Product Engineering and Design Thinking
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Module - 03
Design Thinking and Concept Development
Lecture - 11
Design Thinking and Product Conceptualization and Development

Welcome back. But this time to a new module, module 3 which is Design Thinking and Concept Development. The lecture 11 which is Design Thinking and Product Conceptualization and Development, we will be discussing this because conceptualization is one of the most important factor or activity in product development and product design.

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I first would go to the concepts covered. First, we will talk about the design thinking and engineering design and development which is a perspective of innovation. And then what we will do very uniquely here which is rather to be understood rather thoroughly is the intertwining of design thinking and engineering design process.

Because engineering design process which is the you know way the engineering goods products and other goods at products using engineering technology and methodology are developed. But how design thinking supports it or in other words how with the help of design thinking it is becoming more efficacious that we will understand from this discussion.

Particularly in the front end phase where the conceptualization as I was just mentioning is a very vital component and this engineering design model there are several models. But we have chosen a model that was that has been developed by NASA, which is for the learning of students.

So, that is one model which I felt to be universal and quite useful. So, these are the two aspects why NASA's model has been chosen. I mean this is similar many other models are similar to this little bit here or there, but this is one model which has been chosen. And finally, we will discuss on the DT's by Design Thinking paradigms influence on conceptualization, design conceptualization.

And so with this brief introduction to the concepts covered I move on to these details that it is a it is a kind of tagging with some of the old discussions that I had earlier with you, but then that is necessary to make initiation into this session.

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Design thinking is an innovation process as just I have mentioned. And which of course, the first thing that starts with empathy and followed by other important activities like say ideation and then implementation which are the various steps or phases. And it is actually a means to direct and focus design and development that will effectively be resulting into commercialization.

That is to make a product which is marketable, which is sellable. In the context of product development developing insights based on the empathizing step that we had discussed is very important. Because inside development is one very effective step and necessary step because

if the thing if no if information etcetera are just collected, but from that if the correct info inside is not developed then actually it is not very useful.

Similarly, the user experience study ideating for problem solving in design engineering, building prototypes that is also MVP that is minimum viable product which is the testing product model which is not a full scale product, but it bears certain features, it account certain features which are primarily to be tested. And that is the minimum that is the minimum requirement that customer would need. So, the core features you may call. So, that minimum viable product would have that.

So, when final product will come then there are other features and the you know other forms etcetera, the styling etcetera would be added, but for testing MVP these would give wonderful feedback. So, these are the things to be done to obtain a quick and correct and candid feedback from the customer.

So, that the process can go forward or the process can be about it if the result is hugely negative. Because that is where the important comes in because importance comes in because see if something is worthy then the feedback will indicate it will indicate otherwise also. So, when we hear that fail fast means what? Failing is not the objective, but if it has to ultimately not be successful then early indication should be there that it is no point in proceeding with that.

So, anyhow we will take on the positive side. So, we would say that ok, if it is to be corrected whatever the modifications are necessary those will be done, but it is in the course of discussion these are the aspect to be mentioned. We cannot bypass this because that is an eventuality and very hard eventuality hard occurrence because one in ten products succeed.

It can be perceived that design thinking though it is connected overall with the product development, but its influence on the front end is high that is the product concept level predevelopment level when the resources are commuted fully before that it is very very useful. So, it is recommended that it should be adopted and practiced.

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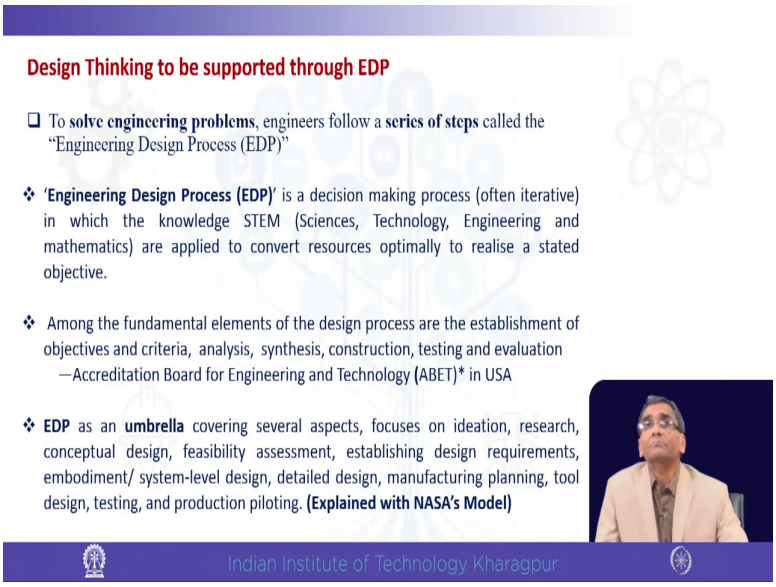

Before I proceed further I would like to tell you because we will have to now connect design thinking with engineering design process. Now, a brief of engineering design process would be necessary then I will explain the steps with the NASA's model. But here if we say it is a series of steps the steps are at the bottom I will tell you called engineering design process that solves an engineering problem or EDP in short Engineering Design Process.

Basically it draws its knowledge from all kinds of STEM disciplines science technology engineering as well as mathematics primarily and also from other areas like say a certain social science area also it draws. But primarily STEM areas are the most predominant here. This I would say among the fundamental elements of the design process are the establishment of objectives and criteria analysis, synthesis, construction, testing and evaluation.

These are the steps which I have picked up from the ABET. ABET is the regulatory body of engineering education in the United States of America USA which has defined it is in this way and it is by and large accepted and are also followed in other places. So, this is one thing because it is targeted for students and students might move internationally, now the world is global. So, it is good to have a definition which fits more or less which is common to me.

Now, EDP as an umbrella term covers several aspects, it focuses on ideation, two research, conceptual design, feasibility assessment, establishing design requirements, embodiment or system level design sometimes is also called preliminary design. And then establishing design requirements, detailed design which means that when one is we discussed about the product breakdown structure, functional breakdown structure and all. So, from that the details will come.

So, that then manufacturing, planning and natural with manufacturing, planning the tool design, tool development and production piloting that is the initial scale production. So, all these will come under the EDP. Because once the first pilot run happens then the teething problems will be will come to the surface and they will have to be rectified. So, this is the scope of EDP.

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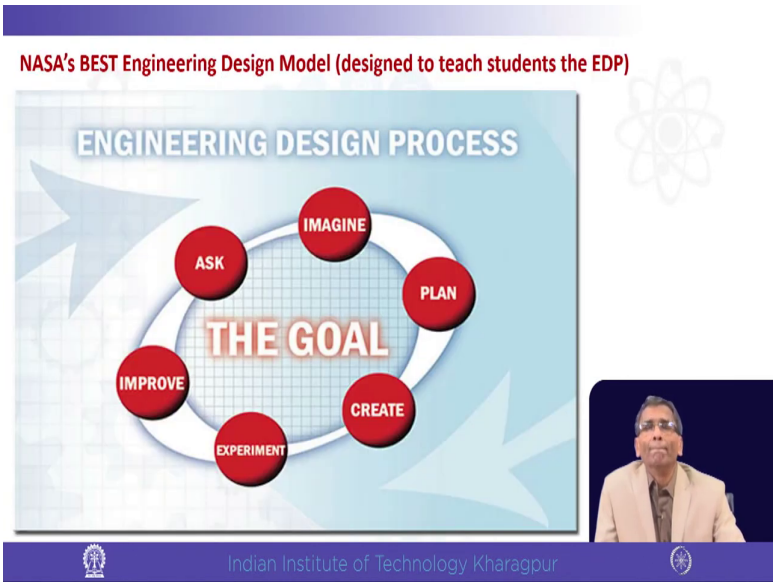

Now, as I was just telling that this EDP, Engineering Design Process that is we are discussing using a model the best engineering design model, designed to teach students the EDP. So, you can see it is see it is a six step process. It starts with ask, followed by imagine plan, create, experiment and improve. Now, what these are? We would go to the next slide to see each one of them what they are.

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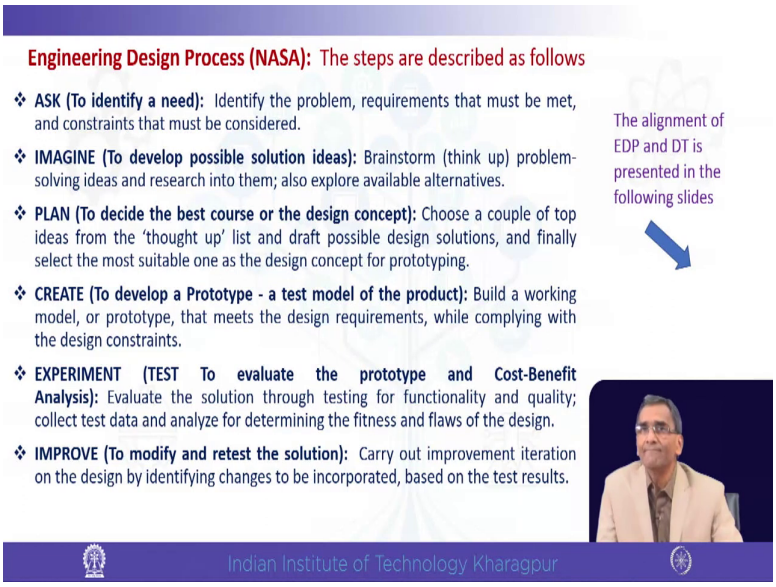

And first we will understand this then after understanding we will see how each one of them is aligned with design thinking. Because these understanding I would say is more required and which is not enough as of now. So, what is ask? Ask is to identify a need. Asking, what is the need? That is asking ask. According to that nomenclature of terminology used by NASA.

So, to explain to identify the need, identify the problem that is the problem is the need the challenge, requirements that must be met and with the constraints requirement must be met; that means, at particular cost within particular range of weight or volume or whatever this specification. So, ask means that it is not just ask with unlimited resource or without boundary.

So, ask means that defining thing. So, define explore and define is actually ask. We will see then imagine. Imagine is to develop possible solution ideas, problem solving ideas. That once we have defined a problem that ok, this is the exact problem then how it can be solved.

So, naturally we had discussed earlier also that so many ideas are to be generated. So, see here it is the engineering design process I am not discussing and we will see the similarity or the matching or alignment with the design thinking process. Particularly, up to the concept level where it is extremely important. Then plan to decide on the best course of action or choose or select the design concept, here when it is a plan means actually we are focusing on what we are going to do.

And when we are saying what we are going to do; that means, out of several ideas we are screening out the best ones and finally, the absolutely the best to take it forward because the resources are obviously, to be committed for not many for the best. So, concept level is very important and that is what is planning this which will be taken forward to the next step that is prototyping.

So, after this plan is the concept finalization. Then actually the prototype is built which is the create step the build, create to develop a prototype which is a test model of the product. Build a working model of a prototype; that means, meets the design requirements.

Of course while as I said meeting with the constraints, different types of design constraints. Like for a laptop it may be the weight for a briefcase it may be the size. Say there are bags which are to fit in the cabins in the aircraft. So, it has to be designed within certain specification of length, width, height etcetera. And obviously, also weight because the bag weight also would matter as the total weight limitation is there.

Then is the test or experiment, experiment and test to evaluate the prototype and to do the cost benefit analysis. So, that is the test with the customer and from that we get the feedback. And improve that is the last test is the modify through certain number of iterations to refine which is finally, would be a sellable product. Because till the product is improved to a point

where the customer is not comfortable using it fully it does not become a sellable item. And so improve is an important thing.

And now after understanding the steps of engineering design process we will quickly go to the various slides and we will not spend much time now, because we have understood these two points very thoroughly. What we will do is we will show the slides and we will see how the alignments are and obviously, all the points that I have discussed mostly you will find those in the slides.

But I have prepared the slides. So, that you can later also if you want to see you can look at them and understand if necessary the or clarify some of the points if necessary.

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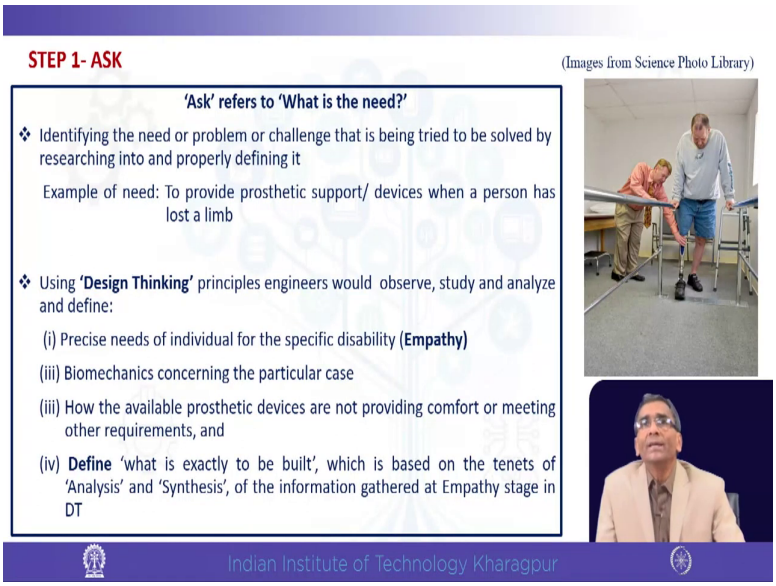

So, here ask that is what is the need here we have said things. Now, it is an example we can provide that to provide a prosthetic support or device to a person who has lost a limb. Now, if someone has lost a limb. So, that person will have certain height body structure and all. So, the particular prosthetic item should fit his requirement his body structure and everything. So, its biomechanics are also to be confirmed or you know to be considered.

So, with this kind of thing we assess the and this is what is known as empathy that how you see the users need from the users point of view. So, the users need is the empathy thing. So, the empathy part is being seen and finally, when we decide what exactly to be built that is the defining which size, what weight, what specification, what material are all so, that is the define.

So, this these two of design thinking you have already have had seen in previous discussions that the empathy and define it constitute ask and if we pictorially place the first two would be like this empathy and define, which also is the understanding the opportunity.

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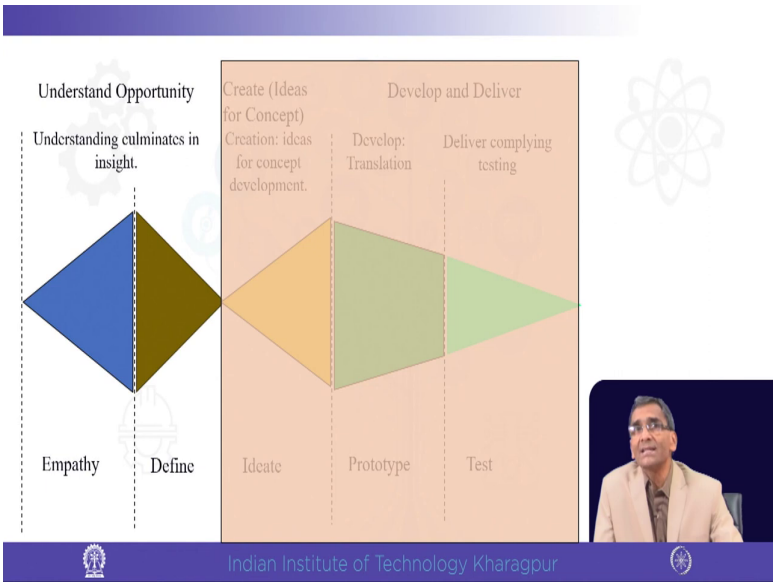

We talk about the opportunity and the opportunity is what exactly can be done or we can do. So, once we define what is the need only then we know what actually to be done. So, understanding culminates in the into the insight that we just had spoken a little while ago. So, this is just for the visualization already the discussion has taken place.

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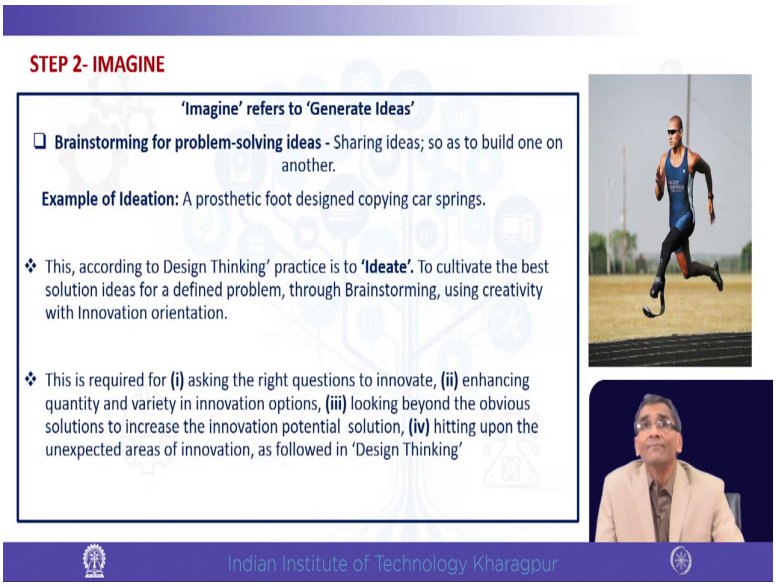

Similarly, I will quickly go through again that the next step is the imagine that refers to generate ideas. So, generate ideas like say one example is the prosthetic food design copying the car spring. There is this one example of ideas. So, here when we are saying idea generation it is the quantity level stage. So, some ideas may work some ideas will may not work, but at the idea generation stage nothing is the hold up.

So, all these ideas will have to be put forward and then at the concept selection stage, which will be refined from those ideas screened from those ideas based on the consideration of desirability, feasibility, viability etcetera. So, we will pass that filter and then we will go to the next step and that is the ideation process.

So, here this requires the asking the right question to innovate absolutely which goes with you know the design thinking aspects, enhancing quantity and variety of innovation options, looking beyond the obvious solutions to increase the innovation point potential solution.

Looking that means to be creative not very obvious this is not a very obvious way of putting a car spring, but I am just saying that even the wildest idea is also welcome at this idea generation stage. So, that is why deliberately this picture was selected to be put in.

Hitting upon the unexpected areas of innovation, as followed in ‘Design Thinking. So, that is the purpose we normally if we do not try to develop the insight or explore or investigate into the details sometimes we miss the opportunity or potential to do something very innovative. So, design thinking provides that opportunity which is a part of that say engineering design process.

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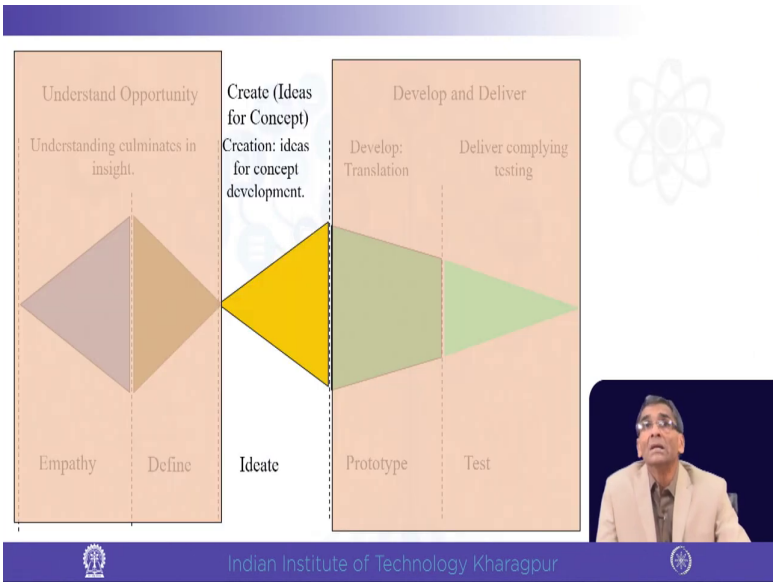

Now, it just is a visualization again just masking the other two aspects only this central part that we have discussed which is the ideate that is ideas for concept. Ideas finally, is not the outcome. Outcome is the concept which is refined or screened once from the so many generated ideas.

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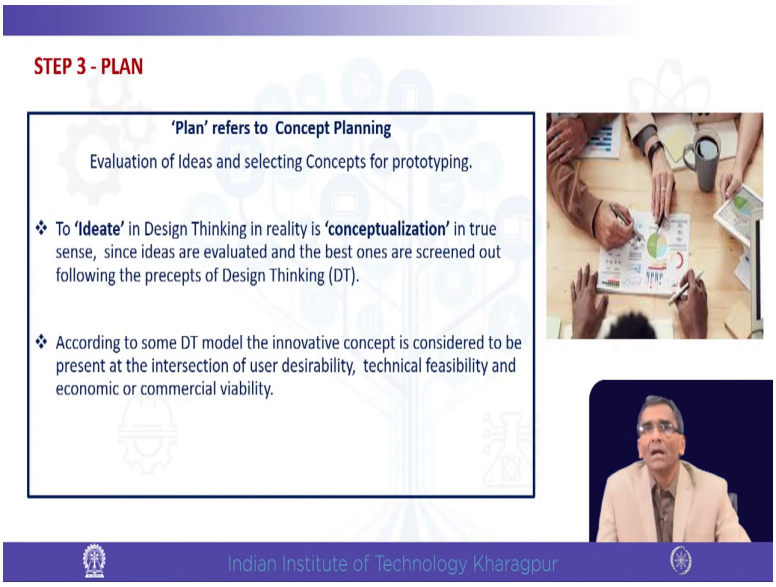

Then plan the next step if you recall that plan is the in the engineering design process is refers to concept planning or to ideate is the design thinking term which means that in reality this ideate is conceptualization. That as the idea by itself is not the end it has to be taken forward based on screening evaluation and screening selection that is which is the ultimate objective is conceptualization in true sense.

Since ideas are evaluated and the best ones are screened as I have just mentioned. According to some DT model the innovative concept is considered to be the to be present at the intersection of the three things I have mentioned just now, desirability, feasibility and viability.

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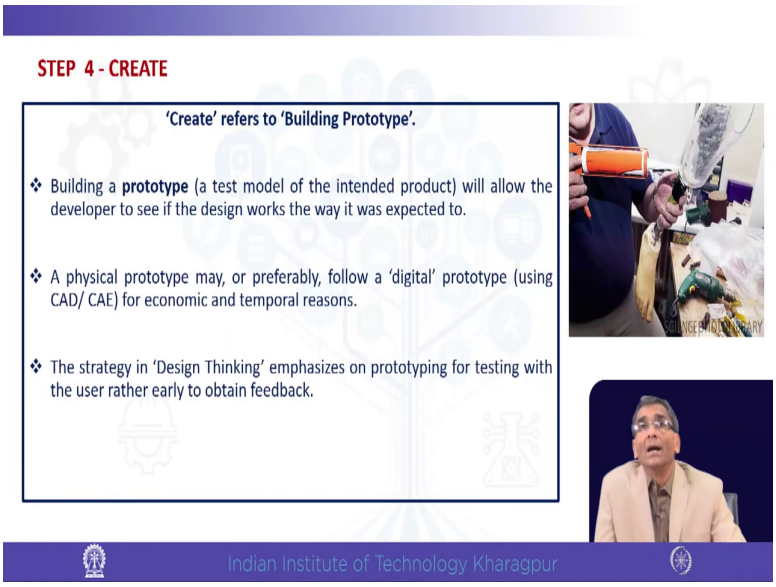

Create the next step refers to building prototype. Now, it is time that something actually is be created. Now, prior to this building prototype the resources practically was not committed much only marginal, it was a thought process, it was an exploration, it was an investigation, it was studied, it was research.

Some expenditure is there no doubt, but not like the one which starts from now from this phase where the material, the labor, the machinery everything will be now deployed. So, create refers to building prototype. Building prototype which is a test model as I said will allow the developer to see if the design works the way it was intended to.

Now, a physical prototype may preferably follow a digital prototype because see physical prototypes are expensive to make time consuming and difficult to alter. But before that it is

always advisable now because now these software are available that one should try first with a digital prototype.

If the digital prototype is successful then out of few digital prototype solutions the correct physical prototype can be made with better surety and reliability and with ease and with minimal expenditure and also very quickly in minimal time. So, that those are the benefits. So, now you have the you know digital for digital prototyping we have CAD; we have CAE that is Computer Aided Engineering which is the simulation.

You have heard many popular software about it already you have studied perhaps in the CAD CAM subject or CAD CAE subject that you have a heard say solid works it may be Pro E it maybe a Unigraphics or it may be ANSYS or Abacus or Adams and so and so forth which are the CAD CAE tools, which are very handy in this digital prototyping or in general for product engineering or engineering design process where the step is to build prototype which is absolutely very important step.

The strategy in design thinking emphasizes on prototyping for testing with the user rather early. So, that you know course correction can be done from early on and without major hiccups and without major investments it can be done. So, you see that alignment all through is going very nicely and smoothly.

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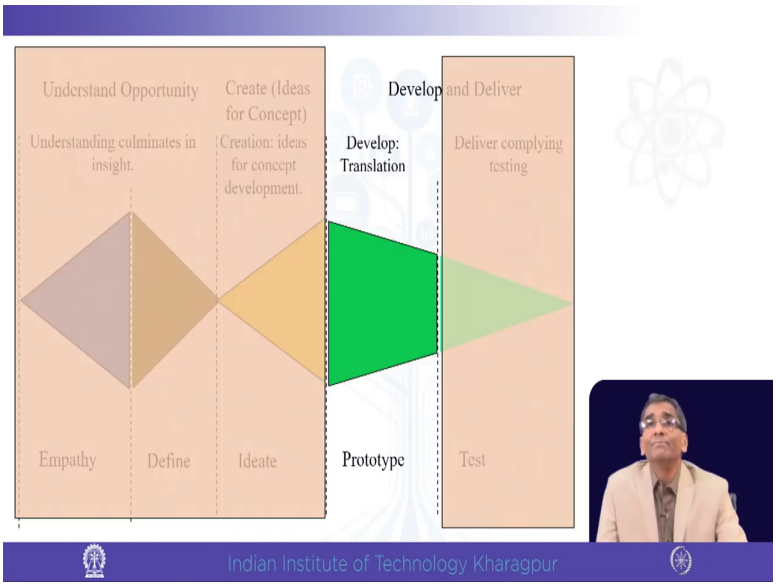

And if we show it visually it would it is this phase the prototype phase it appears to be like this slice.

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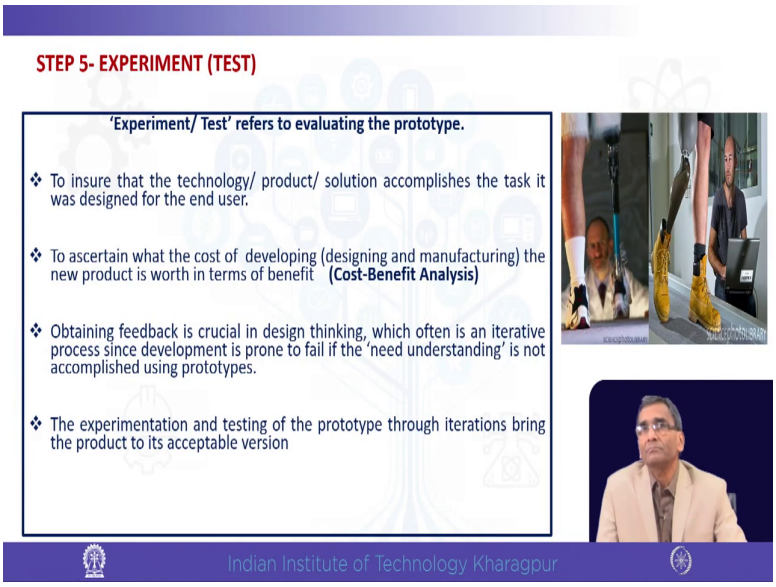

Similarly, the experiment or the test experiment at test experiment means a continuous experiment for testing that is experiment test refers to evaluating the prototype, how the prototype is functioning the test that is the experiment, to ensure that the technology or product or solution accomplishes the task it was designed for the end user.

To ascertain what the cost of development or design for manufacturing the aspect is to be ensured. The new product is worth in terms of benefit is what is to be seen also which is called cost benefit analysis. Because finally, if a product is developed at a cost and the utility the customer finds the net is not matching then it does not have that value.

So, the value is actually sensed from the cost benefit analysis, benefit on top cost at the bottom that is numerator is the benefit denominator is cost. So, from that the ratio determinants or tells us whether it will be valuable for the customer. And in the test

obviously, I do not have to overemphasize I have already said that the feedback is very important.

Because need understanding is the most important thing which can come only through the feedback and the experiment and testing is the way of the that prototype can be put through the improvements through several iterations to bring it up to the acceptable version. Till it is the acceptable version the experimentation actually cannot be seized or stopped.

I here I would like to mention for many companies due to time pressure or some that people feel that this step can be skipped and something can be launched in the market quickly and they shorten this step. And that is a big mistake because at this stage if a big mistake happens and a faulty products go out to the market then that to recover from the loss is immense.

It is not only the monetary loss it is a loss of goodwill and brand and reputation. So, experiment and test is wonderful I mean absolutely necessary and. So, visually it is this.

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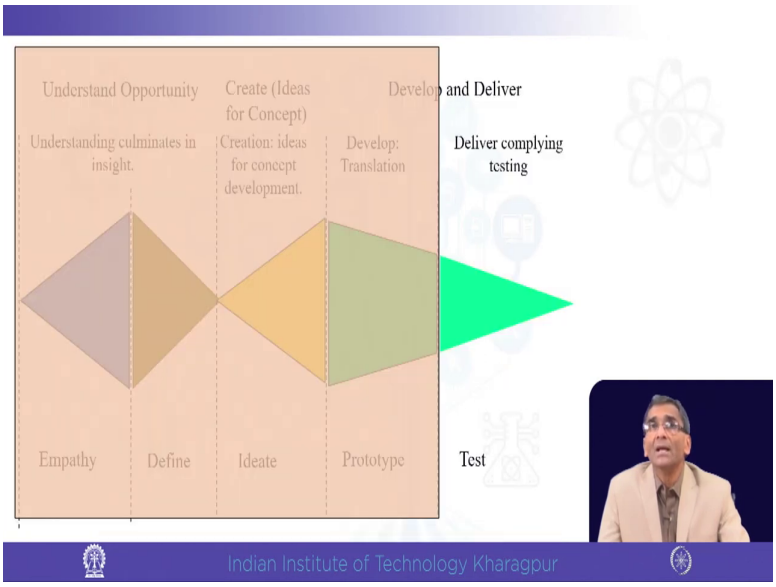

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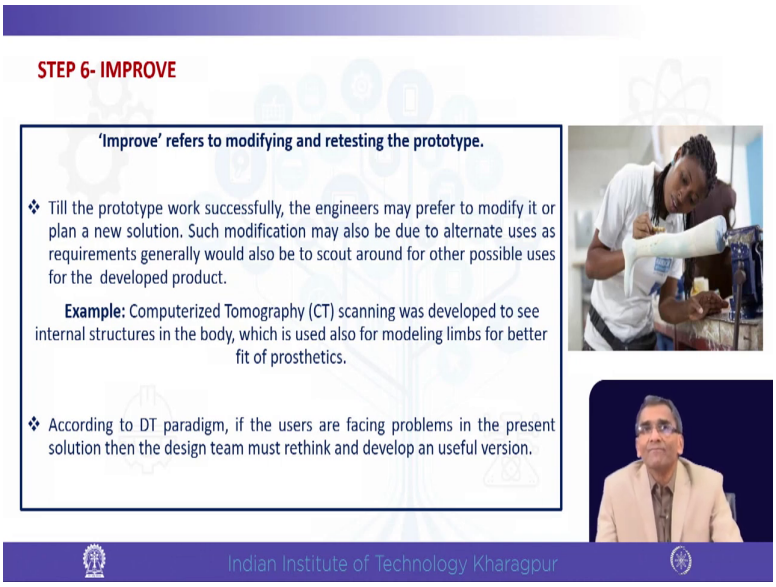

Now, if we see that the last step that we talked about the improve which I said that based on iterations we have already said that through iterations it has to improve. And also the improvement involves that it can be improved in a way that it can be used for other purposes also.

Say an example the Computerized Tomography a CT scanning which we commonly know was developed to see the internal structure of the body which is now used also for modeling the limbs for better fit of prosthetics that we just had seen in the previous examples. According to DT paradigm if the users are facing problems in the present solution then the design team must rethink, reconsider and develop an useful version that is the purpose of this improve.

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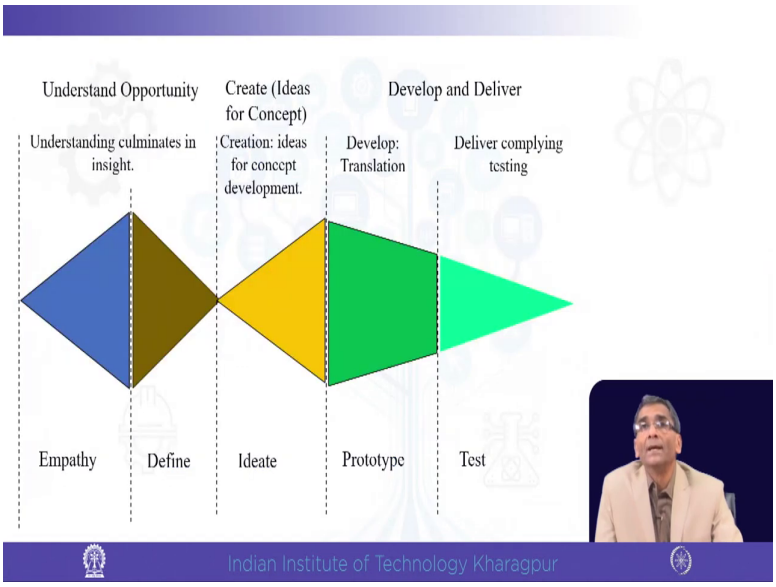

And now if we remove the mask the whole thing is actually a double diamond which we had discussed earlier with the five elements of design thinking. Now, you will see all comes here empathy, defined, idea, prototype and test and with these steps that we have just now discussed.

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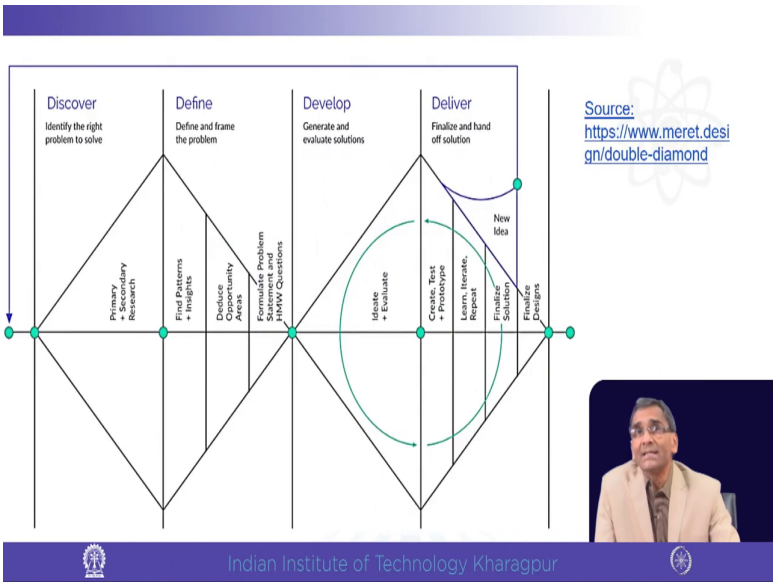

We are towards the end of this discussion. So, I would present one model which may be difficult for you to see, but it has to be brought in one slide for obvious reasons. So, what I have done I have given the source of this diagram and it is an acknowledgement thereby. So, if you want you can go to this slide and see for yourself what it contains is the diamond that we are talking about the discover, define, develop and deliver the four major stages.

And further if we look into we will see that the first phase which is first is the diverging and then it is converging again in the develop stage it is first you know diverging and then again it is converging. And if there is a new idea comes it goes from the development to a new idea at all if it goes which is a different kind of a s curve, but currently we would be talking about the double diamond. And then the in the first block you see the, which is the primary and secondary research to find out identify the need.

That is the that is the in the first part. Second part obviously; it is difficult it is difficult. So, I am reading it out so, that you can later on of course, you can go to the website and see for yourself. This I thought is important. So, I just would share is the find pattern and insights is the next phase including the converging phase, including deduce opportunity areas.

And finally, as we had said that the finally, define phase ends with the question of a problem statement, what is the final problem statement? And the problem statement if you recall we said the problem statement will be having a question format called How Might We, HMW which is written there maybe since it is very small you will not be able to read from here, but I am explaining that is why here and I am giving the you know link so that you can see and enlarge.

And then the next is again the ideate and evaluate. And where when ideate there are so many options being generated and then it is coverging by creating test prototype, learn and iterate; that means, we are narrowing it down as we go we are eliminating some, finalize the solution and thereby finalize the design. Now, the next slide exactly is this, but that part we will consider the phase output and phase activities which are product development activities.

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So, here I on the other hand try to retrace back how design thinking is actually getting aligned with the engineering design process. So, here the phase output is unstructured research findings and the phase activities are observed challenge and all that is what I we had discussed the stage wise it is already shown. So, you can see it later from the link.

The phase output in the define is problem statement and HMW questions which we just now have said. And phase activities would include make sense of findings, identify themes, define insights, frame opportunities, sort and condense. Like this the development phase also will have the phase output that is ideas and hypothetical answers which ultimately will be in the solution would be the solution.

And the phase activities of the development is generate ideas, explore solutions, evaluate solutions, experiment, draft, simulation etcetera. And the last the phase activities of the final

deliver stages create solution, prototype, test, gathering feedback, capture, learning's, define success.

So, these are the steps which you will see in detail later, but this is just to give you the glimpse for assignment part this will not be included much because this is primarily to build your insight these last two slides which is written in small fonts will be not part of your assignment, but definitely it is a very important learning, which you can take from this too. And I would request you to please see and I urge you to please see go to that website and see this.

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So, it can well be understood that design thinking has the intertwining with the product engineering and design development process, it is very evident now. It especially influenced

the front end I have already said. Retracing from the DT model which is just now I have seen, retracing from DT model we find that the alignment is true with the EDP.

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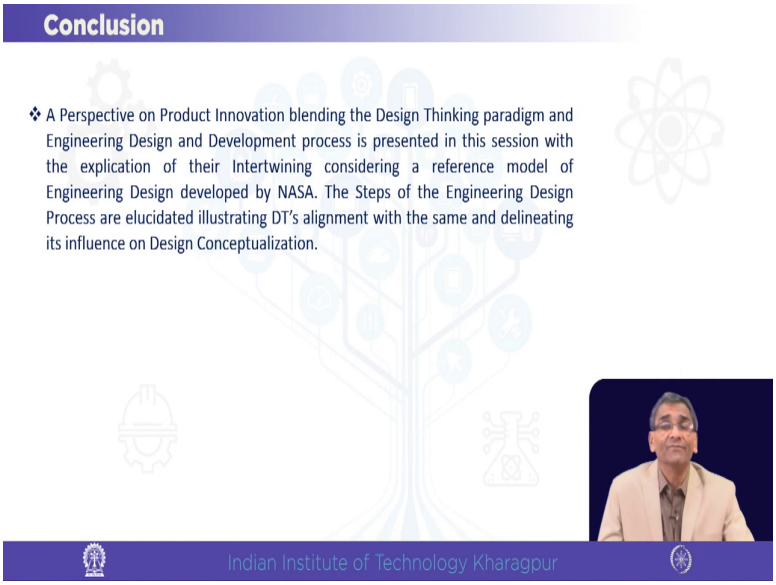

And so, we can conclude this session by saying a perspective on product innovation blending, the design thinking paradigm and engineering design and development process is presented in the session with the explication of their intertwining considering the reference model of engineering design developed by NASA we have studied that.

The steps of the engineering design process are elucidated illustrating the DT's alignment with the same and delineating particularly its influence on design conceptualization. That is the most important takeaway that we were emphasizing from the very beginning.

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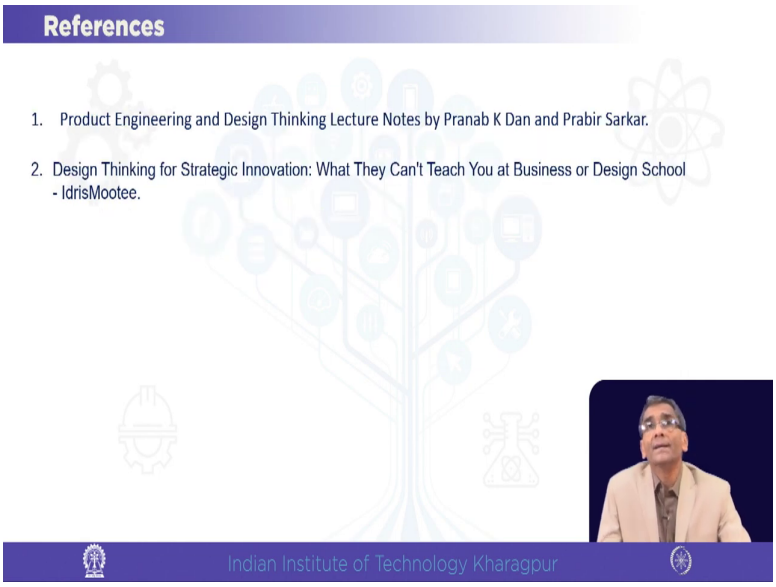

And this is the references for study which you can go through. And finally I thank you, thank you very much for your patient hearing and listening to the this course and I would like you to go through the material and understand it if there is any clarification required.

Thank you very much.