Disability Studies: An Introduction
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Lecture - 20
Assistive Technology: An interview with Prof. Madhusudan Rao

Hemachandran Karah: Hello, and welcome all. Again, yet another talk on disability studies, but this time it is not going to be just talk, it is going to be an interview with Prof. Madhusudan Rao, IIT Delhi. He is a Professor of Mechanical Engineering. Now, he also heads Design Engineering Department in IIT Delhi. Prof. Rao has pioneered many things, many, many technologies in the field of Assistive Technology. I remember at least two which is one a Braille computer, a most affordable one. And second an ultrasound mobility cane, cane for visually impaired people, both coming from the third world and so on.

Before asking him about all these things and much more, let me say a few things about what is technology and Assistive Technology in particular, why that should matter for a course on disability studies. Well, people associate technology with machine and tool, but much more broadly technology is a network of systems consisting of people learning environments, operating systems, cultures, powers, the ways one does production, several sign systems such as watching TV, consuming video, photography and so on. Then technology can also mean how one network and processes and even thoughts that shape self and culture may be a whole system altogether. So, technology is just not machine, it is much more. In that way there is a special field called 'Assistive Technology' (AT). I do not want to define what it is, but I can say pretty much that Assistive Technology comes in myriad shapes. It can help people to breath, think, learn, converse, even live. So, it is a very specialized form of caring, accessing information, learning and living in society.

With that note let me start our conversation with Prof. Rao.

Prof. Rao you have been in Assistive Technology field for a long time, but before getting into that can you tell us briefly about yourself, your training as an engineer, and how you happen to get into Assistive Technology.

Madhusudan Rao: Ok, so, I am primarily trained as a mechanical engineer and I joined IIT Delhi, Mechanical Engineering Department about 22 years back after my Ph.D in Mechanical Engineering. I also work on areas which actually are kind of cross section of Mechanical Engineering and Information Technology. And the way it happened is one of our student groups working on Assistive Technologies for the blind in the Department of Computer Science. And in that particular project they needed somebody with Mechanical Engineering background, and they approach me if I can probably help with their projects, and that is how our 12 years journey with Assistive Technology started. And now, I think, in last 12 years, we have been working on multiple Assistive Technologies for the visually impaired. And we have now at least four technologies we are able to take it to market. And they have now close to about 100,000 users of these products developed which came from the lab. And I think it was more of an opportunity for us to apply a technology for I would say a social good that is what probably brought us to Assistive Technology.

HK: Wonderful. So, in the last 12 years, do you see your work in Assistive Technology in anyway shaping your thought about your mother discipline say Mechanical Engineering, how you think about your discipline, how you teach your discipline? Has it in some way influenced your work with Assistive Technology?

MR: Yeah, sure, it is not only mechanical engineering, but what we see worldwide is that many interesting things are actually happening where more than one discipline are actually intersecting with each other. So, as I said a lot of Assistive Technology is to do with the information technology with design, information technology and mechanical engineering. And I think this coming together of multiple disciplines to address the real-time challenges facing our society has been a wonderful experience for us. Sometimes individual disciplines probably cannot address a problem, but I think when more than one discipline set people with different expertise come together, we have seen that more impact is being made and many more solutions are coming out.

HK: So, can you give us some example. Many of our audience can be engineers, young engineer. So, if you can some specific examples, it will be grateful.

MR: Yeah, OK. So, if you know we have been working in two major areas of Assistive Technology. One is to address mobility challenges, and second is with regards to educational challenges. So, our initial work in Assistive Technology lab at IIT Delhi was concerned with looking at mobility related issues. Actually we started with education, but then we realized very soon that mobility is a precursor to education. And we gave priority to mobility. And the first few technologies which we took up were to address the problem of outdoor mobility of the people with visual impairment without any sighted assistance. So, these actually lead to a product which is called 'Smart Cane'. And what Smart Cane does is, it help visually challenged person to basically negotiate unwanted collisions and obstacles and to be independent in terms of mobility without the need for any sighted assistance. Usually the white cane which is commonly used by the visually challenged people is helpful to address obstacles up to knee height, but knee to head obstacles cannot be detected by the white cane.

HK: Oh, definitely, I have on innumerable situations walked into a truck actually; rear side of the truck is a usual culprit. This is because one cannot detect it through eco-location.

MR: Standing truck is a very big problem, I think, particularly country such as ours.

MR: And also

HK: And projecting windows.

MR: Please go ahead.

HK: Yeah, window projections as well.

MR: Apart from projecting windows, projecting air conditioners, tree branches, and roadside billboards are other problems. So, we have found a large number of a people complaining about unwanted collisions with these obstacles. And that is how the product journey of Smart Cane began which started as a project by an undergraduate student in Computer Science. But I think soon we also had a Mechanical Engineering student joining this particular project. And we also found why multiple disciplines were needed.

When computer science students who did this project took the product to people, most of the problems which were pointed out were not related to computer science, but they were related more to Mechanical engineering.

HK: Such as what, Sir?

MR: For example, people said that weight of the cane is very high. In other words, it is very heavy. People said that using the cane for longer hours leads to pain in their palms because of an imbalance. Therefore, it needed ergonomic consideration to be taken care of. People also gave inputs with regards to the material. Then we thought that many of these issues can be addressed by mechanical engineers and that is how the teams came together to address these problem.

HK: Did it also involve engineers from, maybe Sound Engineering or Biotechnology? Because all these ultrasound devices interact with the human body in a peculiar way. Did it also involve Environmental Engineers? I am just thinking like a typical humanities person. My question also may be wrong, so maybe you can correct me and also address this question.

MR: Yeah, but what we felt is that it started as a Computer Science project and then the Mechanical Engineering team was brought in. Subsequent problems were less with other branches of the engineering. But at some stage, we felt that design is a very important component in all product design. So, we had Industrial Design people working with us. And then we addressed some of the Design and Engineering problem. We also felt that Social Sciences is a very important component in terms of understanding the people who would be using our product, their daily lifestyles, their habits and capturing that became very important. And also even understanding the social stigmas which are associated in using such technologies clearly came out. We also had a consultation with the faculty from Social Sciences. And we had to also work with trainers who trained people in mobility, like orientation and mobility experts and social workers. So, it is became a really big interdisciplinary team with almost eight to ten people with different specialization, and that probably was also one of the reasons for success of this product.

HK: Wonderful! At this point, maybe it is worth mentioning that Assistive Technology as a field is quite a diverse field in itself. I mean Prof. Rao was highlighting upon the idea of inter-disciplinarity and multi-disciplinarity. And not just that, it is also has a

diverse catchment area. For example, IT industry may take people with mobility and dexterity problem, that is one modality. Say, somebody does not have use for limbs or has lesser use for limbs, or deafness or hearing loss or blindness or low vision. Maybe someone has perceptual and cognitive limitation, somebody might have problem with memory, has short term memory, and even speech loss because of which one is not able to communicate well due to a vocal cord condition because of an illness, Parkinsonism can lead to that. So, all these human conditions and I have said five kind of conditions, they will require different kinds of imagination and look at the possibility of diversity of interdisciplinary engagement such an exercise can do. Prof. Rao you have said you have come with four products. Can you also mention about some of others?

MR: Yeah. So, one of the products which we worked on is basically for visually challenged people allowing them to use public buses independently. That's a second mobility device. We have now deployed some of these devices in Delhi buses and we are doing a large pilot.

HK: What do you mean by using buses independently? Can you explain it to the audience?

MR: So, generally what happens is, if a visually challenged person has to use a public bus independently, there are two problems which he/she need to overcome. One is to know what is the number of the bus that has come. That's the first problem. And a bigger problem is to know where the entrance to the bus is, because in a country such as ours you know that buses do not stop at a particular position or in the bus bay. They may be standing a few meters away from the actual bus stop, or maybe few meters before the bus stop. So, one of the biggest problem which a visually challenged user faces is to know where the entrances of the bus is. So, when they know that there is some bus which has come through audio perception, they start moving towards the bus to find the entrance to the bus. And in this particular process, there could be a serious collision. So, our innovation basically addresses these two problems. One is to know the number of the bus which has come, and second is where the entrance to the bus is. So, in order to do that, we have put a small unit at the entrance of the bus with a speaker and there is a hand held device which user uses. So, this hand held device can be used to query the bus which are in the vicinity. And it reads out all the buses which are within a certain range. The moment user selects one of the bus numbers which he or she has to board, the audio

device at the bus entrance starts speaking the same number in a louder way. Thus, you use the audio clue to know where the bus is and can board it independently.

The third product was to make diagrams, particularly in textbooks, accessible to the visually challenged learners. So, one of the biggest problems which we face in India particularly is that there are many textbooks by State governments and Central government, and NCERT, where the text portion is accessible, but the diagrams are not accessible. Because when they actually convert the book into an accessible format, they delete all the figures, only convert the text portion into Braille, and students are left to study only the text portion of the textbook without reading the diagrams. And this actually is a serious problem, particularly in terms of learning. When you go for higher classes and subjects such as Science, Mathematics and Economics, it becomes extremely difficult to learn the concepts without pictures. So, what we do now is that we have converted quite a few NCERT textbooks into an accessible format. And in order to do that, we use a plastic sheet and emboss the diagrams onto it using a thermoforming process. That gives learners a tactile feel of the diagrams through tactile perceptions and are able to imagine the diagrams. And proudly, now they also have some of the books which are accessible both in terms of text and the diagrams. So, this is another project which we have done. And we are still converting large number of books and many of the materials with diagrams into in the form of these books. And here also we have reached out a very large number of audience already, a few tens of thousands people are using these books.

HK: Actually thermoforming is nothing but a kind of photocopying of Braille; hard papers impression gets carried over to the plastic sheet. Is that right, Sir?

MR: Right, that is true. So, what you do with thermoforming is you heat the plastic sheet and pressed onto a master. So whatever is the impression on the master is transferred onto a plastic sheet.

HK: And so, and you replicate the process for thousands of copies.

MR: Yeah, and you can do any number of copies once you have a master.

HK: Hm.

MR: So, but preparation of a master is a precursor.

HK: Hm.

MR: And in order to do these masters, we put technology to work. Like we use more contemporary technologies, like 3D printing, to make these masters quickly, and then using the 3D printed moulds and master, we produce the thermoformed tactile diagrams.

HK: And to test these copies you distribute them to school children, so that they give you feedback about relief points, and how they are able to access particular information, for example, something is shaded, something needs more tactile relief and so on. Do you get such feedbacks to develop the system?

MR: We do, we do. We do take continuous feedback.

HK: Hm.

MR: Not only from the students.

HK: Hm.

MR: But we also work with large number of a special educators.

HK: Ok.

MR: And one of the good things which has happened in 12 years of working in Assistive Technology is that we are able to build the relationship with the more than fifty organization and a few hundred experts in these areas, like special educators, and orientation and mobility experts.

HK: Hm.

MR: Who actually help us, or you can say that they are part of our team.

HK: Correct.

MR: And we go create solutions working with them. You mentioned about interdisciplinary. So, what we found is in Assistive Technology space, user and special educators are very integral part of the team, unlike other technologies where someone

designs and someone else uses. What we found that in Assistive Technologies, bringing the user and other stakeholders very early in the innovation process is extremely important.

HK: That is an entire product and process, they are co-creators.

MR: Yeah, they are co-creators. Right!

HK: Fantastic. Sir, that makes me ask you about Human Technology Interface (HTI). I picked up this term from the internet because it is this protocol that technologists talk about when it comes to user ends; how they want to design architecture and all that. How are you able to connect with that kind of mainstream vocabulary when it comes to AT (Assistive Technology).

MR: Yeah if you actually look at it almost all major Assistive Technologies require this human machine interface or human computers interface, which is a very integral part of it. And if you have actually looked at the Assistive Technologies, which have come up in last 10 years, many of them also use mobiles and computers extensively. So, the Human Computer Interface becomes an extremely important component in all our design of Assistive Technologies. And now it has become a separate area, for example, human computer interaction is a big area in Computer Science and Design. And the large number of experts are now available and also large number of people are being trained who can do Human Computer Interface. And so that interface is extremely important and many a times, the solutions to these problems actually come from the users themselves. In other words, like one of our approaches has been to do lot of iterates to the product with the users who actually kind of ratify our approach to Human Machine Interface.

HK: So, in some sense, did you also find that in AT world, people who are users are more intimate with AT than users of mainstream technologies. Do you find that any time? I ask this question because I am a AT user, I use screen readers and so on. If three or four of us meet, we debate about which speech is good — whether JAWS synthesizer speaks better on NVDA, and we end up fighting actually. This is because we are intimately connected with the voice that gives us access to learning and living. You have done lot of field work with AT users, and you have done a lot of interaction with them. Do you find this intimacy is one of them? I am sure there are many others that users of AT relate to AT in very peculiar way.

MR: Yeah, but I think our interaction, now almost for a decade, also shows that... You mentioned about two terms Technology and Assistive Technology.

HK: Yes.

MR: Ideal situation is when we actually do not want to differentiate. Ideally. In fact, if you ask me what is the Assistive Technology which people would ideally want, my answer would be 'none'.

HK: Hm.

MR: Because what they want is whatever Technology which is accessible to the sighted user or the normal user, ideally they would like to use the same thing provided it is made accessible rather than developing a separate technology exclusively for the particular impairment. So, in other words, what an ideal user prefers is a universal design, like if I am designing a product which is actually meant for, let us say a sighted user, it should ideally work for a visually challenged user also, provided you add few additional controls. For example, one of the persons actually came and said, 'Every time I go to buy my vegetables, weighing machine is not accessible. It does not speak out what is the weight which is being weighed'. They want that weighing machine should be universally designed, so that you can also have a small interface, where it can actually read out the weight or speak out the weight. But I think there are some cases where Assistive Technologies are inevitable, like you said about screen readers and Braille computers. Like for example, Braille is very specific to a particular type of a disability. But I think one of the approaches which ideally we would like to take is to make the technology products which are available accessible to visually challenged as much as possible. Wherever it is not possible, Assistive Technology is the only solution.

HK: Yes, that makes me think about millions of websites, some of them are accessible straight as they are introduced, but many of them we have to fight, beg, and plead and so on to make them accessible. And some of these websites are very basic because they help you doing shopping, book your air tickets, train tickets, bus tickets or even pay your tax and access information about health and so on. Many are not accessible. I heard about a software called Bobby - B O B B Y 3.0, it seems it can help designers of websites to basically run their websites through and check for accessibility in self-check

mode. There are some universal designs, like the mobile phones I use that are accessible out of the box.

MR: Yeah.

HK: But many others are not. So, you are right about saying in an ideal world Assistive Technology as a field does not have to exist, but since it is not [an ideal world], it has come into the picture. That makes me ask you about your next product, i.e. Braille Computer . Can you say little more about it, Sir?

MR: Yeah. So, before I go to Braille I would like to just mention about what you said about particularly the websites and the mobile applications. We are also doing major research in those aspects. So, one of the things for example, if you take the mobile phone, mobile phone have a lot of accessibility features. It basically helps you to use it in almost the same way as any sighted user would do. But I also agree that there are a lot of limitations. And you mentioned about a particular software, but if designers of the software, mobile interfaces designers, and website designers can be trained, there can be much more wonderful and value added things that can happen.

Just to give an example, whenever an interface is designed, like a website or a mobile, three things are very important. One is Utility, second is Usability and third is User Experience. So, what we found is utility is somehow taken care, but usability and user experience is something which is seriously lacking in many of the mobile applications. Just to give you an example, suppose if I want to buy a product from one of the commerce website. Let us say I want to order a book or let us say any of the products from an e-commerce site, sometimes for a visually challenged users the experience is not the same. Somehow they are able to order it, but I think they have to go through a lot of hassles and mistakes, before they are able to accomplish. So, I think that is where we are actually trying to look, and at how to prepare guidelines to improve the usability and user experience apart from the utility aspect which is somehow taken care. That is an important component or missing link which we trying to address.

The second thing is, coming to the Braille computer, we call it as 'dot book', it is a refreshable Braille display. It is like any other laptop except that instead of a visual display, we have a Braille display. You can display up to 40 characters. And this particular dot book can be used to read, write, browse, chat, listen and edit, just like any

other computer or a laptop that is used for multiple applications. And in other words, this is like a one single device which can be helpful for visually challenged user to access any digital content, whether it is a computer or a kindle or a mobile or internet, one can access through Dot Book. A very good example is, when we were actually training a group of students on the Dot Book in one of the sessions, the student actually went onto social media and posted within a few minutes his experience about this particular device. We did not even come to know that this person is actually using a social media and actually trying to write about this particular device. We came to know much later actually.

HK: Well, it is good that you use the word 'usability', because there are different kinds of vocabulary/ terminologies that do the rounds. One is accessibility. A product can be accessible in a vague sense, i.e. I can somehow get through it, I can in some sense will be able to login to the system, but not logout. It is kind of a Chakravyuha once you get into it. But usability is that through which you make it your own, you connect to it, you fully use it, and you become a full customer, in that sense. And there is one more term doing the rounds — 'accommodation'. But that again comes to how a system can bring in a customer or a user, say, a university, a college and how it can accommodate people with different requirements, including disabilities. But, the dot book gets you some experience that you did not see before by way of working with people with visual impairments. What is your Human Interface Learning in that area, Sir?

MR: So, one thing which we did is we not only built the hardware, but we also looked at what are the user requirements in terms of the kind of interfaces. So, we also worked, for almost 3 years now, on the software aspect of it. So, the software aspect actually captures lot of things which users would ideally want. Like, for example, let us say if you want to know what are the headlines of today's news are from any of the websites of a newspaper. What happens is, you can probably go and open the website, but before you are able to reach out to the headlines you would have clicked maybe some 15 tabs before you reach to the actual news. But I think the Braille computers help us to build the interfaces which are specifically suitable for the visually challenging users. So, in other words, if I am using a Braille computer or a refreshable Braille device to access a website, I will get a much better experience than using a typical screen reader, because

screen reader goes very sequentially, and it has to do because it has to go through the same html format, i.e. from the top to the bottom.

But I think in the Braille device, your interface need not be the same as any other interfaces. And I think that actually kind of helps you to improve your user experience in a much better way. And other thing which many users wanted was text to Braille, rather than text to speech. I would say a text to speech and text to Braille both are required, but text to speech was easily available for many students, but that actually did not contribute much to the learning, because the text to speech is still a passive way of learning. For example, a student who is actually able to go through a story would read a story through audio output, but probably may never learn the spellings, because it is only a reading and there is no writing that is involved. So, text to Braille actually gives a much bigger advantage for an active learning. And we found that many people feel that these devices will help in terms of their higher education and employment opportunities.

HK: Well said, Sir. Actually you echoed my own sentiment with Braille. I will make a comparison. You make somebody read a story, and then you have it on print and take it privately and read. Latter goes in, it becomes much more intimate. Maybe you wish to pause on a sentence and imagine the situations. You might want to read back and forth. And even the format of the Braille, along with the story, gets registered in the mind. It's a kind of animation, just as you will remember a graph on a printed page when imagining a mathematical problem. It automatically comes to your mind. For a musician, playing a notation on a paper may also magically reappear in the head. I would say reading Braille is as multisensory as that. Along with audio rendition sometimes Braille animates in your head. When I think about the letter L, I automatically associate that with the three letter word instead of the other thing. Having said that, Sir, I want to ask you something. Lot of your counterparts and colleagues around the globe, are also into this larger debate— Universal Design or Assistive Technology. But is there something that differentiates AT embedded in advance world as oppose to third world or developing society like ours. What is the difference? You are working for a third world and not in England.

MR: Yeah, difference is very huge. Particularly what happened is, many of the advanced countries have realized the power of the Assistive Technology very early, and also made a lot of investments in terms of development of these technologies and also taking it to people. So, Assistive Technology is one area where even the most advanced countries

give a kind of a subsidy or through distribution of these devices to the people free of cost or at a subsidy, so that it reaches the people. Because, if you see, Assistive Technologies are not market driven even in countries which are very advanced. So somewhere the role of Government comes in. But when it comes to countries such as India and almost 90 percent of the world, Assistive Technologies have still not made much of a penetration. So, technology development work started very late. And second, very important thing which we found through our own experiences and research is that products which are actually designed sometimes for the advanced countries, they do not work when it comes to country such as India. Because of the environmental conditions and the regulations as well as the kind conditions under which these products have to be used are very different. Because we found that some of the mobility devices which we actually bought from the advanced countries and gave it to people, people came up with large number of problems, because they do not work in country such as India and that is why we have to do this complete co-creation with the users, and then take it to the people.

HK: Sir, can I give an example, a personal example? I used to use a folding mobility cane in England. At the bottom of the cane, the tip was in the form of a roller. Why roller, because roads in that part of the world are absolutely predictable and flat. And the pavements are just 1 inch, they call it Crib— one inch above the road. So, instead of tapping my cane all I had to do is to roll from left to right making an arc movement. When the nature of the road changes, say I am about to hit the platform, the roller gently slides up. And I know that I am going to hit the new pavement, but that is not how it works in our country, I mean there are no pavements in the first place. So, you need a tapping cane not a roller cane. The kind of obstacles which you need to negotiate here are different and are not found in countries that have more regulations, and same is true with bus identification

MR: Right! Buses always stop at a bay, you do not need actually bus identification system.

HK: Correct, correct.

MR: So that is why we say when it comes to Assistive Technologies, science is global, but technology is still local.

HK: I like that, Sir; I am going to say this everywhere.

MR: Yeah.

HK: I think in talking about the differences between the advanced world and the developing societies, cost effectiveness does matter.

MR: Yeah, yeah.

HK: I am tempted to ask this question. See, when India completed the Mars mission, lots of newspaper columns carried some references about the idea of 'Frugal Engineering', that involves low cost materials. And we were able to achieve a huge exercise, like Mars mission, with less cost than many advanced world. So, what is the conversation between frugal engineering and your work with assistive technology— you are an engineer with feet in both the worlds. Can you say little more?

MR: Yeah, I think what we are seeing is that a lot of frugal engineering is happening in Assistive Technology, and that is why it is able to reach out. We also have a new generation of students and innovator who want to connect with the real world and are coming up with a lot of innovations in AT which either are reaching the market or have a potential to reach the market. Other thing which is also important is that the technology is now available at a very affordable cost. Earlier there was a time when electronics used to be very expensive. But if you look at electronics now, it is available at very affordable cost. And hence if we can actually make use of the frugal engineering skills, we can reach out. For example, when we made Smart Cane, we could actually do it at a price which is like almost one-twentieth of the price of a similar device which was available globally. And of course, with many more improved modifications. So, technology is definitely changing. But having said that, still, in order to reach Assistive Technology to people, affordability is one aspect which we need to address. There are two more which are very important. One is that access and awareness are becoming much bigger bottlenecks. Like, I can tell you that I was actually attending a workshop from where lot of school teachers were discussing about how to make Mathematics accessible to the students. And the kind of problems which they brought us, we know that solutions are available for them, but only thing is they are not aware that such solutions are available. So, somewhere we need to address the awareness. And second is, how to make these Assistive Technologies easily reachable to the people through multiple schemes and business models— this is the second thing which we have to figure out. So, if we can

crack this 'Affordability', 'Access' and 'Awareness', and I think we can really do wonders in countries such as ours in penetrating Assistive Technologies.

HM: So true, Sir. People talk about digital divide in the electronic world, where you talk about people who are information rich and information poor.

MR: Hm.

HM: I read a nice article by an academic, Vandana Chaudhary. She calls it 'Visual Iniquity', meaning, well, this information exists but if you are in part of the world, where that information is not circulated, say in suburban India, or some information reaches me with in an aggressive visual format, I will not even know about its existence. I mean, just ignore it or just let it pass.

MR: Yeah, I agree with you that this divide has kind of increased also. The moment Digital Technologies came, pictorial content increased tremendously. So, the gap which is getting much more stronger unless we have a good Assistive Technologies to access the pictorial content, which still the world does not have in a big way, this divide will continue to exist.

HK: Yeah, that is where the relevance of your Dot Book comes into existence. Sir, what is the future that you are looking for in terms of your personal involvement with AT and in also the larger picture.

MR: Yeah, I think our journey with AT for last 10-12 years has been both professionally and personally very satisfying.

HM: Hm

MR: And I think we will definitely be continuing this journey in future. And we know that there are a large number of unmet needs that need to be addressed. At the same time, we are very happy that there are large number of students and people from younger generation who are coming forward to basically work in the space of Assistive Technologies. So, in other words, we basically look at a huge opportunity. And there are two more opportunities which are very interesting, As we are developing these products, though they are being developed for countries such as India, they are also finding market in global world. We said, products which are developed in advanced countries may not

work here, but the reverse is not true. So, if we are developing affordable technologies, they are not only being sold in countries such as India, but they are also able to reach countries such as UK and USA, where there is a huge market for these products, that is one.

And second, particularly which is relevant to your course is that as we are trying to use technology to solve these problems, it is actually throwing away new research challenges particularly in terms of understanding Disability and the Social Sciences aspects. And we are also looking at how we address these challenges. For example, when we were actually working on these tactile books and tactile diagrams, one of the challenges which we always had to address is how visual route to learning is different from tactile route to learning, particularly with regards to how does the brain perceives tactile information versus visual information. And this was actually throne up new research and Ph.D problems for our students.

HM: Also, this is cultural as well.

MR: Exactly.

HK: Yes.

MR: So, we started with frugal engineering of technology to work, but we are also ending up with much more basic and fundamental questions. So, we always say, first do a research and convert research output into products and solutions, but Assistive Technology has done a reverse for us. We started with an application, and application is throwing away new research challenges.

HK: Wonderful, Sir. So, do you think special educators may have to windup their jobs and go, do you see them still lingering around, or do you require them more now than before?

MR: We require them more now.

HK: Than before.

MR: There is another gap which we have probably. It is important to know that we also need another professional which is completely missing; we call them 'Assistive

Technology Professionals'. People who can actually evaluate Assistive Technologies, who can actually suggest Assistive Technologies to people, and may do the impact studies related to Assistive Technologies. So something which is called as Assistive Technology expert presently does not exist in countries such as ours. So, we are still thinking a complete degree in Assistive Technology. I think in future the country needs large number of such people and even special educators. The number of special educators per capita in our country is one of the lowest in the world. So, I think we need large number of special educators, mobility and orientation experts as well as AT professionals as we go into future.

HK: Do you find place for robotics in that course which you may launch in the future on Assistive Technology?

MR: Yeah. Particularly, countries such as Japan are using it for rehabilitation. And Assistive Technologies for the elderly is another segment which we have not discussed much, but I think that is where lot of new applications of robotics is coming to help elderly. But I would say India still needs a lot of affordable technologies which can make a big quick impact and I think robotics is still little far but definitely it will happen one day.

HK: Wonderful. So, we are almost nearing the end of an hour. I cannot help telling you the time passed by like ten minutes. It was so wonderful talking to you. But let me summarize a little bit for the benefit of the listeners here.

See, Assistive Technology is not necessarily an isolated field, it is quite integral to technology and thinking in technology. Second, it is interdisciplinary and multidisciplinary. Assistive Technology is not necessarily just for learning, it is for human conditions that exist from cradle to grave. An Assistive Technology requires a larger attention, including across the spectrum. We need Technology assisted special education and much more than ever before. And people who work on disability and who may not work on disability will have to pay attention to Assistive Technology, because it is a sound and fundamental commentary on the technology world that we inhabit now.

Thanks so much, Prof. Rao, for wonderfully sharing your experiences, and even more much clearly for us. Thank you so much.

MR: Thanks. I also thank you for this wonderful course which you are doing.

HK: Thank you, thank you, Prof. Rao.