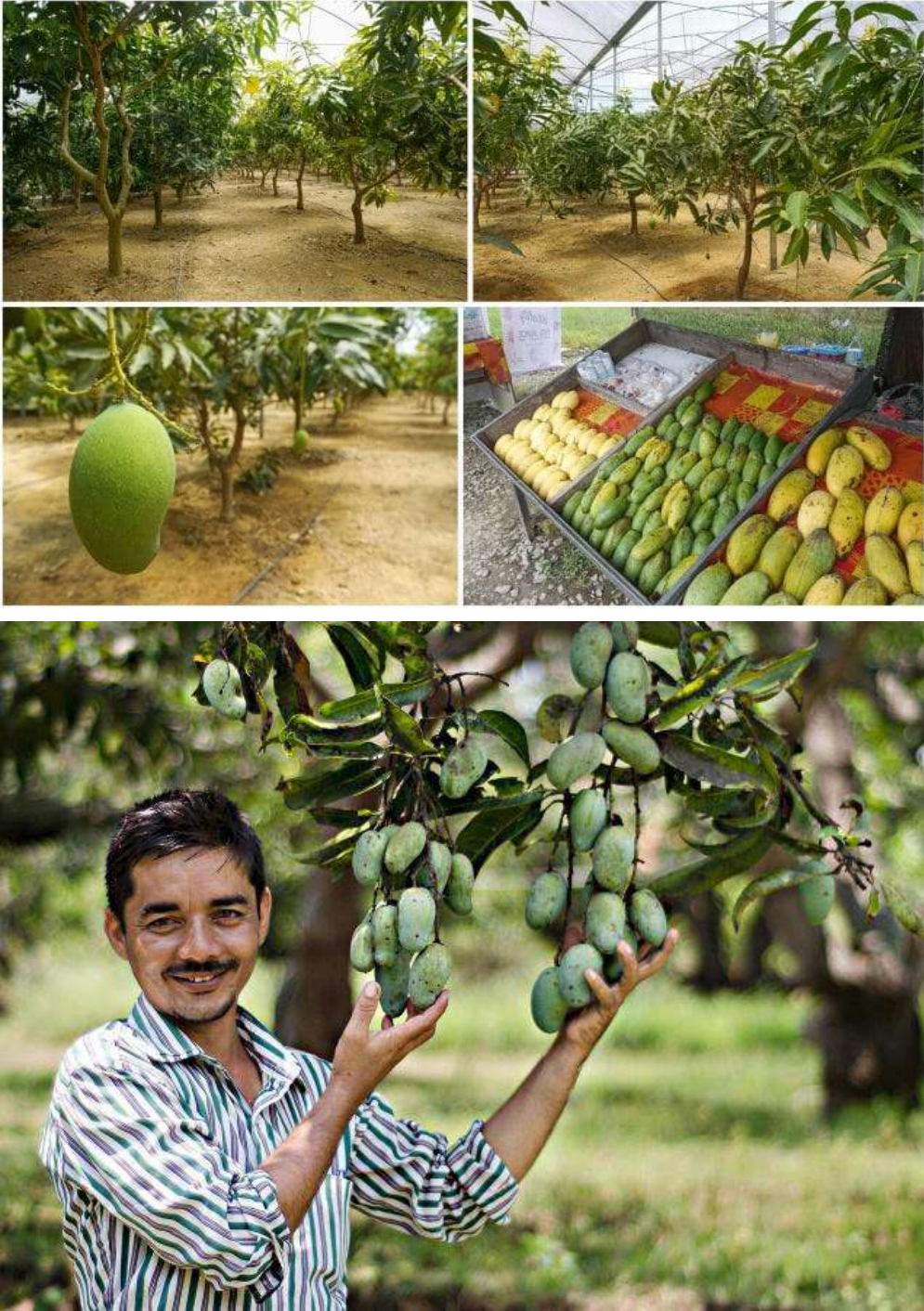
**Summary of interviews carried out and findings:**

Details / Questions	Case study 1	Case study 2
Name and qualification	Zaman , mango farmer in Pakistan.	Sidarth , Forest researcher in India
What challenges do you face in your daily work?	My mango tree is getting attacked by insects like bark beetle which cause tree to sudden death.	It is challenging and time-consuming for me to check every tree physically and detect any infections or damage.
How do you expect your challenges to be mitigated?	If we know the insects' attack in the initial stages, we can tackle the problem and save trees from damage.	As a researcher, I need a solution that will help me quickly check which trees have been infected and the results immediately
What is the common practice in the field to protect trees?	If we see any tree become yellow and folded the leaves, then we took help from an arborist and apply the pesticides.	Uses pesticides and vaccines.
What actions does take whenever trees are infected by organisms?	Stage 1 is to apply pesticides. Stage 2 is treatment Stage 3 cut the infected tree to stop disease from spreading.	Separate the infected part with tree.
Cost of current solution	It depends on the tree size area and availability of products but estimated 150 \$ to 200 \$ per acre.	If we found any forest infected by deadly diseases, then it can be buget of millions of dollars according to the forest size and damage.
What equipment do you use in detecting/fighting/preventing attacks?	Currently we use magnifying glass to analyze every infected tree and take pictures and take samples to send to the lab for further investigation.	Acoustic sensor, infrared sensor, Beam motion sensor, magnifying glass, microscope.

# # WEEK 5 - Problem formulation



Forestry and Farming



## Problem Formulation

### Point of View

Zaman Shah from Pakistan uses farm of his ancestors as source of income for him and his family. He had to cut his ancestor's planted trees to prevent the spread of infection within other trees of the farm, since the infection was no longer curable with the use of even costly pesticides. He needs to identify the infection at an early stage or else he may end up cutting or burning the infected tree/s.

### Questions

#### **A. What if...**

1. What if the infection to the trees is identified at an earlier stage?
2. What if the farm is opened up to agricultural students at a near university for a trade off of labour for the farmer and research ground for the students who can help identify disease?
3. What if we can see the insect with the naked eyes?
4. What if the infection does not spread to any other trees?
5. What if we can use the lenses to detect the eggs?
6. What if we can use pesticides to destroy eggs?
7. What if Zaman has a device to identify infection at the initial stage?
8. What if the lenses can detect and then dispense a pesticide automatically? Similar to automatic sanitizer dispenser
9. What if we have something to boost natural immunity of the trees defensive mechanism?
10. What if Zaman can plant bug resistant seed?
11. What if the health of the seed can be examined before it is identified?

#### **B. How might we?...**

1. How might we identify bugs/insects/infections at the very start?
2. How might we prevent the spread of infection from one tree to another?
3. How might we reduce the infection capability of the bugs?
4. How might we spray the pesticides when we determine the movement of bugs?
5. How might we identify the eggs laid within the trees?
6. How might we boost defence mechanism of trees?

### What do we know about our problem?

Guiding question - How might we identify insects/spread of infection at a very early stage?

### Details about our problem

What is the problem that we are trying to solve?

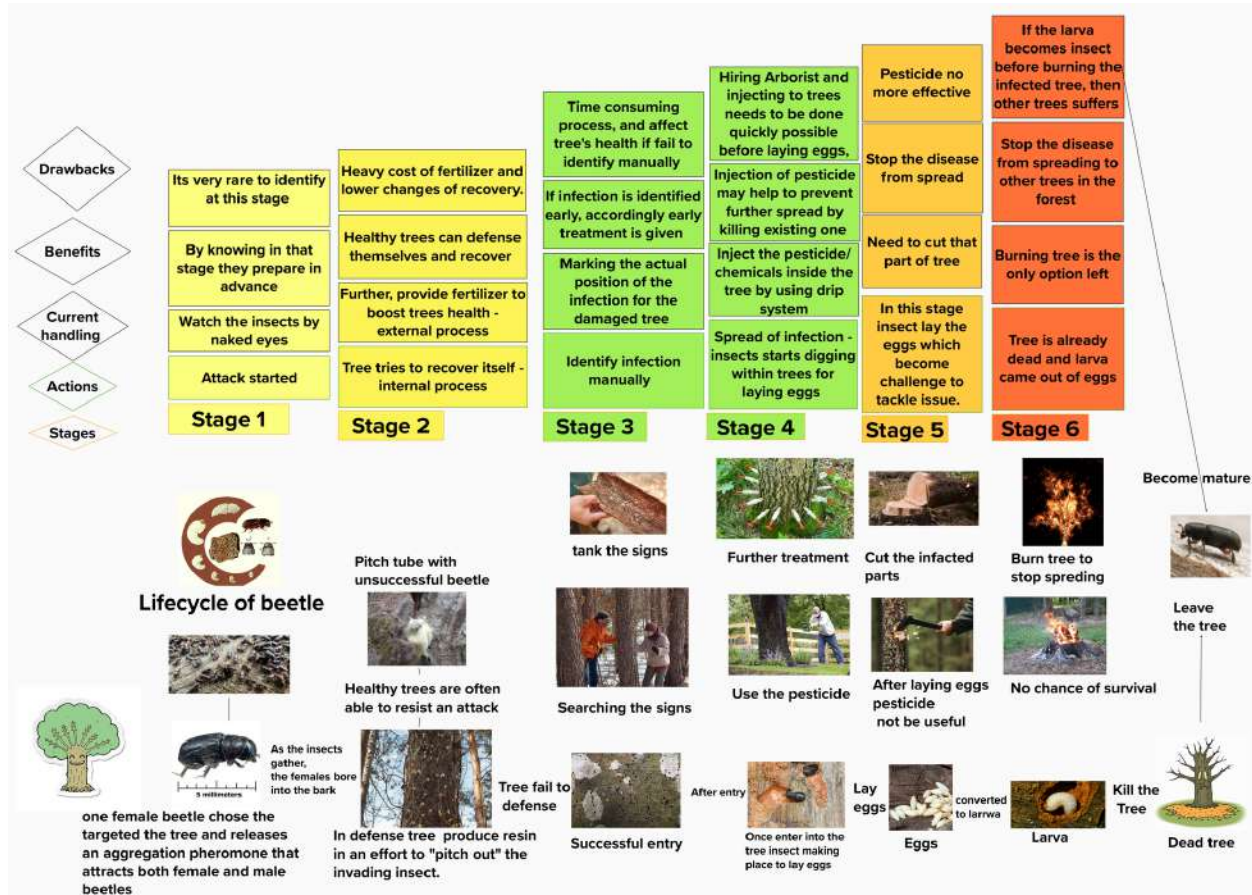
- The farmer, Zaman, cannot see the insect, infection, and the extent of the damage caused

Why is it an important problem to be solved?



- We identified three stakeholders that are impacted when the problem is resolved within the forest. Ultimately, the farmer and his livelihood but also the other trees in the forest that could be infected and the infected tree itself.
  - To stop the spread of infection of infection within the damaged tree
  - To protect the healthy trees from getting infection
  - To secure Zaman's source of income so that he is able to take care of his family

What do we know of the context in which this problem is happening?



Who is suffering this problem?

- **Zaman** - This is the immediate party affected. Zaman has a legacy to keep but more importantly he uses the income he generates from the Mango farming to take care of his wife and family
- **National economic impact.** We also identified the impact a shortage production would have on the economy as a whole
  - Pakistan for example ranks sixth among world's mango producing countries. Approximately, 5% of the worlds mango production is from Pakistan  
Reference: [http://nhb.gov.in/report\\_files/mango/mango.htm](http://nhb.gov.in/report_files/mango/mango.htm)
- **Global Impact.** On a global scale

- Burning and destroying the forests adds to deforestation and could contribute negatively by adding more pollutants into the atmosphere. Preserving the forests and trees however, will have a positive impact overall in the bigger picture of slowing down the effects of global warming

#### What are the consequences for these people?

Zaman

- He will struggle to provide for this daily resources and livelihood
- It may result in loss of investment in his land
- It may severe the emotional attachment he has to his Grandfathers land

#### What do we know about our solution?

- It is an affordable nano-size device used to detect insects which cannot be identified with the naked eyes. These insects are the source of an infection, that if spread in the tree can destroy them through infection

#### What do we know about our problem?

- What do we know about our tech?

Current equipment: Is bulky, costly and has inferior lenses

Meta: Portable, nano sixem superior lenses and affordable if mass produced

- How does it relate to the problem?

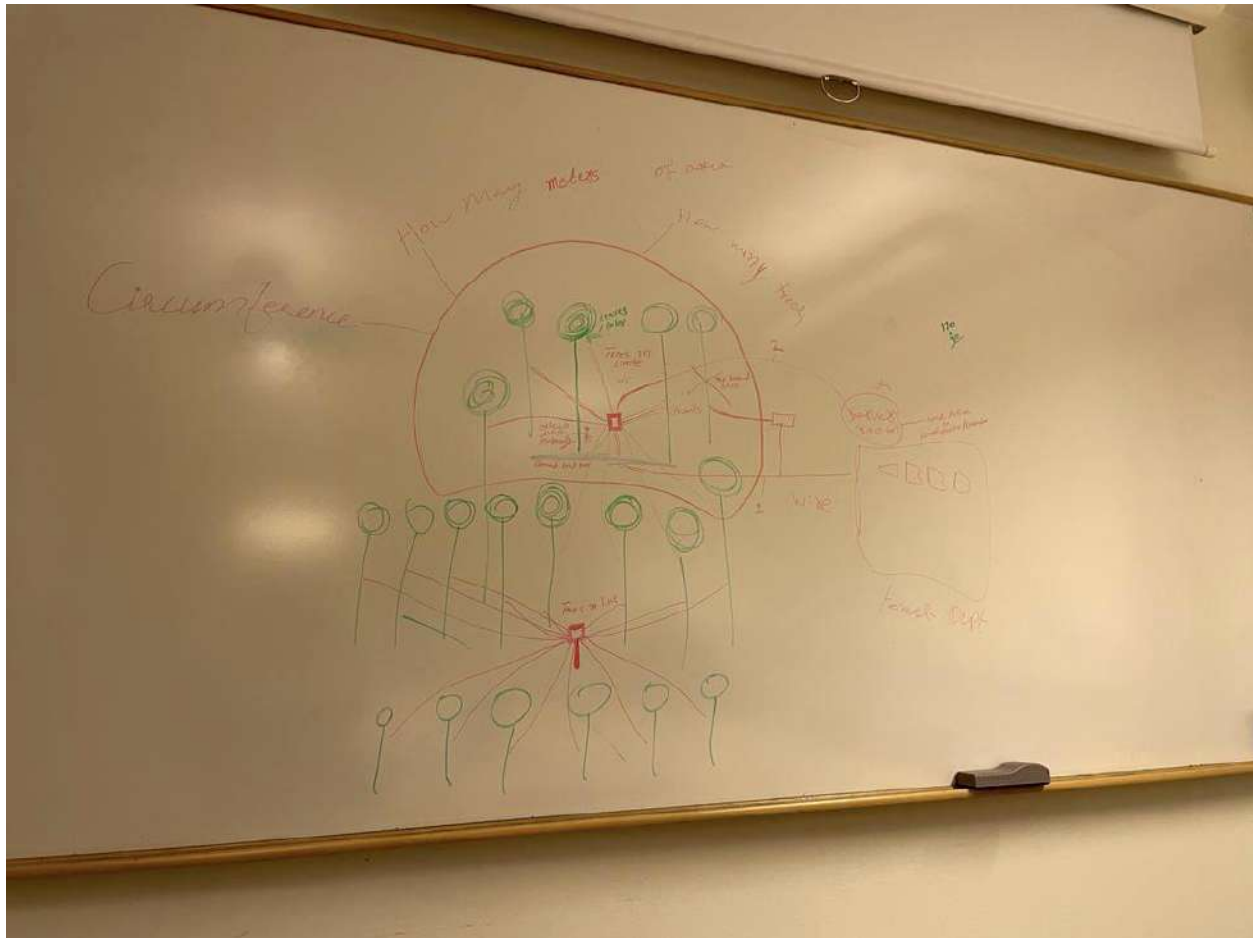
Current equipment: Due to the poor quality of lenses, it takes time to detect infection and as a result it may be too late to act

Meta: Early detection of is made possible

#### How can it be used?

##### **Scenario 1:**

For a given area, the device is attached to the tree to sense movement, capture activities in the respective area. The out put is shared via an application to a laptop or mobile phone to reduce the time required to identify the infection and simultaneously dispense a pesticide to prevent further damage



**Scenario 2:**

The farmer will measure for a specified circumference, 8-10 trees aligned in a circular form. The device is mounted into the ground to sense movement on the trees. The device should be ready to insert and will not need any additional technical set up. It will be connected via

- Wifi - Suitable to big projects such as with researchers. In this way output is sent directly to a server room or whatever technology is being used to monitor or synthesize information.
- Wire system - connected to the device and near by computer or any kind of device used for monitoring
- Plug into the device and download the data/output - The farmer can go to each device and plug in for a example, a simple usb or phone (QR code). This is the cheapest alternative

The output is likely a picture that shows whether the activity is normal or something that the farmer should be aware of and he can take action.

**Scenario 3:**

The farmer will measure for a specified distance, 12-15 trees aligned in a linear manner. This scenario is the same as scenario 2 with the exception of how many trees are covered.

#### Scenario 4:

The fourth scenario makes use of a motorised miniature device fitted with both sensors and lenses to capture activity. The suggestion is to have poles mounted around the perimeter of the farm, with wires connecting each pole and the device will rove around to detect and capture any negative activity. The device would have to be pre-programmed to focus on reading for activity only on mango trees and for specific issues the trees may be subject to.

What are the requirements of the proposed solution?

- Wireless internet connection - Applicable if the farmer chooses the first connectivity option
- Instruments for collecting output. Either of these can be used
  - Server room
  - Computer
  - Laptop
  - Phone
  - USB drive
- Waterproof device - Pakistan is characterised by the monsoon climate with heavy rainfall being experienced frequently. It can average annual high rain fall of 1.5m. As such, the device needs to be able to withstand the heavy rain as well as maintain the integrity of lens or sensor on the device.

Reference:

[https://www.metoffice.gov.uk/weather/learn-about/weather/types-of-weather/wind/monsoons#:~:text=A%20monsoon%20climate%20is%20characterised,5%20ft\)%20in%20many%20places.](https://www.metoffice.gov.uk/weather/learn-about/weather/types-of-weather/wind/monsoons#:~:text=A%20monsoon%20climate%20is%20characterised,5%20ft)%20in%20many%20places.)

- Crack resistant - To serve as protection from bird beaks that may attack the tree
- Smudge and dust proof - Due to the terrain in the farms

What are the limitations that should be taken into consideration?

- The output may be compromised for trees that are at a very far distance
- Connection between devices may sometimes fail and collecting data for analysis
- Access to infrastructure, setting up costs may be expensive if network providers are not readily available
- If trees are placed too close to each other, it may be possible to misdiagnose the extent of the infection
- If the farmer does not collect the data in time or the correct intervals, it may be too late to act

## Appendix

**Armchair Research:** Detailed research on the microscope, its parts, and functioning:



The microscope is made of many parts that work together to make it function successfully. The light that emits from the illuminator passes through a hole in the middle known as the aperture, through the specimen and through the objective lenses where the image is magnified.

The magnified image is projected to the eyepiece lens through the body tube (the part that connects the eyepiece to objective lenses), where the image is further magnified for the viewer to see.

Microscopes are used to make objects appear bigger, hence used by scientists and students and in hospitals to view bacteria, cells, tissues, and other microorganisms.

### What more do they want it to do?

Currently, the compound microscope has a maximum of 4 objective lenses to switch between magnification. Even though the four lenses are varied and allow the user to switch between different lens size, the users would want to have a fifth objective lens to enable users see even smaller objects.

Other products like the omano microscope, trying to solve the issue of the costly nature of the microscopes for students are now selling at 650 dollars.

Looking at how cheap this microscope is, Omano objective lenses cost 99 dollars each (4 needed) with eyepiece lens at 30 dollars each (2 needed). Making the full microscope of Omano lens estimated at 650 dollars have its lenses only costing 456 dollars.

The limitation associated with this device is that they do not possess a high-resolution image as needed [\[Microscope Parts and Functions \(microscopemaster.com\)\]](https://www.microscopemaster.com)

## Bullet points for Week 4 research and documentation:

### Education - Microscope

1. Update journey map (Static map)
  - Be very specific in the journey map
  - Start with a question and use the journey map to answer the questions
    - I have to pay high fees for education as a Medical Student in Developing countries
2. Stakeholder map (More dynamic, what are the influencing, what is the reason they interact)
  - Put the person that is suffering from the problem as the focal point
  - Other people that influence
  - Use the stakeholder map to understand how the different people interact, how does feedback travels between these people, and what their motives are.
  - Possible stakeholders include:
    - Main stakeholder: Medical student – Problem – Limited access to and use of microscopes
    - Other stakeholders: Family, Government, Education regulatory bodies, Manufacturers, Doctors
3. **Persona**

### Tips for drafting a Persona

- Do not use market segmenting approach
- Give your persona an identity and create empathy
- Understand their dreams, hopes, fears and such
- Do not base it in one interview/ create persona from a variety of interviews

Persona - (Who is our user?; What is the story of our persona?)

### Persona 1 - Student

Ahmed is a first-year medical student in India. He and 33 other students must wait for 3 hours to get to use a microscope which is shared by the whole class. When it is his turn timeframe is restricted yet the microscope that they use is outdated and has poor quality lenses.

### What is their journey through the problem space?

1. Ahmed's waits for his turn to use the microscope
2. Gets microscope
  1. Time is limited
  2. Outdated microscope – Refurbished with lower quality lenses
3. The images Ahmed gets are not clear

### **Needs** (Job to be done)

- Microscope of superior quality – To improve resolution

- More access time – Can finish the assignments, allows for more practice time; Learn more about organisms (movement of cells and tissues)

**Insights** (Discoveries from deeper exploration; Usually bring out the need)

- Ahmed needs to finish his degree in the stipulated time

### Persona 2 – Educational institution (University)

In 2021, approximately 200 000 candidates sat for the MBBS entrance exam for only 30 000 available seats in Pakistan. The Khairpur Medical College offers 100 of these seats for the MBBS program. The average yearly fee for the program is 38 900 Pakistani rupees. Private education costs Rs. 995,000/- to 1,220,000/.

### What is their journey through the problem space?

1. Public universities are underfunded and must seek cheaper ways to procure equipment
2. Purchases second microscopes and fits with locally made lenses
3. Microscope is sufficient as a temporary solution but degrades more over time
4. To avoid wear and tear, limited use is enforced on the device

**Needs** (Job to be done)

**Insights** (Discoveries from deeper exploration; Usually bring out the need)

4. Synthesis (Point of View) = User + (needs) Need + (because/or else) Insight

- POV 1: Ahmed needs a microscope with a good lens so that he can see and diagnose his laboratory samples better. With the current microscope, he is unable to focus much on his samples (zoom in, zoom out, lateral movement)
- POV 2: Ahmed needs more opportunities to use the microscope so that he can
  - Do more detailed analysis with his samples and get a detailed understanding
  - Get more practical knowledge
  - Can do more research for his exam
  - Explore some theories or interesting facts he has read about
- POV 3: Ahmed needs more opportunities to use the microscope or else he will not get his practice hours in time and may not finish his degree in time

5. What is the cost involved in current microscope?

6. Why is the microscope needed? Purposes the microscopes are meeting (jobs currently doing?)

7. Journey of medical student with microscope? Can there be any alternative for the microscope to give the same amount of information / teaching to the students?

8. Limitations with microscope

9. What are the expectations with microscope which are not satisfied / meeting currently