Effective Engineering "Teaching" in Practice

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Lecture – 11a1
How can we use research in education ? - (part - A1)

Welcome back to this course on Effective Engineering Teaching in Practice. We are toward the last part of the course, maybe last 25 percent of the course.

We will begin looking at how can we use a research in education? As I mentioned in the beginning of this course there is a whole body of knowledge strategies and so on and so forth frameworks understanding mainly in or from research in the education process in the learning process and this is a very old field of research. Therefore, there is a lot of knowledge lot of frameworks and so on so forth, but it is in a formal form. It is usually not accessible to the regular faculty members, regular teachers who are trying to do a practical aspect of teaching or handling classes.

This course or this part of the course aims to bridge this particular gap or at least begin bridging, there is a huge gap therefore, we will begin bridging this gap in this part of the course or in this major chapter. How I planned it is I will start out with some aspects that are very practical essential or I think is essential yes, but which would be relevant to a class, a practical class. And then towards end of the first part I will show you how to look at that from a formal point of view which makes it a lot more gentle, a lot more applicable and so on so forth because it is based on a certain understanding certain frameworks and so on so forth that exist in the literature. And then we will slowly move towards that to become familiar with some important aspects of what is available in the literature and then it is all up to, you can go and pick up whatever you need on your own, there is a huge body of knowledge out there.

So, let us begin here how can we use research in education as the topic of this particular major chapter. There are four sub parts to this chapter. Before we begin the first sub part, let us look at some of the terms, most of the terms you would have come across in this particular course itself thus where, some of the terms you may not have, that is essentially because we this is a 10 hour NPTEL online certification course or a MOOC and therefore, we needed to choose things to present to you. I will present the terms,

terms that are not familiar please go ahead and find out for yourself. I am sure you will understand it based on the background that you have picked up in this course.

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Let us begin with some of the terms. Active learning, I am sure all of you know what it is now, problem based learning we did that in this course earlier, think pair share yes we did that, discovery based learning to a certain extent in the lab courses we did that yeah it is discovery based learning, constructivist methods this will come up very soon maybe in the next part of this chapter, cooperative learning of course we did, collaborative learning you can pick it up one minute paper, this is a specific exercise which you can pick up maybe somebody else is mentioned it already, self regulated learning this is a slightly more formal term. We may come across this in this chapter itself in this part of the chapter itself, blended learning you can go and pick it up, flipped classroom of course we did this, cooperative learning we did this, we called it cooperative group learning which is a more current term and so on and so forth.

All these methods strategies and so on so forth or evidence based methods can improve the learning of a majority of students in the class who are somewhere in the middle. And therefore, they are very useful and whenever you need evidence based on a large class you would need numbers and the numbers would come if the strategy or the method is applicable to a large variety of students. So, that is fine. So, thus far in the course we have looked at the majority in the class. But that is not what the class is made of, you

have people who are very good or people who are not so good and that comprises the entire class whether you like it or not right and that is what we are going to see as the first part of this chapter.

The class as a whole is what I would call it, you can interpret it in several different ways, I would leave you to your own interpretations.

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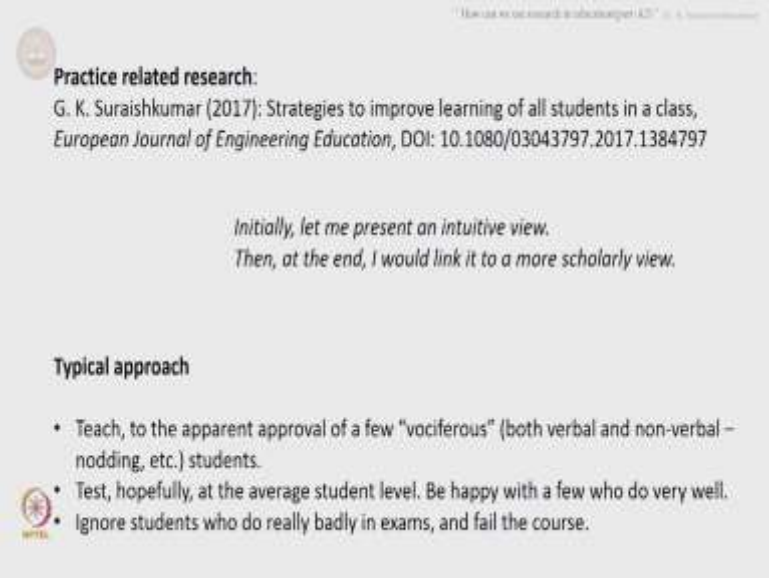

This work has resulted in a paper, this is what I called practice related research. The title of the paper is strategies to improve learning of all students in a class, this was published recently in the European journal of engineering education, which is the journal of the society or the European society for engineering education, it is a society journal, prestigious.

And the DOI is given there, you can go and look up the paper, but I would suggest not as yet. Just be with me because what I am going to do first is I am going to present an intuitive view, the way it came to me first and towards the end of this chapter or this part of the chapter, I am going to link it to what is called a scholarly view, the link to frameworks, the link to better understanding and so on so forth. So, the way things have come are have been put together, in fact this particular work needed about three or four different theories altogether because it was all done intuitively and then I went and checked and found that yeah there are theories which is kind of relate to this, so, maybe I can present it in that framework.

And that is necessary for a scholarly view because everybody can have a view and only if it is vetted by some understanding that is already there or some understanding that you develop on your own and it is acceptable by peers would that be applicable to a larger part of the population. And therefore, the rigor and the acceptability are important aspects when somebody goes and contributes something to the literature and that is what comes towards the end. I will explain further when we get there, do not worry too much about it. Now let us take a very intuitive view so that the understanding is a lot better at the level where we are right now.

So, the typical approach of a teacher even an experienced teacher is something like this, teach to the apparent approval of a few vociferous both verbal and nonverbal, you know some people go like this, some student go like this and we kind of relate to such students and think that they are understanding, whether they are understanding or not is a totally different aspect and so on and so forth right. There are various different cues that we pick up on and most of those cues may not be even valid, that is what I am trying to say.

So, we teach pretty much to them and then test hopefully at the average level of the students, it takes quite a bit of experience to really figure this out unless you have an a an inherent skill. And be happy with a few who do very well, typically we tend to focus on those who done very well and say that this person did so much and I did not expect this understanding to come out at all and so on and so forth especially in the tougher problems. And we are kind of fine with the average and as we grow older the kind of shift our focus from the people who are performing very well to somewhere in the middle and we rarely look at this part, we ignore students who do really badly in exams and fail in the course and this started bothering me.

And when I started looking at this, I did not even know how to look at this. I talked to some senior colleagues of mine who are reputed to be very good teachers and what they told me was it was unfortunate they are in the system, which somehow I could not accept. They are a part of the system and for some reason they are not performing well, they would probably be very good in their own right and they are just not performing well in the courses. And this was the motivation for me to get into this, but this will come in the later part of this chapter, this part of the chapter, but now let us start looking at things in the little more gentle or let us start in place where it is a little more gentle.

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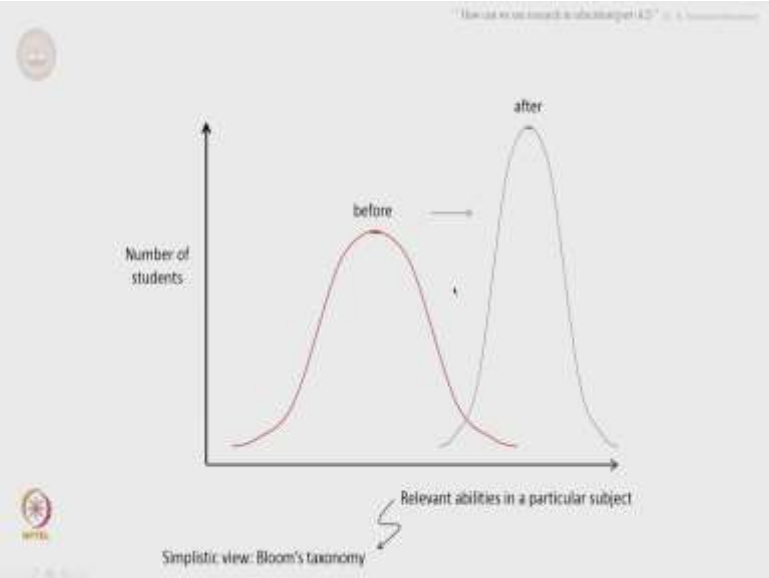

So, this is a distribution of the number of students in class here on the y axis and their relevant abilities in a particular subject on the x axis. And what I have shown there is a normal distribution, which is kind of the expected distribution in reasonably large classes anywhere about 20, you would see this coming up. This is of course, an ideal approximation, there could be skews and so on and so forth. This is a typical distribution a number of students and what I call see relevant abilities in a particular subject.

What was here earlier before the beginning of the course, we would like the distribution to move to the right become narrower and taller at the end of the course right, you realize this is the number and this is the relevant abilities, we would like to move the entire, the abilities of the entire class to the right as well as decrease the spread in the abilities. This is what ideally we would like to do. And what do I mean by the relevant abilities in a particular subject, in a simplistic view it is nothing but the Bloom's taxonomy aspects right.

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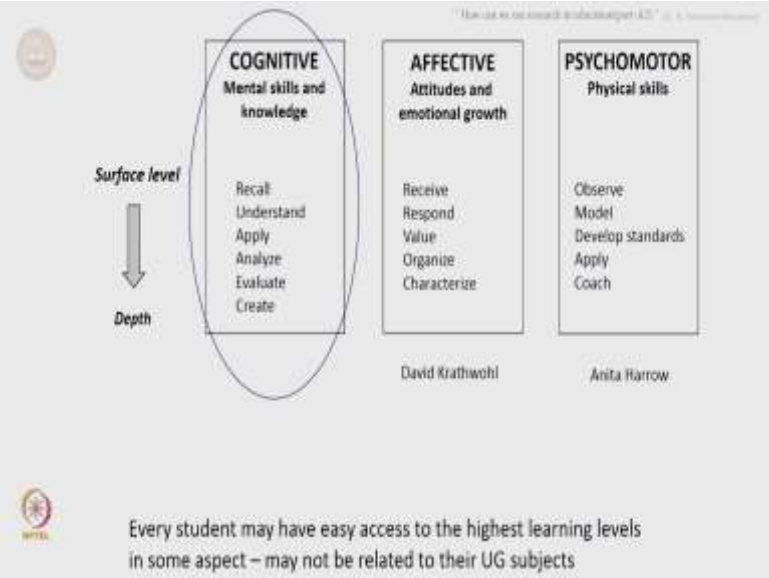

Let us briefly review what we did about Bloom's taxonomy earlier. We knew that there are three major domains, the cognitive domain, the affective domain and the psychomotor domain and cognitive domain consists of mental skills and knowledge, affective domain consists of attitudes and emotional growth, field and psychomotor is physical skills. And typically we look at, focus on the cognitive domain. This of course, is by Bloom predominantly, this was made more popular by Krathwohl and this was developed by Anita Harrow.

In the cognitive domain which consists of mental skills and knowledge, you have recall at the surface level and with increasing depth you have understand, apply, analyse, evaluate and create skills. We are going to look at these skills as the relevant abilities in a particular subject. Somebody may have high skills in one particular subject, but not so high skills and maybe a totally different subject, those variations would exist, but we are looking at one particular subject here, the subject of interest.

So, we all know that every student may have easy access to the highest learning levels in some aspect and it could be in music, it could be in dance, it could be in performing arts, it could be in painting and so on so forth. It could be related to the undergraduate subject of the student or it may not be related to the undergraduate subject of the student. But we are interested only in that particular course or in the undergraduate program that we are looking at. But it is good to know, it is good to realize that every student is good in

something whether the student knows it or not at that stage, some even in their 18s in early 20s do not know their strengths right.

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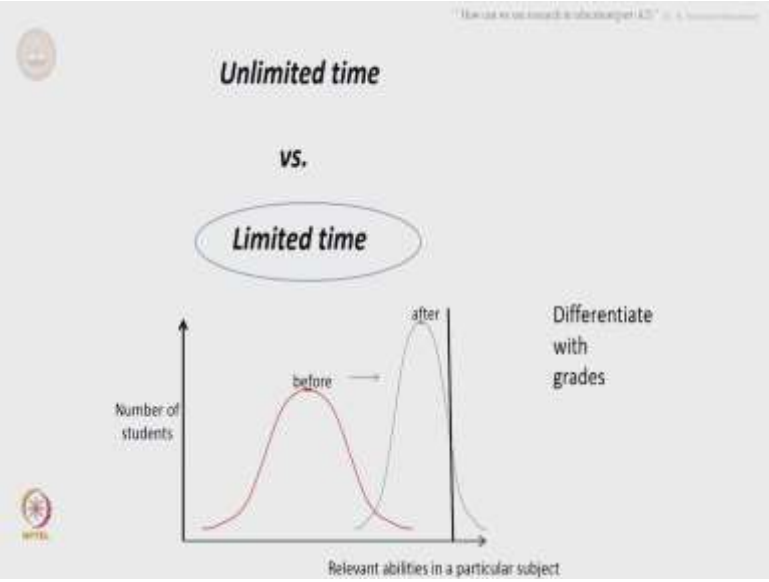

And this we need to keep in mind, this would help us view every single student as the same right and that I think is very important.

In most of our courses, we have a limited time of a semester to do the course right and therefore, we cannot give an unlimited amount of time for the students to develop the skills that we deem to cross a certain high bar for passing the course or for getting a high grade in the course right and therefore, what do we do? We differentiate the performances of various students by grades above certain grade, above certain level, we give the highest grade and then differentiate by grades and if its below a certain basal satisfactory level, the student earns a failure grade, that is typically what happens because we have limited time. Some people have experimented with unlimited time and so on so forth as experiments. But the majority of, the overwhelming majority of the programs run with courses which have a limited time for engagement.

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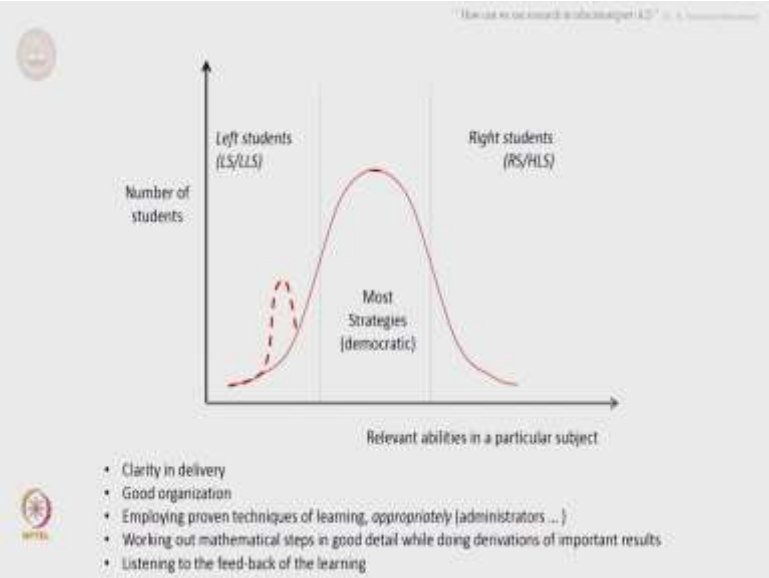

This is the same graph that I had shown earlier, number of students versus the relevant abilities in the particular subject. Sometimes there could be bimodal distributions, even the lower end typically there are a larger number of students with lower abilities, happens due to various reasons. And if we concentrate in the middle which consists of a very large number of students in class, the majority of students in class, the most strategies that we have talked about so far, most evidence based methods that we talked about so far caters to this population. And we have students on the right I call them as right students who have high abilities, RS right students or high learning abilities, students with high learning abilities and on the left you have left students or students with low learning skills LS, low learning skills and high learning skills you have these students also in a class.

For these people, let me just add a few strategies and move on to the others, this is not the focus of this particular chapter. These particular aspects also improve the learning apart from whatever you have discussed so far, we have discussed these as a part of these strategies. But let me highlight some of these, clarity in delivery when we lecture or know the extended part of the lecture, good organization of the various parts of the lecture, employing proven techniques of learning and appropriately, I think we have discussed this earlier I will not repeat it here, orking out mathematical steps in good detail while doing derivations of important results - I have demonstrated this to you earlier, listening to feedback of the learning and this is important. And this will come

towards the end of the course, this is the very last chapter that you will that there is as a part of this course, given by Professor Karmalkar, he will deal little bit with, a lot with feedback and reflection and so on.

So, all these would significantly improve the learning of this part of the class.

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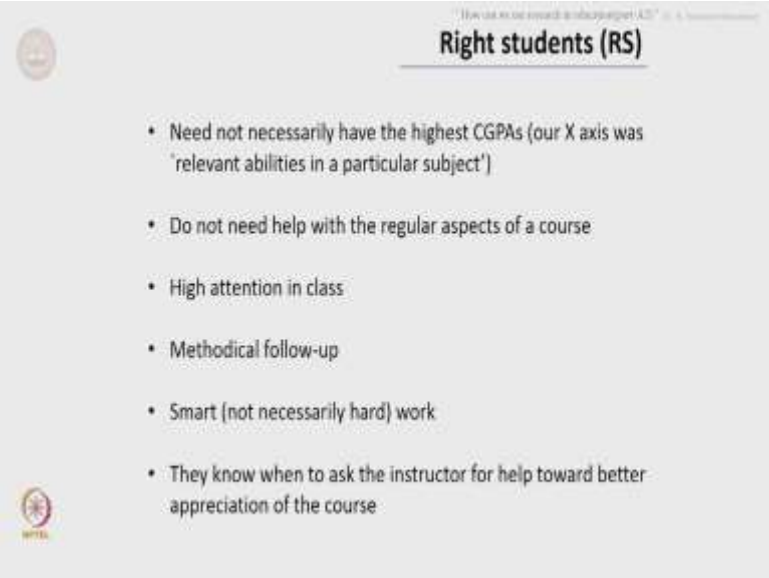

Now, let us look at right students RS. These students need not necessarily have the highest CGPAs, our x axis was relevant abilities in a particular subject remember. And CGPA also reflects the ability to strategize you know grades come with strategies and therefore, we are not looking at those students alone or we are looking at students who do not like to strategize. There are very many students who do not like to strategize at all, who feel strategy is beneath them but they are very good. And we are talking of such students also. They could have very high CGPAs with their basal skills, they could have very high CGPAs too and strategy becomes a part of their way of looking at it. Now, they may not need to explicitly strategise also. They do not usually need help with the regular aspects of the course.

Their attention in class is very high, they do methodical follow up of the material that is covered in class, they do smart work - not necessarily hard work, they just do not go bang bang bang bang without really realizing what is the best way to learn the material, they do smart work, they know exactly how to do smart work. And they know when to

ask the instructor for help toward better appreciation of the course, this they do, they know when they really need help and that time they come and ask the instructor for help.

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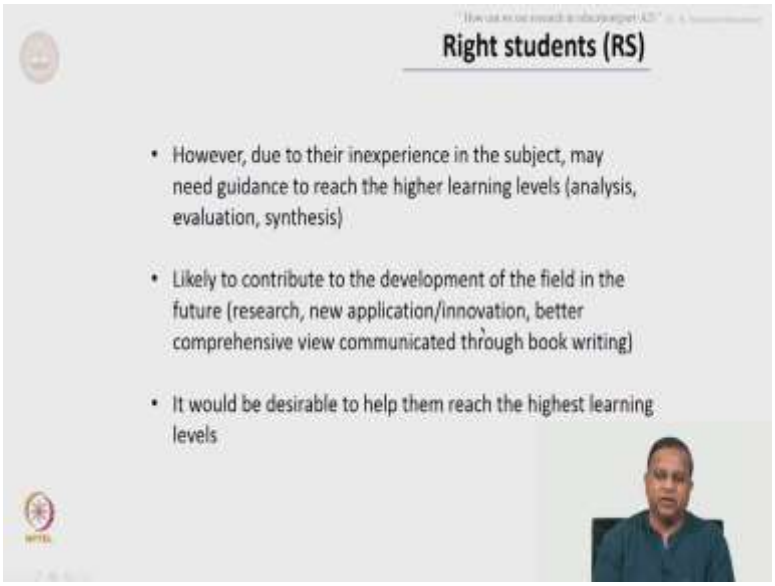

However due to their inexperience in the subject, they may need guidance to reach the higher learning levels. Such as analysis, evaluation, synthesis or create or analyse, evaluate and create aspects of the Bloom's taxonomy. For this, they may need help because they are just inexperienced in that particular subject.

They are likely to contribute to the development of the field in the future through research, new applications, innovations, better comprehensive view, communicated through book writing and so on so forth. Anybody can do this, but they are more likely to do this because of their comfort with the subject. And it would be desirable to help them reach the highest learning levels in this course, it is always better, somebody is doing well, might this will push them up to the highest levels possible such that their possibility to or their inclination to contribute becomes that much higher.

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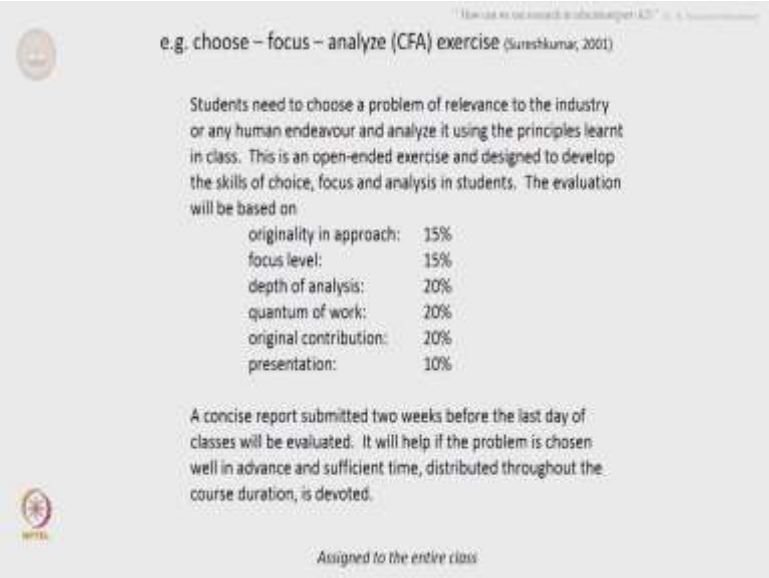

What I do in my course is to give an exercise to the entire class, but which initially I thought would help the right students. This exercise is called the choose focus analyze exercise. I had briefly talked about this earlier, now let me give you the details. Or the CFA exercises, for short. This exercise is assigned to students at the very beginning of the course, in the first class right. Later on I will tell you what surprises I had in terms of where or who this exercise is really helping, I will present some data on that.

The exercise reads like this: students need to choose a problem of relevance to the industry or any human endeavour and analyze it using the principles learnt in class. This is an open ended exercise and designed to develop the skills of choice, focus and analysis in students. The evaluation will be based on originality in approach 15 percent, focus level 15 percent, depth of analysis 20 percent, quantum of work 20 percent, original contribution 20 percent, presentation 10 percent.

A concise report submitted two weeks before the last day of classes will be evaluated, it will help if the problem is chosen well in advance and sufficient time distributed throughout the course duration as devoted. This by the way is a part of a published paper and therefore, it is peer accepted and therefore, I have no qualms in presenting it, it is no longer just an opinion, it is an accepted opinion, accepted piece of work. And as I mentioned earlier, this is assigned to the entire class right in the beginning of the course in the first class itself.

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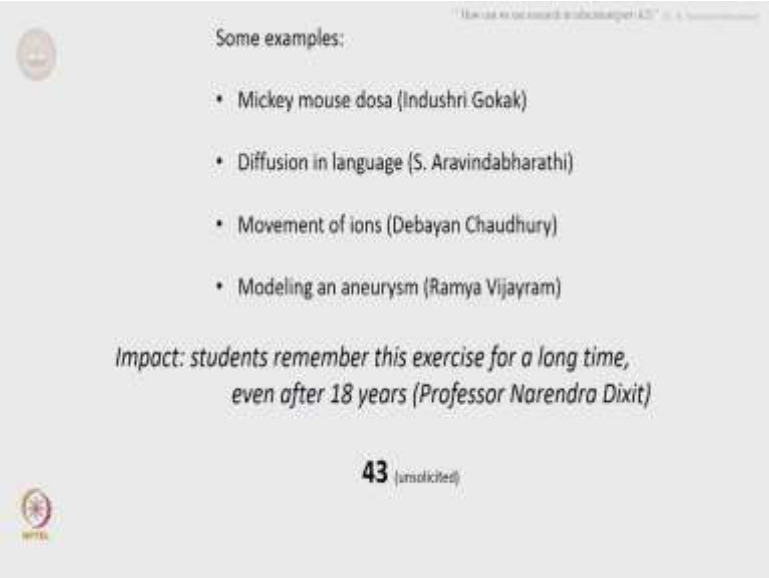

People take this exercise you know very seriously. Many of them get excited about this exercise, they are all pumped up to do the exercise, they do a very good job, typically I get a good number of good reports every year right.

Let me present some examples to you which are interesting and so on so forth to give you an idea of what kind of work comes out of this, out of students, undergraduate students who were exposed to this particular set of principles for the first time through the course, throughout the entire period of the course and they were working on this particular aspect ,this particular open ended problem throughout the semester. And look at the level of work that comes out of these this kind of an exercise.

Let me show you some examples. The first example is what is called a Mickey Mouse Dosa, this was done by Indushri Gokak, almost about 9 years ago right and this is very interesting therefore, I included this exercise as a part of a this course. Let me give you some details right.

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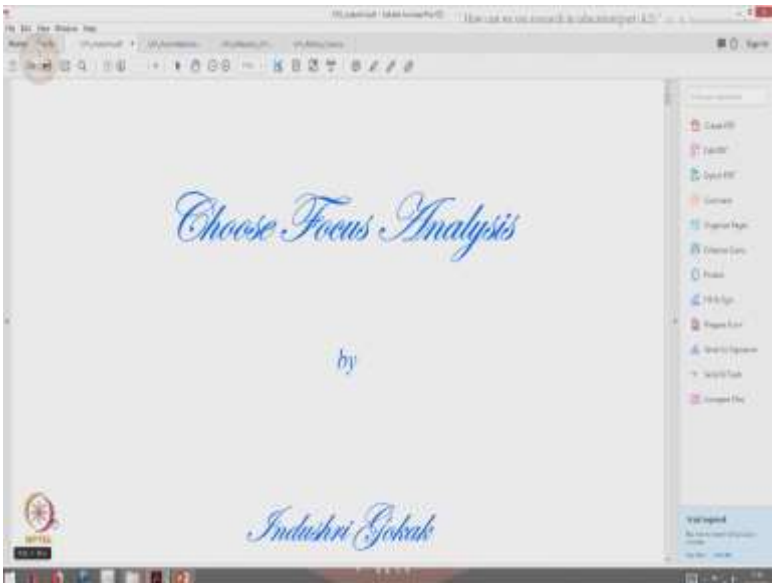

So, you could see if the motivation interest and so on so forth the way the report has come up here itself all right.

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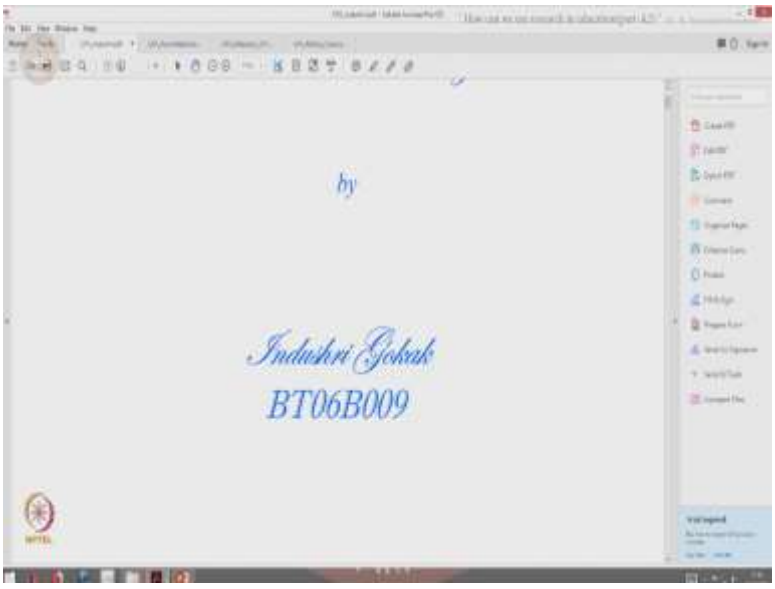

So, this is Indushri Gokak BT06. So, she must have done it in BT08 almost 9, 10 years ago.

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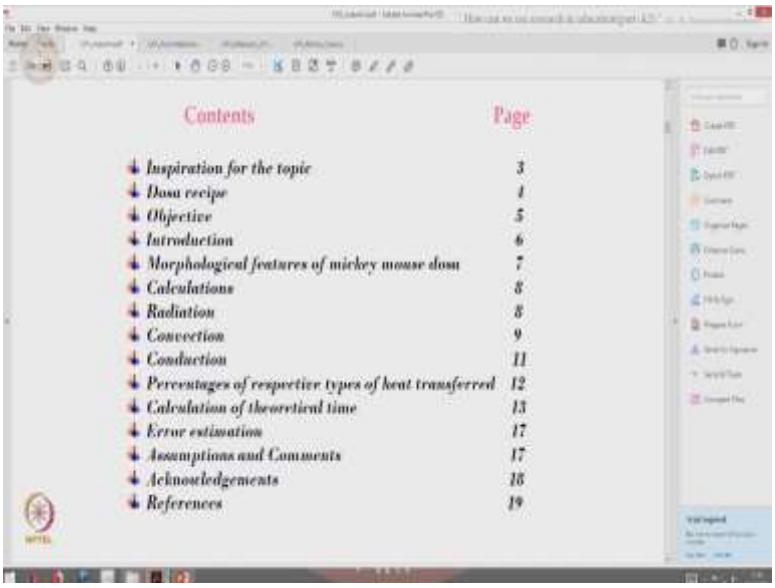

The contents, inspiration for the topic, dosa recipe, objective, introduction, morphological features of the Mickey mouse dosa, calculations, radiation, convection, conduction. This is a part of a transport course. Percentages of respective types of heat transferred, calculation of theoretical time, error estimation, assumption, comments and so on right.

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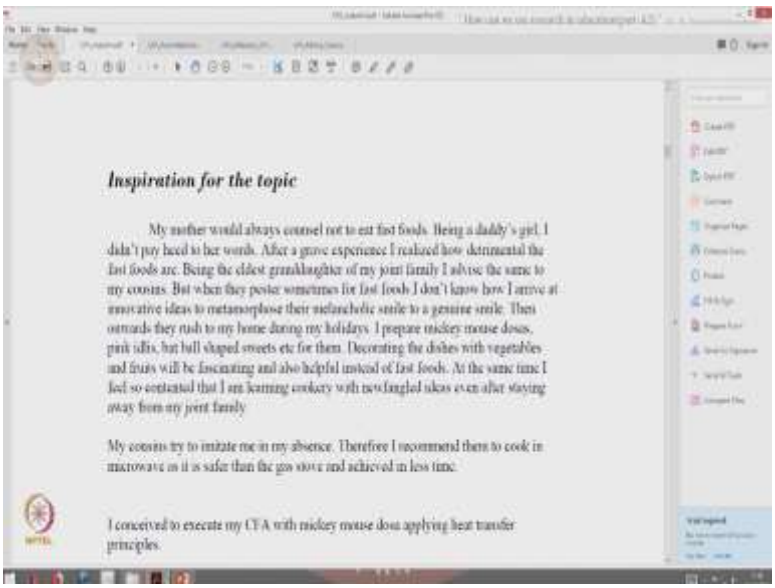

So, I would like to read the inspiration for the topic here. My mother would always counsel not to eat fast foods. Being a daddy's girl, I did not pay heed to her words. After

a grave experience, I realized how detrimental the fast foods are. Being the eldest granddaughter of my joint family, I advised the same to my cousins. But when they pester me, pester sometimes for fast foods I do not know how I arrive at innovative ideas to metamorphose their melancholic smile to a genuine smile. Then onwards they rush to my house during th,e during my holidays, I prepare Mickey mouse dosa's, pink idlis, bat ball shaped sweets etcetera for them. Decorating the dishes with vegetables and fruits will be fascinating and also helpful instead of fast foods, the language and the construction you, it is the student doing it.

At the same time I feel so contented that I am learning cookery with newfangled ideas even after staying away from my joint family. My cousins try to imitate me in my absence therefore, I recommend them to cook in microwave as it is safer than the gas stove and achieved in less time. I conceived to execute my CFA with Mickey Mouse dosa applying heat transfer principles. And this is where the link to the principles in class you know, the only a limitation is that they will have to use at least one principle that is thought in class. So, this is recipe and then objective, very clearly enunciated objectives.

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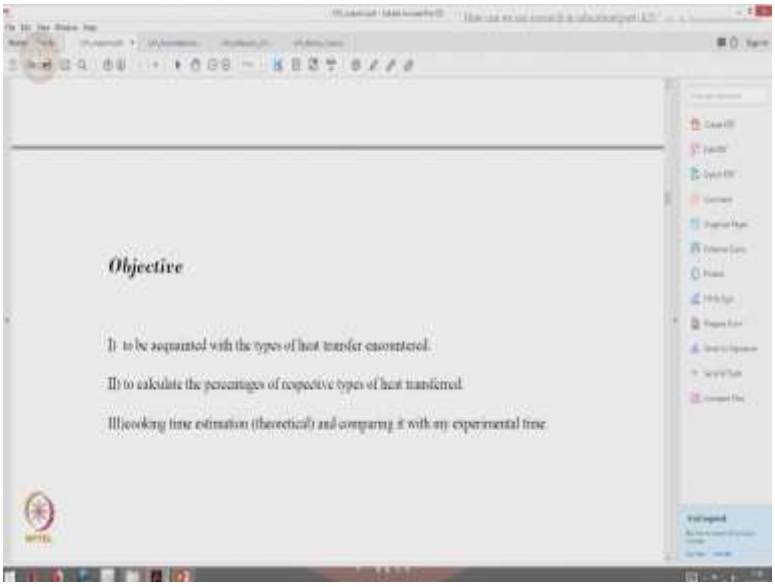

To be acquainted with the different types of heat transfer encountered, to calculate the percentages of respective types of heat transferred, cooking time estimation - theoretical and comparing it with experimental time, very nice.

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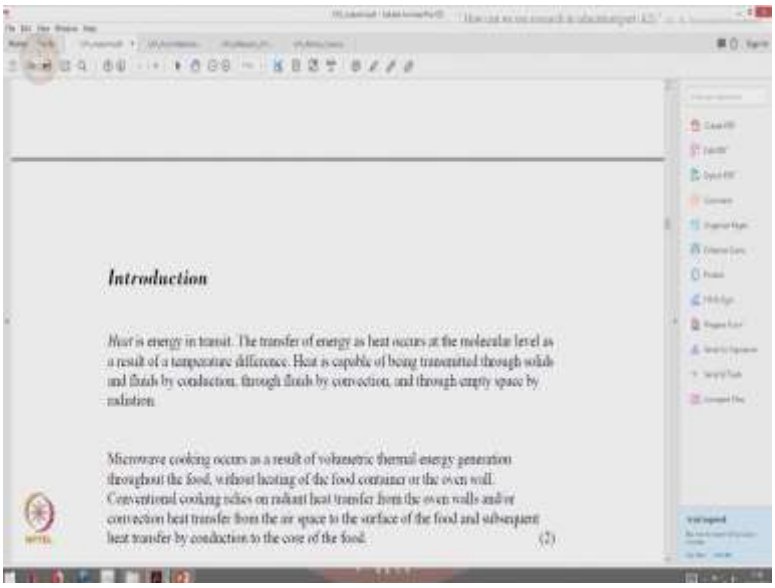

And good level of focus there introduction.

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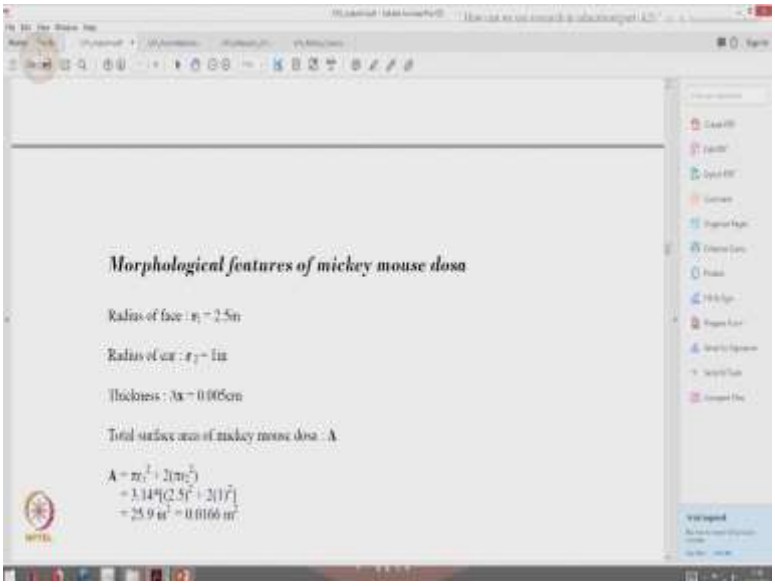

And then morphological features of the mickey mouse dosa.

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This is the picture of the mickey mouse dosa there, very very nice to look at.

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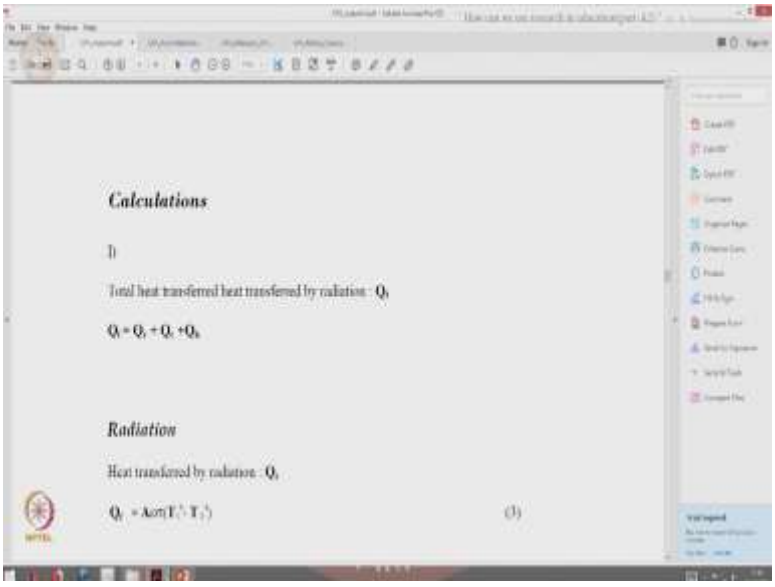

And then she gets into the heat balance calculations, radiation, convection, all this, some of which were covered in class, she went way beyond what is covered in class.

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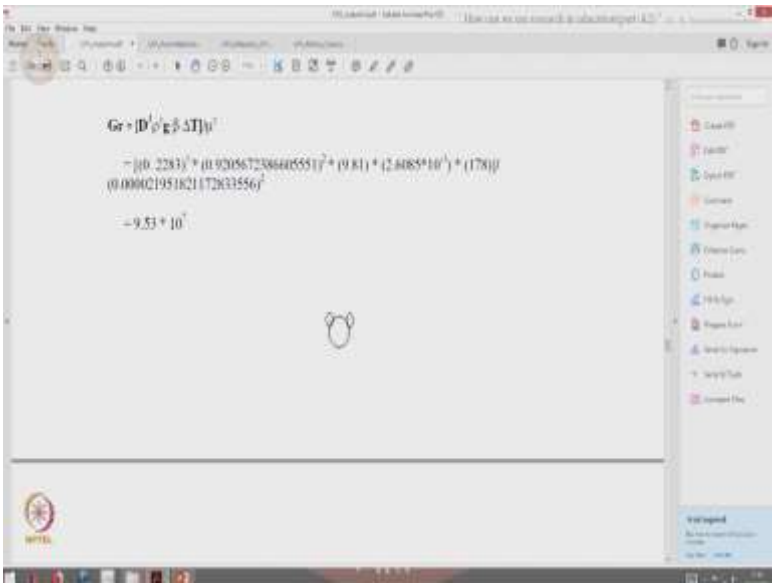

This is a course on transport phenomena in biological systems.

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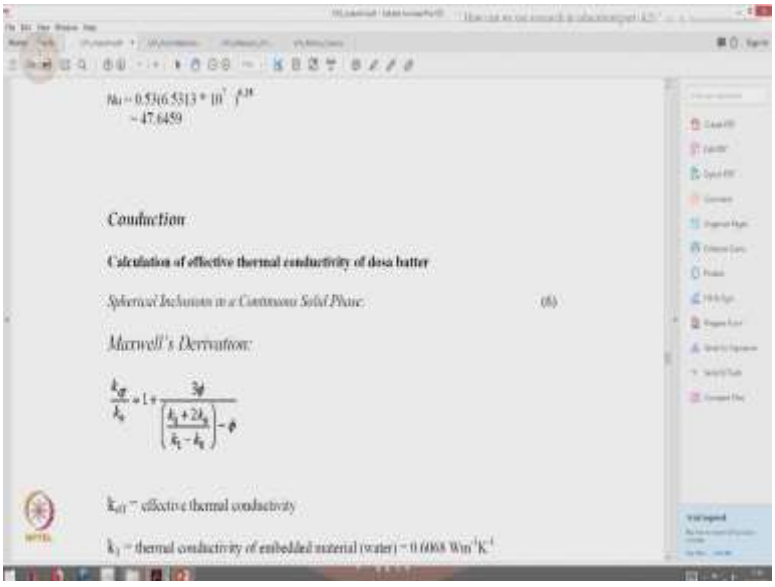

We cover little bit of this in class, but she has gone well beyond that, then calculation of effective thermal conductivity of dosa batter.

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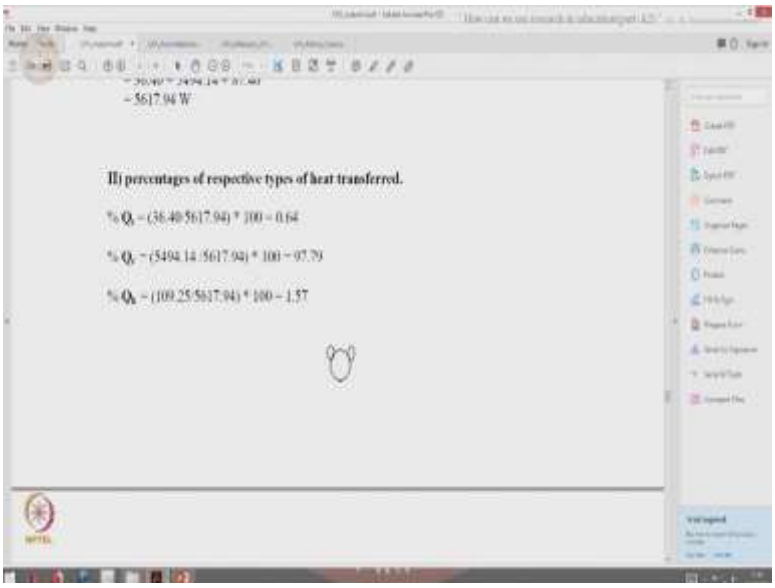

Percentages of respective types of heat transferred, calculation of theoretical time, various calculations here, error estimation, assumptions right.

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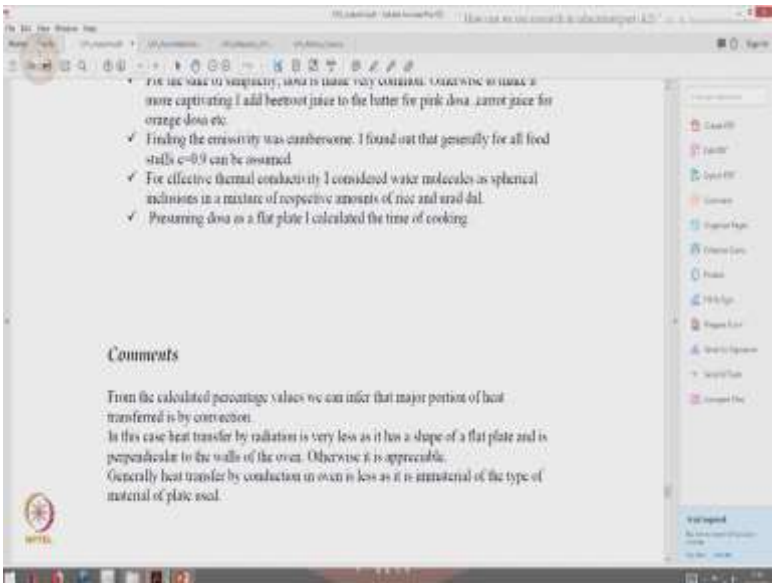

And from the comments, from the calculated percentage values, we can infer that the major portion of the heat transferred is by convection and so on right. So, you could see the excitement, the level of motivation and so on so forth that has come across and the learning that has happened because of this, this is probably the best way to learn a

subject and they would never forget any of this, the some of that data I will present a little later.

I like to present a few more very interesting CFA exercises, this is to give you a different flavour.

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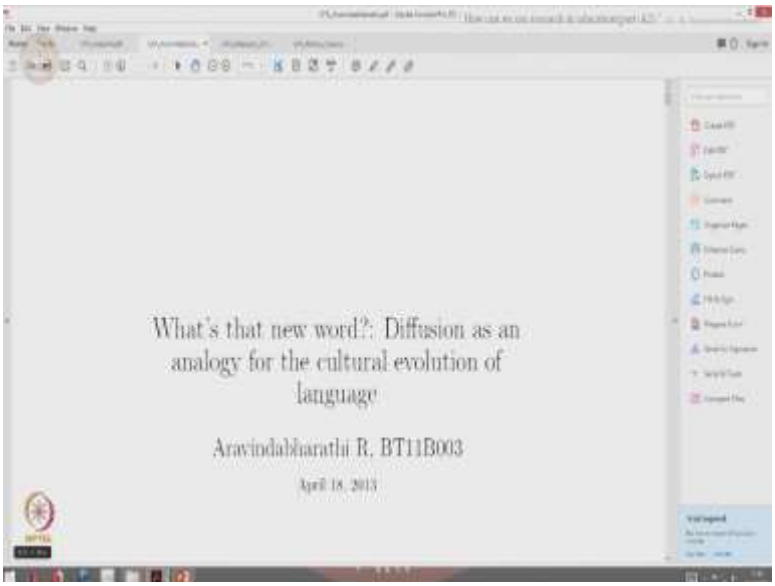

The title is what is that new word? Diffusion, which is a standard principle as an analogy for the cultural evolution of a language, this was done by Aravindabharathi in 2013, he submitted it.

Model for diffusion, applying diffusion to words, diffusion of code words, diffusion of a technical term, competing diffusion processes - a qualitative analysis, further refinement.

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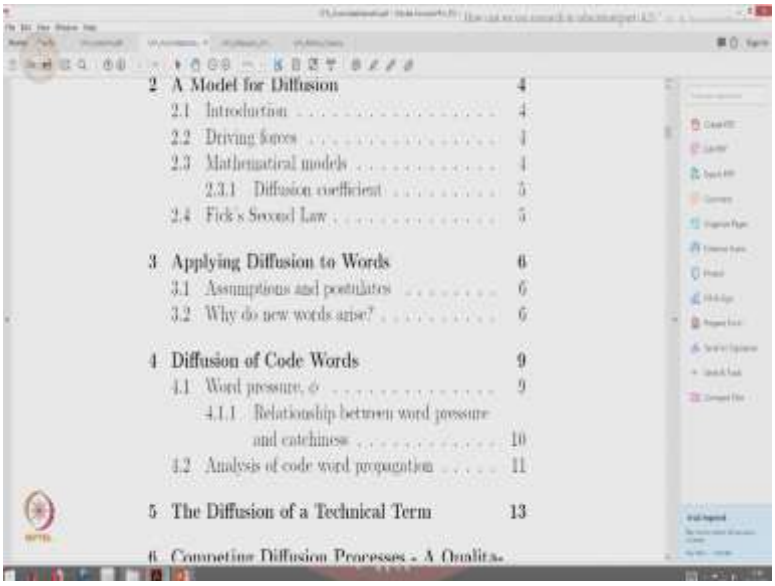

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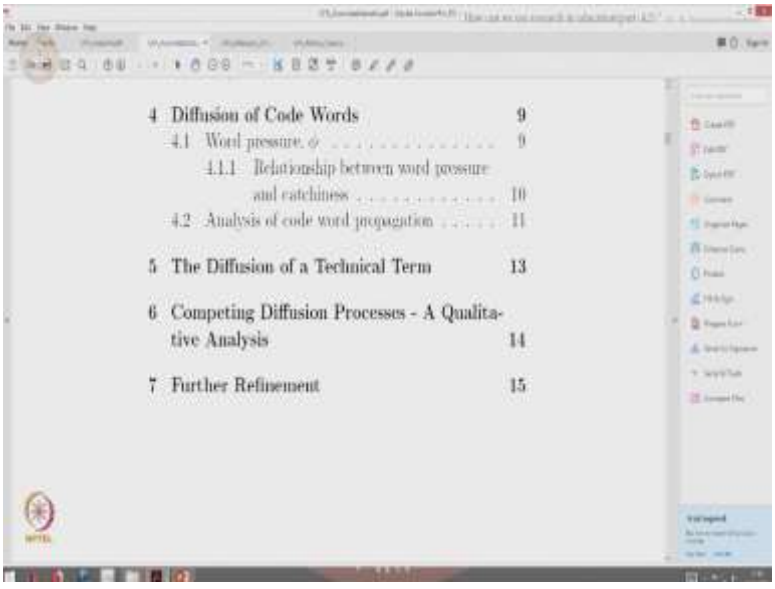

Highly research kind of work here. Language has been called, everything from the basis of human culture and so on then here.

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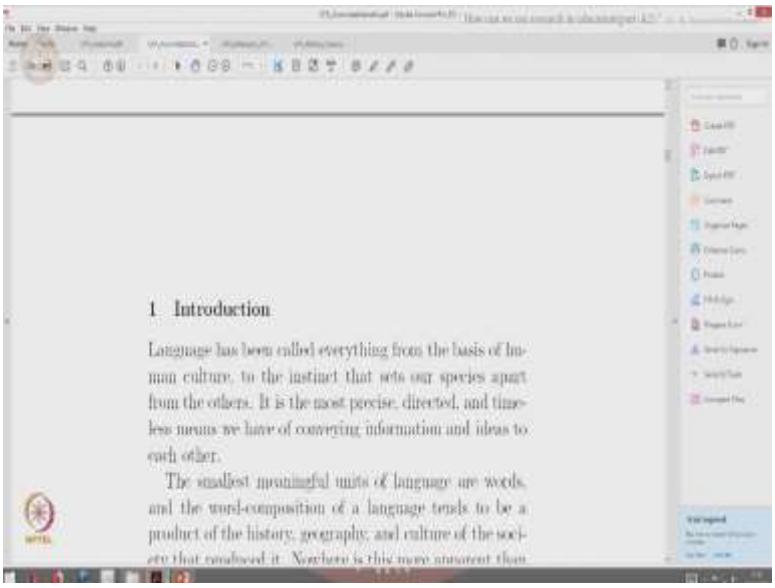

Somewhere here, new where is it yeah, new words after they are introduced in a language take some time to spread before they become part of a standard vocabulary.

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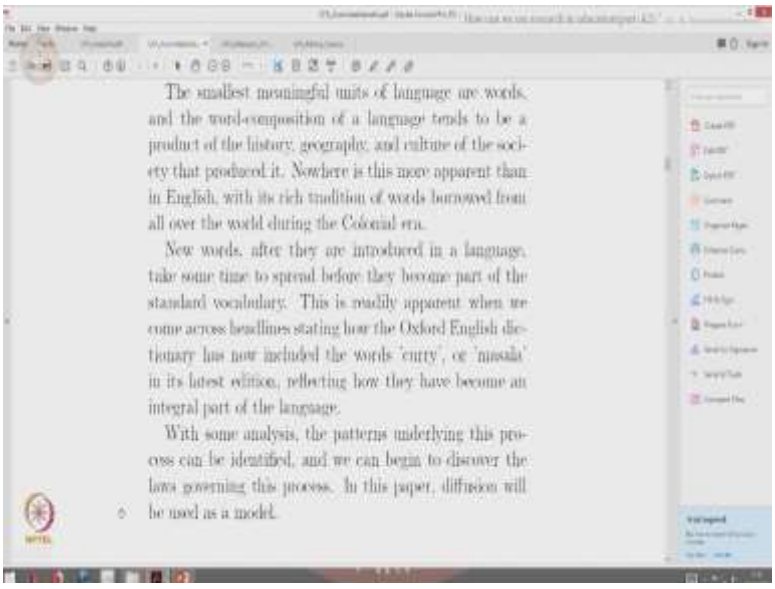

This is readily apparent when we come across headlines reading how oxford English dictionary has now included words curry or masala and so on so forth. With some analysis, I'm somewhere here, patterns underlying the process can be identified and we begin to discover the laws governing these processes, this process. In this paper,

diffusion will be used as the model right. He is using the principle of diffusion to study the propagation of new words, completely creative application of a principle right.

And very good work and there are possibilities of taking this further which the student did for a little bit and I don't know what happened after that, I have not heard after that. But you look at the possibilities in the quality of work that comes out of this and the potential for applications to various things. Let me show you another one here.

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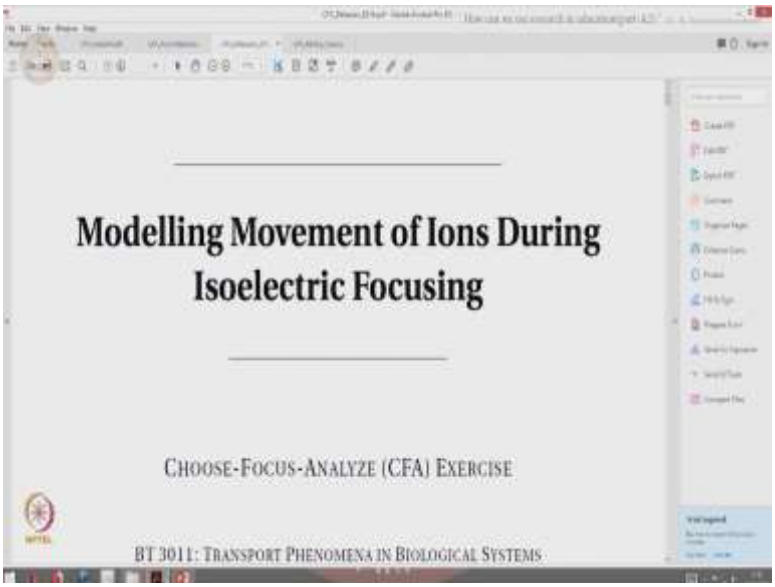

This is a highly rigorous piece of work, modelling movement of ions during isoelectric focusing based on the principles that were learnt in class by Debayan Chaudhury and this is done last year.

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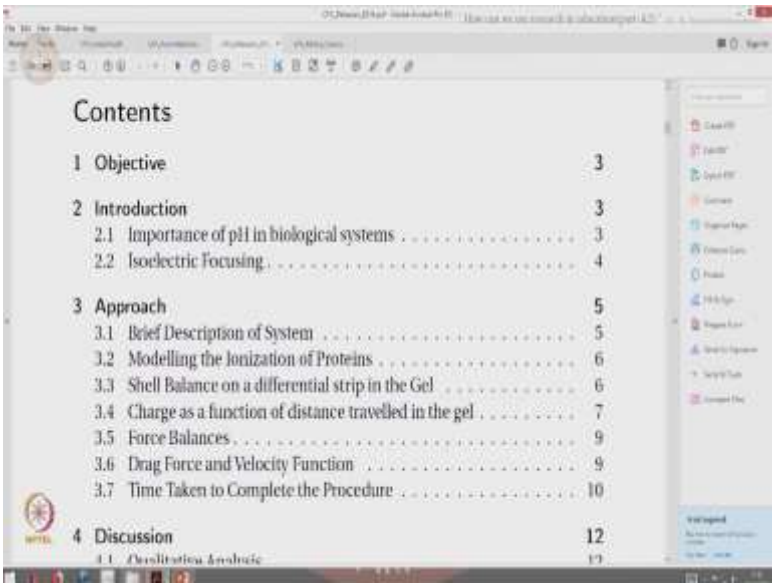

Standard thing, introduction, approach and discussion, limitations and further work and very very rigorous.

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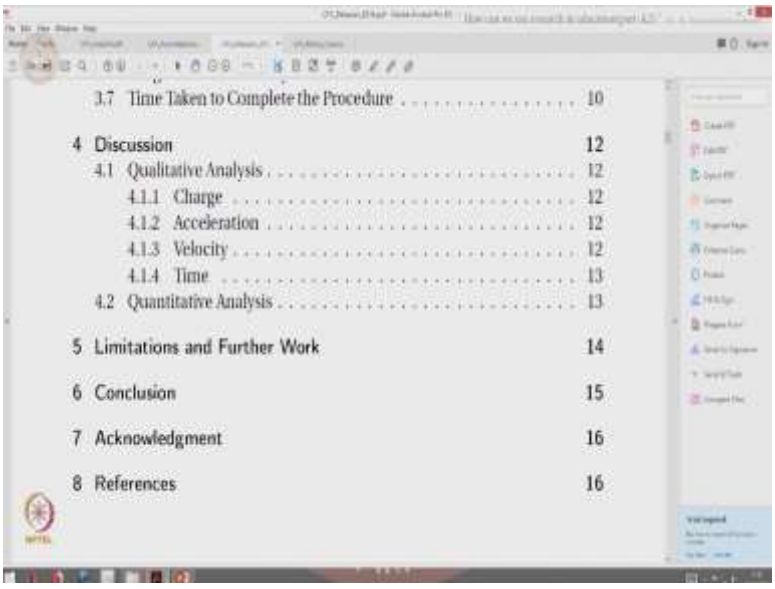

The importance of pH in biological systems, high level writing for an undergraduate student.

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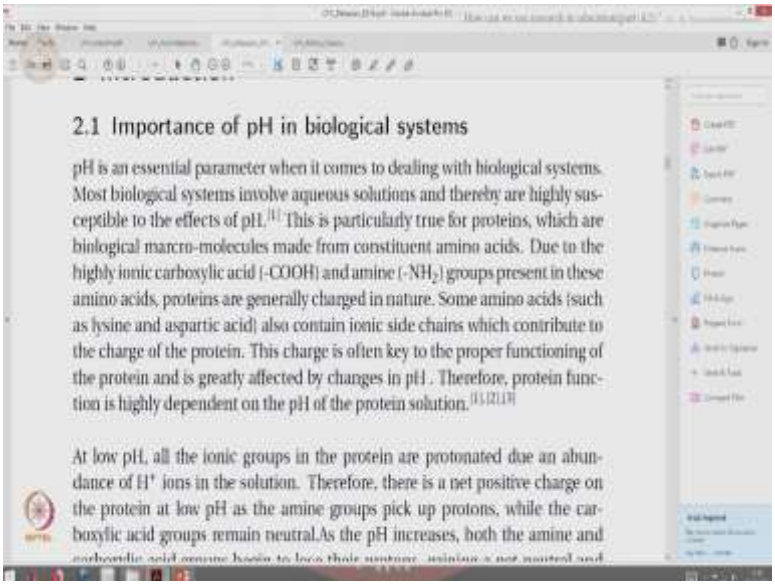

Isoelectric focusing.

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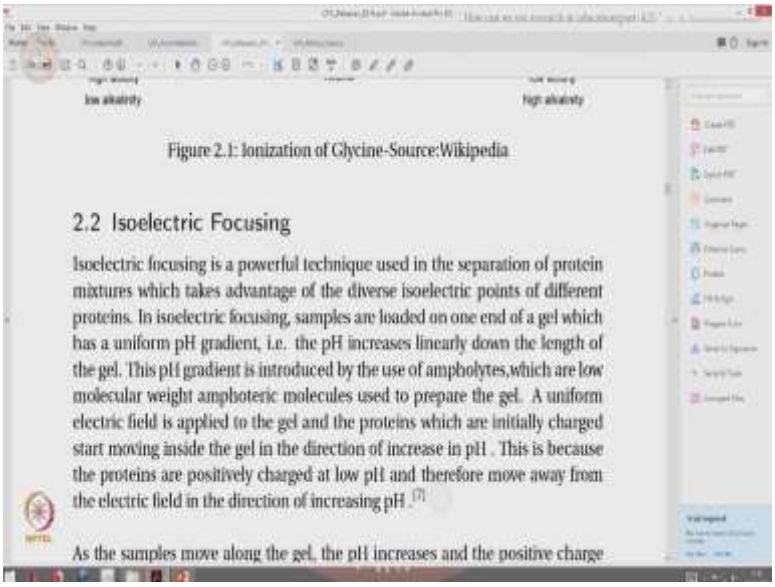

Brief description of the system.

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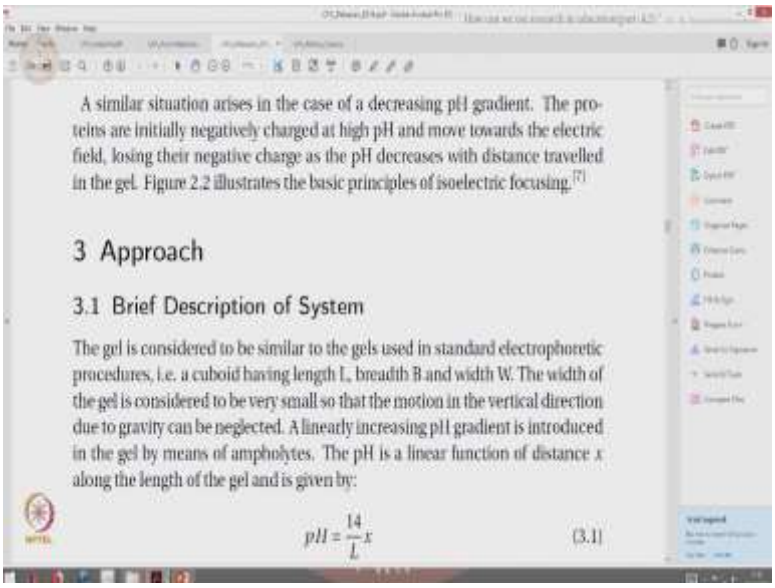

And then he goes on into modelling the entire process on his own right and come up with very relevant expressions which are useful for the design, analysis design and operation of isoelectric focusing.

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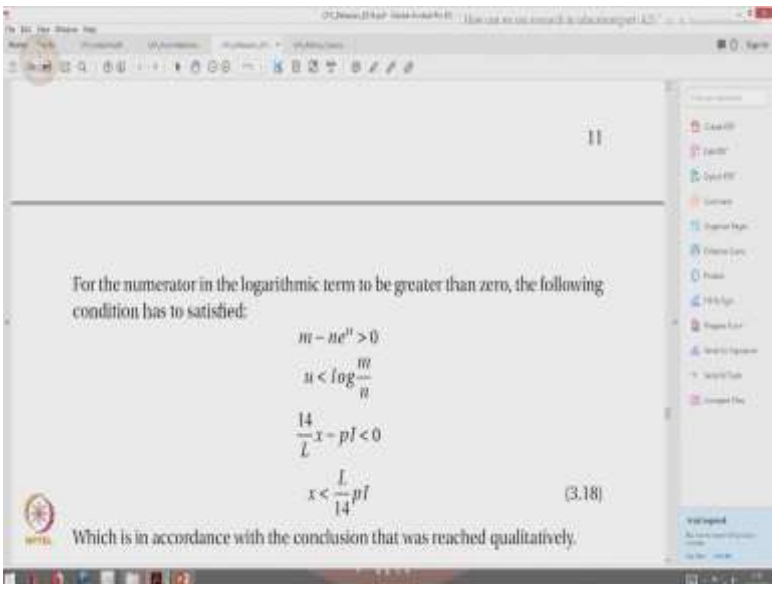

So, and then discussions here, quantitative analysis where he is drawn the various variations and so on right, this is the charge on sample, what is the distance travelled on the gel, there is a variations something like this, all these graphs were generated as a part of this exercise.

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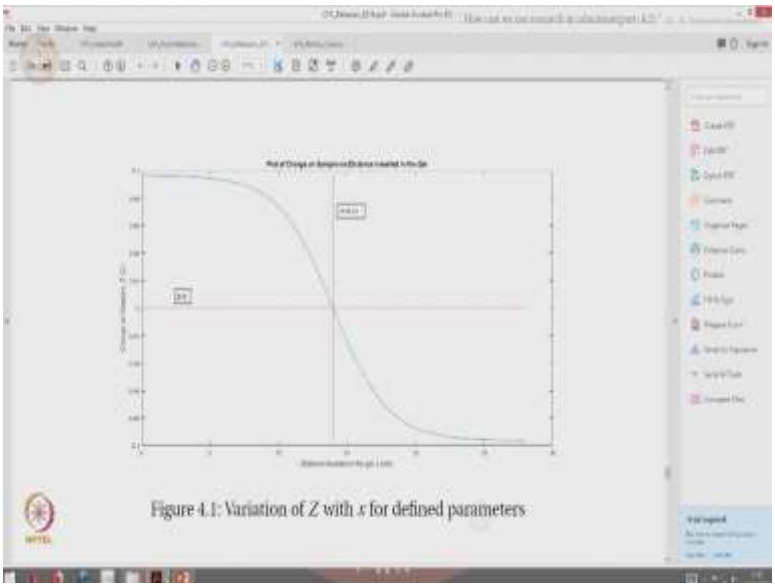

Limitations and further work right and so on.

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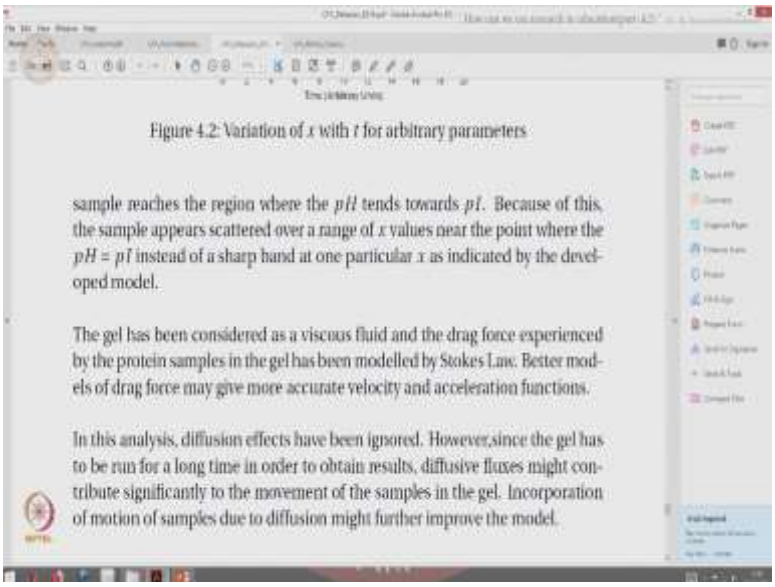

Let me tell you one last example, this is by Ramya Vijayram, modelling the flow of blood through an aneurysm.

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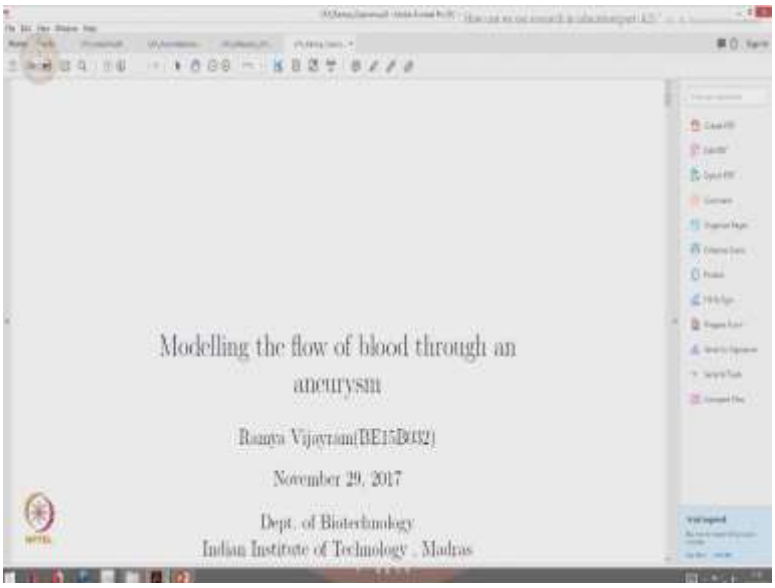

She has done a beautiful piece of work with very simple principles, or application of simple principles. She had done a lot of work with trying to represent it more formally using 3 dimensional coordinates and so on so forth and very rigorous set of approach. Then it just became a little too much for her analysis and then she switched to a more simple approach and came up with something very very useful.

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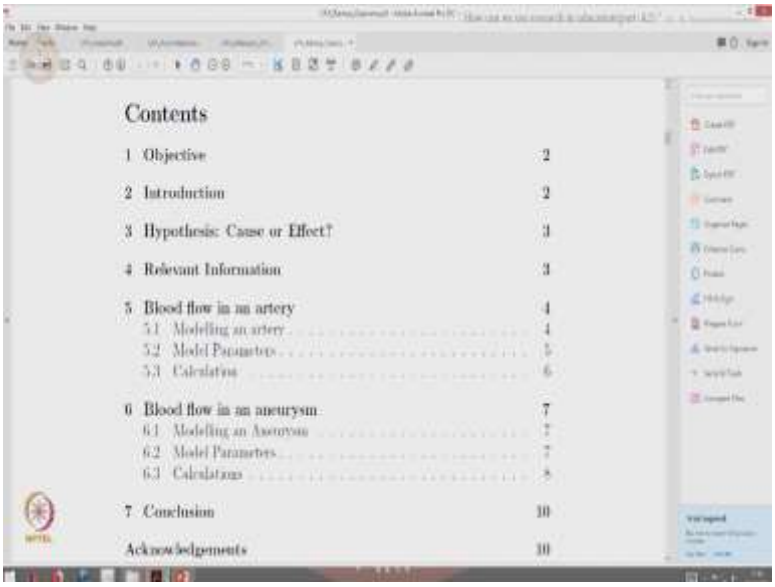

Here, this is aneurysm you know what aneurysm is, swelling in the artery which if it breaks it can lead to death, especially in the brain, its brain aneurysm. So, she is looking

at hypotheses, is it a cause or an effect of something, relevant information, blood flow in an artery, blood flow and in an aneurysm and she actually calculates the pressure in the aneurysm using simple Bernoulli equation here, aneurysm, hypothesis cause or effect, and then she modelled it using the Bernoulli equation, she goes to calculate, that is the engineering Bernoulli equation there.

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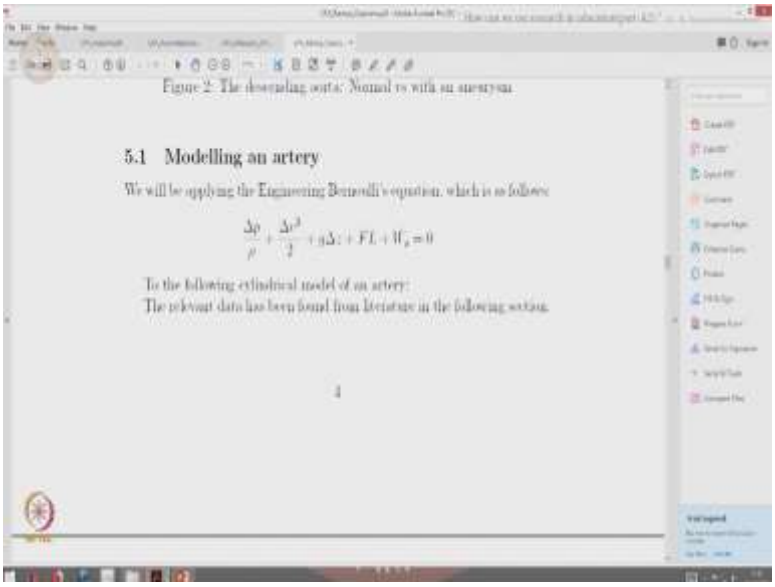

And then she goes to pick up the various values from the literature and then she comes up with the variation in pressure, in delta p with the diameter of the aneurysm.

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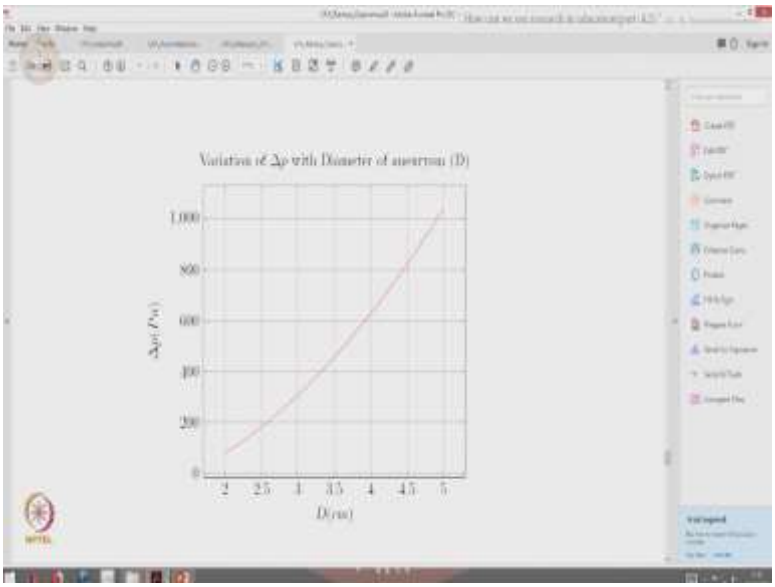

So, as the diameter increases, the pressure increases is what she is shown here. Of course all these have limitations and so on so forth.

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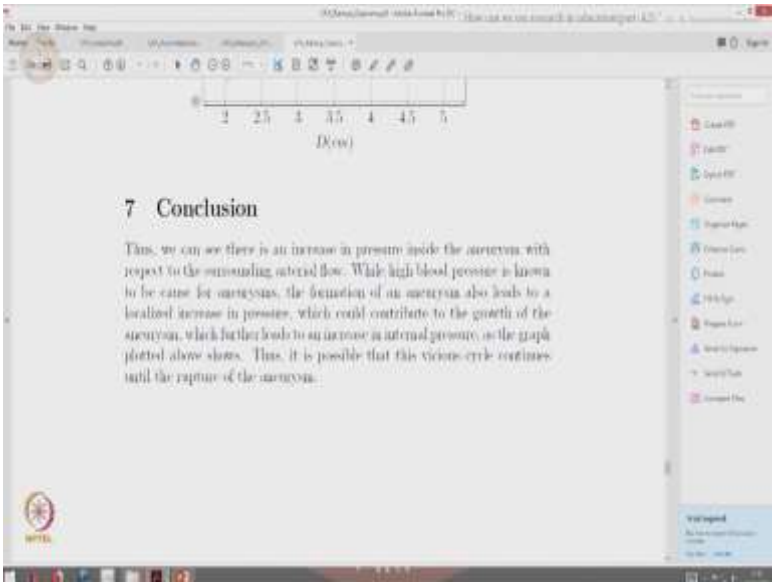

So, this is just to give you a flavour of the kind of work that can come up, the level of excitement that the students can reach, the level of contributions that they can make just by giving them an open ended exercise and following it up with appropriate evaluation and so on so forth. And this of course, carries a good percentage toward the, good weight toward the final grade and that also is a good motivator for students.

So, we have already looked at some examples of good CFA exercises and the impact, the long term impact is something like this. Students remember this exercise for a very long time and the longest I have a known so far is even after 18 years, you know one of my students from IIT, Bombay, Narendra Dixit, he is now professor Narendra Dixit in IISc he came visiting to IIT, Madras. Now, I am at IIT Madras, he came visiting to IIT madras, as part of some doctoral committee. Then he saw me and said hello sir and so on, very nice to meet you, pleasure on both sides to meet each other and then first thing he said was I remember your CFA exercise right. So, that is the power of this exercise. Narendra Dixit was in the very first batch of students that I gave this exercise to, way back in 1996 in a thermodynamics course, engineering thermodynamics course in IIT, Bombay. He had done very well in that exercise, he had taken it further presented it to in various student conferences, won awards and so on so forth.

He had done an excellent piece of job in finding out the thermodynamic efficiency of the breathing process, the lung and things like that. He had modelled the lung as piston and cylinder system and then he calculated various different thermodynamic parameters out of that, I still remember it very well. I have his hand written report, it is I treasure it very highly.

There have been 43 unsolicited recalls so far you know I carry a paper in my purse, if I can show you that. Let me see whether I can pick that up right now, somewhere here, this is the piece of paper that I carry and then whenever I, somebody, some of my old students that I meet recalls this exercise without me telling them, then I make a mark here if you can see the marks right now, it is at 43. So, this is probably the best input that one can have, may not be a formal input as I will describe later, that was a touch and go for the publication part of it. But it is I think is very is real input, I am not in a reminding them of anything they are recalling on their own and that is the best possible input. And of course, I check whether we had talked about it if it is a repeat kind of a thing, I do not make a mark there right.

And even the current students talk to other faculty members saying oh that exercise was very good in G K Sir's class and we should have the same exercise in other courses and so on so forth. They do not come and tell me that, but my other colleagues tell me this. So, this is the way the course is received.

We have been at this for quite a while now. So, let us break here, come back next to the same part of the chapter, let us say a part of the chapter where we will move slowly to the left students and look at them.

See you then.