Lecture-22
**Smartcane for the Blind- A Success Story Part 1**

I am glad to be here at IIT Bombay, particularly sharing some of the work which we are actually trying to do at IIT Delhi. I am associated with the lab which is called Assistech Lab. So, Assistech comes from assistive technologies. Assistive technologies is a very broad word. If you want to take a more generic definition, many of us in the classroom use assistive technology, which many of us also are wearing, so that is also an assistive technology.

But we are basically working on assistive technologies for the visually challenged. In fact what happened is we started looking at educational needs of the blind. Then we found that before you actually address education, you need to address their mobility needs. If you are not mobile then I think education also suffers. So, we went back and started looking at the mobility aspect and then now we went back and looking at education aspects.

So, that is a focus and it is a very different lab. Usually what happens is in an institute such as IIT's, you will have labs which are primarily either called Teaching labs or Research labs, but we call it more as an innovation lab. Because here we look at the grand challenges which are facing society in a particular domain and try to build a solution which is like end to end. In other words, our journey is complete when we know that the design and technology on which we are working has ultimately made an impact.

So, we had almost like 5 or 6 products which are now in the market. I thought today we will discuss about one of the products which was a very early product, which we worked on. And let me also tell you most of the work which is done as a part of this is also part of an interdisciplinary team. A lot of technology students working with design students.

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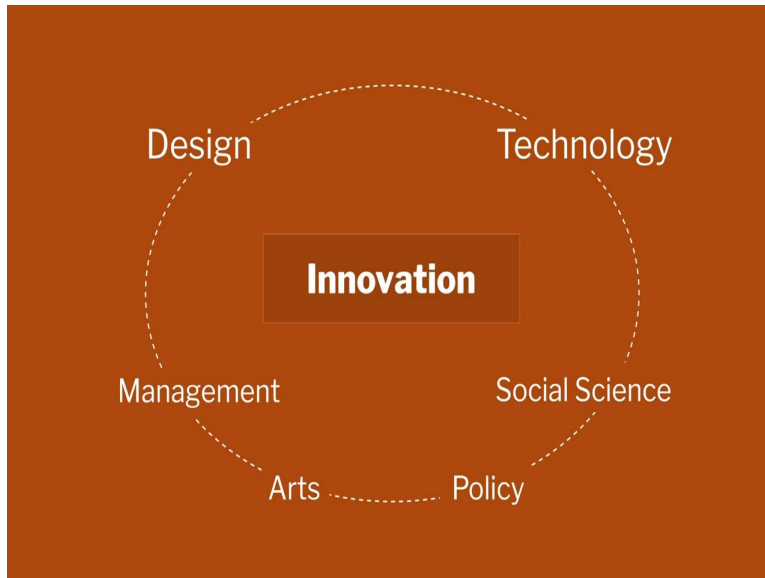
Innovation truly actually required a marriage of multiple disciplines. Technology and Design are major. But sometimes you also need Management, Social Science, Arts, Policy and its actually a very good marriage of these.

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SmartCane™ Device

So one of the products which I wanted to discuss is called SmartCane. All of you are familiar with the white cane which is used by the people with visual impairment. And this is like, a really, a true companion for somebody who is blind.

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Once you are outside, imagine that for a moment you are taken away, like somebody takes a white cane from a visually blind person who is outdoors, the person actually cannot move because you really do not know what the, lets say, the environment would look like. Because this is like a sensing instrument to know where the environment is and you get to know a lot of things whether you are working on a hard surface or muddy surface, many other things.

But the issue which comes with the white cane is that situation such as this cannot be handled by a white cane. It is a wonderful assistive technology if you want to know the obstacles which are knee below.

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But anything (between) knee to head height, people only come to know through collisions. And this is not just India it is universal. It is worldwide, whether you go to US, Canada, Germany. But the only difference which we have is that in many of the countries, particularly Europe and the US, the environment is very structured. So, the laws are pretty strict. So what happens is it is very unlikely that you will have a lot of environment and obstacles which will have upper body injuries when you are actually moving with a white cane.

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But 90% of the world, still is very unstructured and where you will see a lot of obstacles such as this. So this was one of the problems which was posed to us, 'Can we address this particular problem? Can technology and design address this particular problem?' was one of them.

Rohan was one of the undergraduate students who was asked to take this as a project and he not only did a good job. But I think he spent much more time. He went to Oxford to do a PhD as a Rhodes Scholar. While he was a Rhodes Scholar, he continued to work on the project. After his Ph.D he came back and again worked on the same product for 2 years before going to MIT for his postdoctoral. Now he is back as a faculty at IIT, Delhi.

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So one of the solutions which people can think of is to use some kind of a sensor, either infrared or ultrasonic or laser 2 detect obstacles, and then convey the presence of an obstacle in the form of some output. So, what should be a typical output for such a thing? Suppose, let's say, a person encounters (an obstacle), how should this be conveyed to a user? That is where probably a little research really helps. Some of the devices which were built with auditory output did not work for a few reasons.

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One reason is that there is an obstacle but you are not able to hear you are not able to convey this particular information, it is too risky to have. The second thing is the people who are disabled would not like to actually declare that they are visual impaired. It is like if you have a device which is continuously, let say, giving an audio output, you are declaring that, 'here I am, a blind person trying to walk and that kind of a thing', and people do not like that.
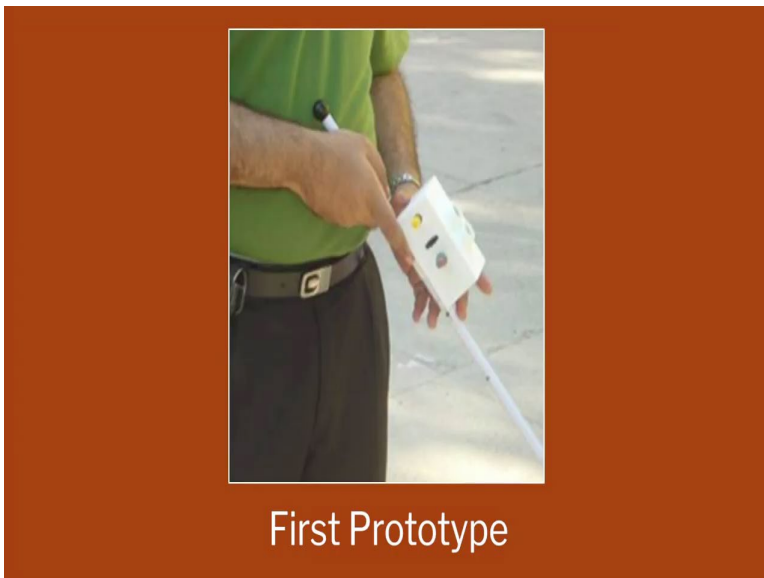
These days vibratory output is very well known. We all use cell phone vibrators etc, it is a pretty one. So, that was the kind of a solution which was initially used.

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These sensors are such that it could cover knee to head height, all the range of obstacles and one could actually go to.

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First Prototype

So this is one of the first prototypes which is built. When educational institutes build their first prototype, it is always like a proof of principle. It is not even a proof of concept whether the concept is going to work and kind of a thing.

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First Prototype

And you take it to people, like, here is a blind person who is actually trying to test it and what happens is this was given to students who were in Computer Science initially. They could address all the sensors, programming issues very well but they probably did not do a good job with other aspects of engineering like material, mechanical, in terms of having a right centre of gravity.

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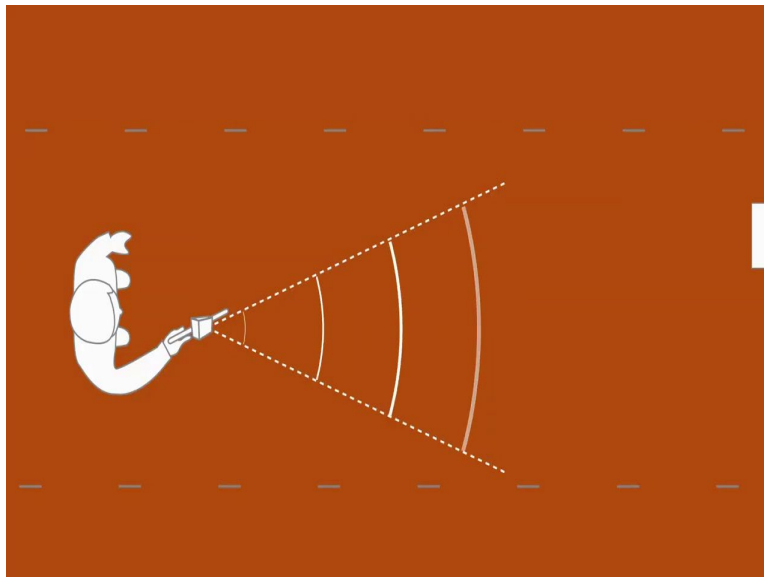
If you see a product such as this, you will always have a small torque which is acting, which will always take the sensor in the other direction. And these things are generally not taken care of. So, this is like a first proof of principle. And users mentioned a list of some 20 to 30 problems with the prototype and why it cannot be used kind of a thing.

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Second Prototype

Then you come back and probably take care of some of the user aspects. Now you bring a few Mechanical Engineers into your team and let Computer Science and Mechanical Engineering students work together and build another prototype and take it to people. Now you have the number of problems, which came in, is doubled. Now not only those problems that some of them remained which did not (get) solved, but now users have many more additional problems.

So what generally happens, this is how most of the projects actually get done in colleges, correct? Usually not many of them go to users. If at all it goes to users, it is something which probably may not meet their requirements. So, then we thought there is something wrong with this type of innovation process. This is ok for learning purposes, for an academic purpose. But if you really want to make an impact then you need to take care of every small aspect of what the user would need.

And that is where sometimes the design and design education and design thinking helps in a much better way to do that.

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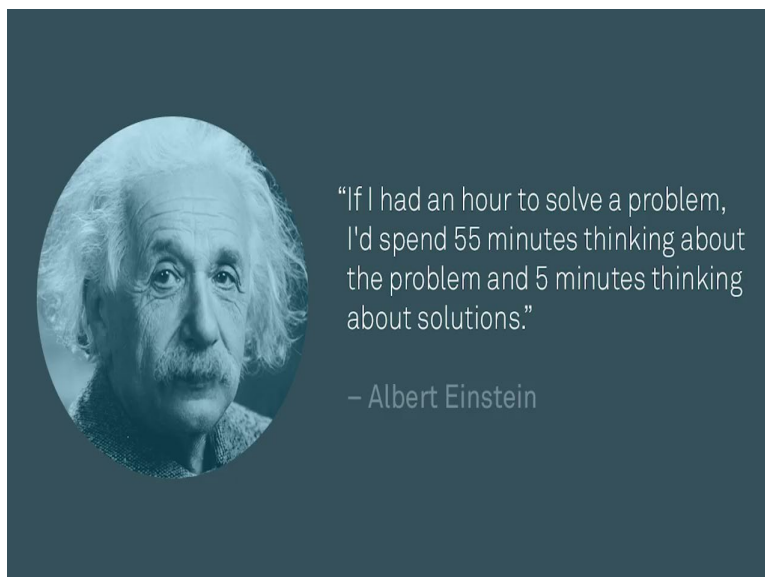
The Pitfalls of Innovation
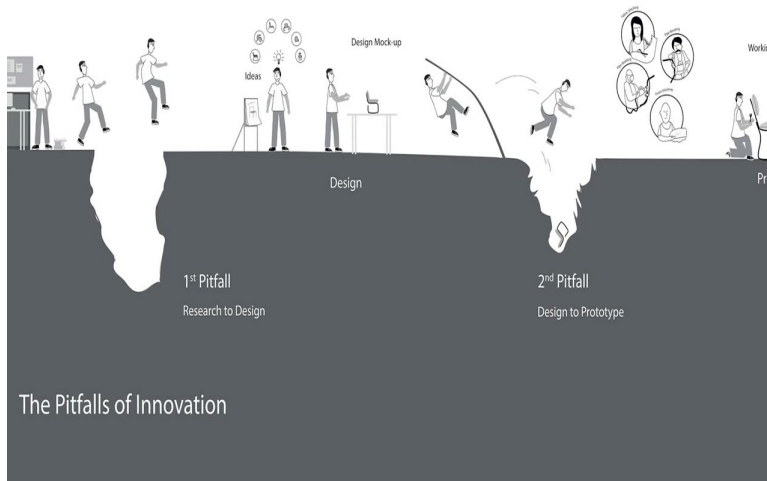
So what was done is that if you actually look at the process of innovation, where you start from one end to another, you have a lot of these pitfalls. So one of the things which was not done is, 'Before I start addressing any problem or finding a solution, did I do enough research even to understand this particular problem completely?' In other words, earlier attempts were more of, let us say, somebody gave a problem and you jumped onto a solution and attempted it, you know that it is not going to work.

Can there be a more systematic process to innovate?

The answer is, 'Certainly Yes' and it says that we have to spend much more time just understanding the problem even before you go to a solution.

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"If I had an hour to solve a problem, I'd spend 55 minutes thinking about the problem and 5 minutes thinking about solutions."

– Albert Einstein

And it also reminds me of a saying once Einstein said that, 'If I have about an hour to solve a problem, I would spend 55 minutes thinking about the problem and 5 minutes to the solutions'. And probably it was not very well understood when he said, but it is becoming more relevant in today's work. Before you even start attempting such problems and solutions, you first need to do a lot of research into certain aspects.

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First thing is understanding the disability. You are suddenly asked to do a product or solution in the space of disability where you have not really studied the disability. You did not understand what disability is. When you actually look at this scenario such as India, whenever you see a disabled person, most of the people would look at a disabled person more from a sympathy or a charity point of view. And I think once you start interacting with them, you know, that that is not what they need.

What they need is empowerment. They want to socially integrate with persons without blindness and do all those things which others are not able to do. Now this comes only when you jump and start understanding interacting with the users, immerse in those environments, shadow the people, let us say, to their daily activities. Then you start understanding many things and that is very essential if you really want to build a solution which can make an impact.

If I just want to do it for academic purposes probably still ok. But if I want an impact this is an important aspect. Similarly what are the assistive technology and understanding users and user environment.

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We generally suggest that if you are trying to do a product or a solution in a space such as this, it is more of a social innovation, immersion is a very, very important to you. That means how many hours, days and weeks I spend in the environment, or put myself in the shoes of the user is extremely important. If I am not doing it, there are certain things or again when I go back to the users, they will give me a much bigger list saying why it is not going to work.

And also, it's not always true that users are customers. Customers could be very different from users. I think we all use products where we are users like Facebook but we are not the customers. Someone else is paying, if I am trying to use it and the same is here. In many cases assistive technologies are actually bought by the Government and sometimes given to the people with disabilities. So, they are not the direct users but they are still there are customers who will buy products and solutions if available in the market.

So understanding all these aspects, even it happens with stakeholders too, and it happens in multiple situations not only this. Some of our students were actually working on a medical device and they actually found that patients really need this device. They spent almost a year and took

this device to the doctor. The doctor said, 'This device is not needed. We are not going to prescribe'. Now if you do not take a doctor into your scheme of things and make them a stakeholder, you may come up with a wonderful product, but it does not go through because you have not consulted a doctor when you started this particular project.

So, the idea is that you do not want to leave out any stakeholder who is a part in this whole game that is a very important aspect. And one should also look at how the problem is being addressed currently. What are the problems, is another important aspect. And there are a whole lot of other things.

Just to give an example, suppose you want to buy a thermometer. Where do I go and buy? Medical shop.

If I want to buy a white cane, where do I go?

Amazon. Is it available? Sure? Ok.

Other assistive technologies?

Doctor's prescription.

But disability is not, all disabilities are related to health aspect. For example if I need a new gaming console, the doctor is not going to prescribe, correct?

And I want something which is more accessible gaming consoles, so where do I get it?

So, the normal E-Commerce marketplaces do have some aspects of this thing, but they still do not house many of the assistive technology.

And second aspect is there is an extremely small percentage of people who need them, use the E-commerce website also. Because most of the people who are with disabilities come from extreme social economically weaker conditions and usually E-Commerce is not a very big thing. Even if I put it, it is not going to sell. We have a product on E-Commerce, probably the number of units which we would have sold is extremely small because it still. It is there on Snapdeal, it is there on other E-Commerce marketplaces, but it does not sell because for this community probably this is not the best aspect.

So, how do I figure out? Like how do I reach out to, let us say, 5 million blind people in India once I have a product? I also need to figure out those aspects and probably this interaction and

immersion with the user is going to tell me that these are probably the roots through which I can actually reach out to people.

In other words what we are actually trying to say is that if you ask me to define innovation, I will say, 'Innovation is something where, if there are 200 reasons because of which your product or solution is going to fail, you may address 199, but still it is a failure, because you left out that one aspect which became a reason for failure'. But how do I know that these are the reasons for failure? Understanding all those reasons and eliminating them is the process of innovation.

Somebody can say that I have designs but there are no takers. Very acceptable, it is very much acceptable. If somebody says I have innovations but there are no takers, it looks a little odd. Why it looks a little odd is if there is some problem because of which innovation is not making an impact, that that particular aspect has not been addressed and hence it is still in incomplete innovation. So innovation is something where you do not want to leave anything to chance etc. where as I can still say that, 'Ok, I have wonderful designs but no takers', that is possible.

Then what happened with this particular product is students and the team went back and said, 'Let us go back to the research and do a much more understanding'. And almost 6 months was just spent with the users, end users, understanding, going to blind schools, going to places where the blind community actually meets, listening to them and trying to understand this aspect. And this investment in research is extremely important not only for product but for the entire life cycle till you make an impact.

I just give an example. Like if you ask, as I said, most of these people come from extreme socio-economic conditions and suppose, let's say, if I price my product 3000 rupees, and if you ask them, 'Are you willing to buy for 3000 rupees?' Most of them would say no because probably having a savings of 3000 is not thinkable for many of the people. Even there are a large percentage of people who cannot afford to buy a white cane which is 200 rupees and you are actually saying, 'Here I have a product, can you buy for 3000?'

But when you interact with these people you come to know that the people who cannot afford 3000 rupees can spend 20 rupees per month. This research and this information gives me that I can still sell. Probably I am going to come up with a very different business model, having understood the people. It may be an EMI or it may be something which may be a rental aspect and it is still going to work kind of. If I do not do this research, I cannot even come up with a better business model subsequently also.

So it not only helps to just find the product and solution. It is also helping you to see, 'How can I reach out to people?' So in this research we found out that this is extremely important. And I think these researches are very well done by the designers usually, we have seen that. The people who are very close to the user and co-create solutions with the users are the best people to do that. You mean to say the smart cane is not the best option for this problem.

So, I think this is a very important question. Can we have, like, a necklace or a helmet. That is where it actually answers this particular question.

How is the problem which is presently being addressed?

There are people who have built similar things. Like, there is a product which is like a necklace. There is a product which is like a goggle, so you have the sensors which are built-in. Somebody made a torch, an ultrasonic torch like this, which you can actually do this. Somebody has put it in a belt and shoes. So people have used all these options and all of them have kind of terribly failed. Why did these solutions fail is that they underestimated the importance and the power of white cane. They tried to replace the white cane and tried to come up with an alternative solution for that.

Imagine there is an ultrasonic torch instead of this thing. It can still, there are a few problems. First thing is your knee to, knee and below is still done by the white cane. So, now if you remove that, when I am walking there may be a serious drop off. How do I come to know that there is a serious drop off? And it is extremely risky to remove white cane in the situation.

And the other thing is white cane gives you a lot of information. If you see people who use white cane they sometimes probably also, you can see them waving that is basically trying to understand the environment. And Now what happens if I have an ultrasonic torch then there is an extra thing that I scan it in such a manner, that I am not going to miss anything. If I miss then it's going to be

a risk. Those aspects become extremely important, that anything which you try to replace generally have not worked and they have closed. People have tried and given up. So this is important that people have tried and given up for this reason, becomes extremely important for me not to try and probably try something which is a new aspect.

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So, what we found is that often we give a lot of importance to understanding the user and user environment, but a large number of innovations, which have been done in assistive and medical, we found that the stakeholders, all the stakeholders are extremely important. For example, somebody who is called as a Healthcare professional is a person who trains visually challenged people on mobility. So one of the versions of the product which we built, the person came and said your product looks good, but it is extremely difficult to train people on.

Since we did not consult those people from the training perspective, they kind of rejected our product in one of the versions. So then we realise why each of these stakeholders is extremely important and where failure is likely to happen. Let me give a very interesting example from Mumbai for the stakeholders.

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A case of Stakeholder
(Bus identification system)

We were working on another product and solution where a visually challenged person can board a bus independently without sighted assistance. So there is a small handheld device which helps me to know two things. The first thing is which number bus has come and the second thing is where the entrance to the bus is so that I can actually walk and board independently. Now, when we did this particular product, we thought, we did not consult many of the stakeholders, and when we came to deploy this particular thing in Bombay in one of the depots called Back Bay depot. So we wanted to put it in 25 buses, then we discussed, we found that there are at least about a dozen stakeholders in this whole process, starting from General Manager who heads, like, BEST (Brihanmumbai Electric Supply and Transport) to the conductor, the driver, the depot manager. Unless you take all of them on board, they are not going to let your innovation go ahead. Then you need to convince the value which it brings before you can actually take them onto a board aspect.

This is, like, the real life solutions where you go through a process and realise how important this stakeholder was and how ignoring this stakeholder has cost me things which probably would not have. And then when you do a research you not only come to know it is not just the tree branches which are there, there are dozens of other obstacles like standing trucks to protruding air conditioners, all require a visually challenged person to negotiate. And this is also probably needed for most others because you are not going to build a solution for one obstacle, it's for all types of obstacles kind.

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Typical obstacles encountered by people with blindness

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What are the different ways in which people use their grips

When you give one of the prototypes to try to the people you also come to know that you expect people to hold the smart cane or a white cane in a particular manner. But when you come and do research you see that people hold in 4, 5 different ways, the product. And how they hold is extremely important for your product and solution to work. Because why it is important is the vibrations which are felt is important to know what are the obstacles in your knee to head height?

But whatever is the information which you are getting from the White cane, like surface texture etcetera, that should not be lost because of the vibration. The moment you, like, one type of output dominates, you again fall into a risk and you have to rework kind of the thing. And for that you

need to know how the people are going to grip. Depending on the grip your sensor position is changing, you know, whether it is actually pointing out to head, or below head, or above head is also all that information becomes extremely important.

And all these things generally come when you do more user interaction. Technology sometimes happens quickly, but at least the first cut of technology. But the real problems are very different. What we did is we also bought all the existing products in the market, particularly the international market and gave it to uses for one week and said, 'Try and tell. Give the feedback about the existing product'.

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This is like an ultrasonic torch which I mention and people said this is something they would never like to use.

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What are the existing products in the market?

There is another one where the vibrations are felt in your head. And people said they, many of them did not use it, not more than 3 minutes. They said, 'I do not want my vibrations in the head'. It is a very awkward kind of a thing.

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What are the existing products in the market?

The feedback which came for this is they said, 'I have been used to using a white cane with a particular grip for the last 15 years. Now you are asking me to change my habit'. And people are extremely reluctant to change their habits just because you are now trying to design a new product. People will do that only when the value addition is extremely high. You think of any innovation where you bring a very small value and ask people to change their behaviour and habits, it is not going to happen.

So, there are various feedbacks, but they also gave good points in this. So now as a designer and as a technology person, I know what are the choices which I can make in terms of sensors, in terms of form, in terms of this thing, so that I bring my own USP where probably I am going to do better than the existing one. Why these existing ones did not reach the people is that they typically cost anywhere from 600-700 dollars to 1,500 dollars and you are actually trying to sell to people who have difficulty in many of them buying a cane of 200 rupees.

So, that is a bigger challenge. Even though these are in the market for quite some time, some of them are of course now close, but still they are not able to reach out to the 90% of the world population.

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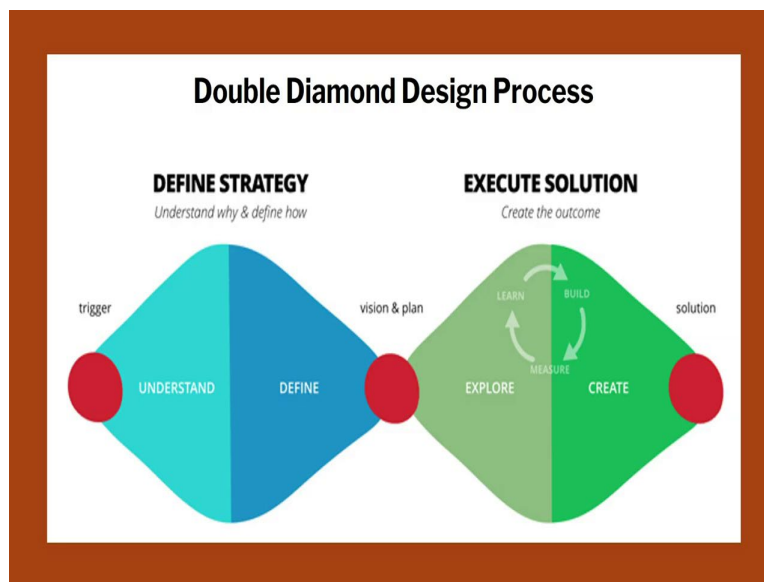
What we found is that it is extremely important to go back and apply the design principles. So we always say about divergent convergent thinking, which is there. So we thought let us do both for the problem as well as for the solution which is there.

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Multiple Iterations

Design → Build → Test → Fail → Modify

Then it went through a lot of iterations and I think the one common rule in all the innovation is fail, but fail fast. And probably one iteration is not going to give you all the inputs and take care of all the user requirements in one. You can take care of most of them but, again, you have to come back to your prototyping and redo when probably rebuild the prototype solutions in order to do the kind of thing, which is there. And it went through a multiple prototype.

The version which was launched in the market was the 12th prototype. Some of them were probably not the functional prototype. There may be, like, look alike, work alike prototypes. Some of them are functional prototypes, but all together we had to do about a dozen prototypes before we could say that here is something which people are going to accept. And now I am very confident that during these prototyping sessions I have addressed all aspects, or at least the most of the aspects which the user would require.

So, I think this is a very good question in the sense: What should be the detection range? Which you are saying. So, typically one is of course knee to head height.

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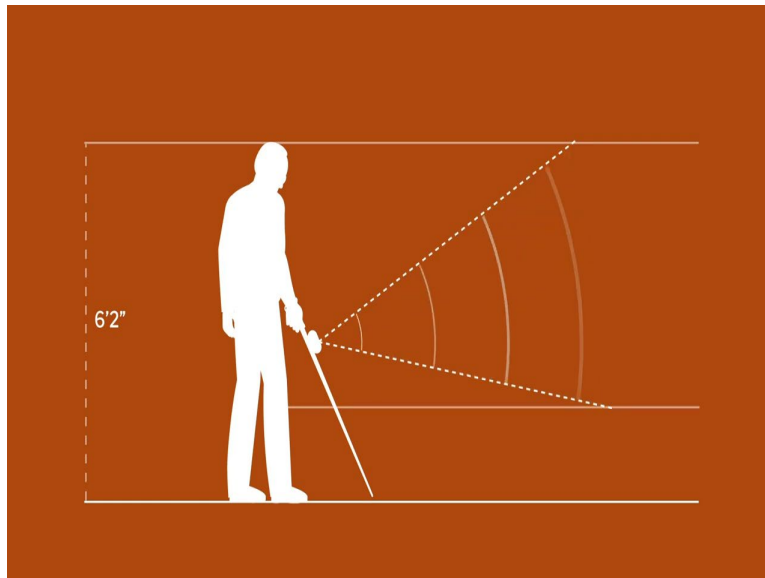
So usually you take a certain thing, for example, we took typically 6 feet 2 inches as the height, which is the height it should cover. You can also broaden a little bit, there are methods to do that. The second thing is it is not only important to cover the vertical one. You should be able to cover the horizontal one also.

So, how much horizontal? What would be your answer? Suppose if I wanted to know?

Around 4 feet? But that is, like, not 4 feet. That would be much smaller than that, correct?

So, the problem with 4 feet is, let us say, I am inside the room. And have to exit from this particular room.

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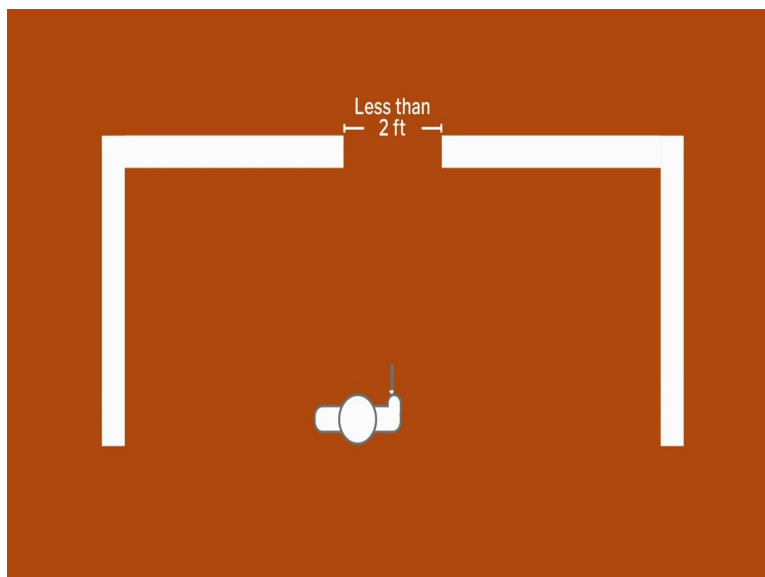
And if I have, let us say, a door which is less than, let say, 2 feet, then I will never be able to detect that there is a gap through which I can actually go. So, you need to keep it narrow as he said, you take the width and add a plus or minus, and that is how probably you should be able to do. The moment I make it this thing, my obstacle detection increases, good, but path finding becomes very difficult. You know, if you know ultrasonic ranging, it is basically a conical correct? Which is there. So, that means the more the distance it covering, more of a diameter kind of a thing.

So, it can detect anything up to 3 metres. 3 metres is the range. Now 3 metres also when you have a range, you do not want to have just telling that there is an obstacle at 3 metre and there may be something which is just very close to you, in both the cases you are saying an obstacle does not help you. So what you what one needs to do is that you need vibratory patterns which in some way are also proportional to your distance.

So, when you are at 3 metres, you are walking and suddenly at 3 metres you encounter, you have one type of a vibratory pattern, it only alerts you it does not stop. And what happens is when I am using a white cane, when I am still, let us say, waving it to find an obstacle which I still do, then I know that in one particular direction there is no beep, there is no vibration, but in other direction there is, that basically gives a clue that probably right side there is no obstacle and I can still clear it off.

So, it also requires a little bit of training. And users have to use, are given a 2 hour training and orientation to understand this, and we found that is enough for people to be independent, but you keep learning for a period of time. But after, like, a few weeks you are probably as good as using your white cane facility. It is basically, like, when we start driving a car for the first time we know how we make our decisions and once, let's say, you have been driving for 3 years or 4 years, your maturity level is entirely different.

Same thing happens, in the same mobility, here too. How do I restrict, let us say, the width to be a smaller and vertical to be higher is that you can do it through programming. If you know how to program for the sensor and sensor information, you can always actually do this particular aspect.

So, what happens every time when you go to a user you always have a big checklist. So from the checklist the first thing which you are going to decide is. What is that you are going to address and what is it that you are not going to address?

When we took this particular product people wanted a few more things on this which we did not address. Somebody said, 'Can your smart cane, can also detect, for example, the dogs?' In one of the campuses there have been too many dog bites of the visually challenged people. Can there be a sensor to know that there is an animal or a dog. We said that is not we are doing. If I want to do that then probably I need a slightly different technology, different cost and different market. So, that decision has to be made when you actually do that.

Another person said, 'Suppose, let us say, if I keep my smart cane somewhere in the room and I do not know where it is. How do I know? Can there be another sensor which can be like an object detector? Ok through my mobile phone I should be able to know. You have another sensor which beeps, so that I can use the audio close to find out'.
We said we are not going to do that. If you look at their wish list, it is always much more. But I think somewhere you need to say, once you have decided that these are going to be specifications, at some stage you need to say this is going to be the specifications of my product.

And once you know that those have been addressed, tested, that is a time when, it is also like a gut feeling. I do not think there is any rule or a green light or a red light which says, 'Oh, now it is a green light. Stop the iterations'. And it can always happen that even after you launch a product in the market you may still have a couple of things which you may have to change and sometimes for very different reasons.

I will just give an example. When we took this particular product we launched this product, most of them asked, 'What is the colour of this product?' Now, probably you did not think colour is something which is very important, but colour was extremely important for them. Like, that is the mistake which we do that somebody who cannot see, they do not have a colour choices etc., that is not it. Somebody in fact, very arrogantly asked also, 'How does the colour matter to you?' I

think that is probably the one of the biggest mistakes the person is committed in asking this question.

And everybody was angry. They also answered a little arrogantly. They said, 'When you buy a shirt, like, I think you are, this thing, it is not just that you like it. You also want others to like it. Then why are you denying that opportunity for us?' So, the aspirations is an extremely important aspect and unless we do a good user immersion, we may ignore the aspirational aspects and at the end of it the product which may fail because it did not meet the aspiration.

So, it is a very balanced kind of thing. And it is also possible that if somebody does an urgency and does not do enough prototypes and goes to market, the product may be a failure and somebody may probably do more iterations, but then there is also a risk of, probably, not being the first to market. So it is a very balanced view. But if you think that the prototypes which are doing is going to add a lot of value then I think it certainly is.

I think there is a very interesting paper which you should read called Second Paradox of Toyota. So when the entire world was reducing the number of prototypes to capture the market, Toyota went and did more prototypes and came up with the product which kind of captured the major US market. In fact people thought in a world when there is a lot happening digitally, why did Toyota go and do a lot of physical prototyping and spend more money and time and delay their launch.

But I think ultimately the launch proved that it is something. So it may not be the case always but we need to make a very judicial choice when to stop the prototype. And sometimes prototyping may be for just, testing one particular feature of the product. So that can be done very quickly. You do not have to build another functional prototype.
The market consideration actually comes, the earlier they can come the better you would be placed.

That is what I think you have seen the slide which is Pitfalls of an Innovation, you have, like, there is a thesis to design, design to prototype, prototype to scale and scale to market. What happened is if I look at this process as very sequential then it is quite possible that somewhere in the 3rd Pitfall,

I realise that my design is not going to go through the 3rd Pitfall. Then you have to go back and re-do this particular aspect.

But if you had a little, lets say, an idea how the market is going to look like, probably your solution will take a very different path and it is more likely to succeed or you end up doing less number of iterations. You may still succeed but end up doing more prototyping and more iteration.