**Entrepreneurship**
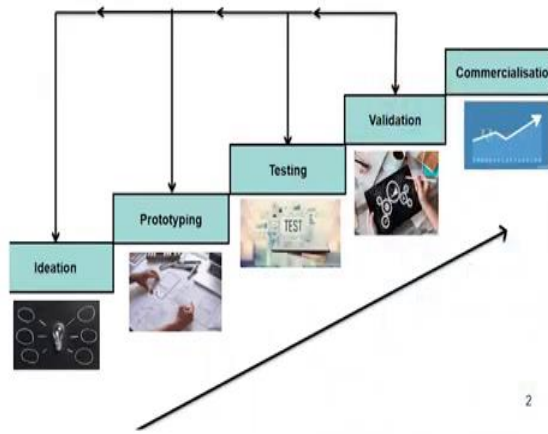**Professor C. Bhaktavatsala Rao, Ph.D.**
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**Testing and Validation Part 1**

Hi friends, welcome to the course on Entrepreneurship session. In this session, we will concentrate on testing, validation and commercialization of prototypes and products.

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Just to recap, we have considered 5 stages of product development for an entrepreneurial firm. We said that it starts with ideation which also includes the phase of empathy and design. The second stage is prototyping. Third is, third phase is testing. Fourth phase is validation and the fifth phase is commercialization.

In this session, we will talk about 3 things together, testing, validation and commercialization. Obviously, like every other step, each step is closely intertwined with the other step or even steps before that. The issue is that each step has to be performed seamlessly, iteratively and appropriately for the step we are considering to be very effective and efficient. So, let us consider the importance of testing and validation in entrepreneurial firm's journey.

What are we doing as an entrepreneurial firm? We are providing a value proposition to the customer, which is significantly different from what exists in the market. In general, whether it is an established firm or an entrepreneurial firm, every product has to demonstrate a value proposition to the customer.

But in the case of an entrepreneurial firm, the value proposition has to be significantly better, significantly more demonstrative because entrepreneurial firm or a start-up is trying to seek an emerging market. It is also trying to expand the available market and in most cases is also seeking to create its own market.

And what is this value proposition? Value proposition is a statement of gains and benefits from a product for the customer, both in the short term and also in the long term, what could be the types of gains one can expect from a product? The gains could be many, one could be the cost savings, second could be increased level of functionalities.

And third could be the revenue and profits that have accrued from the product, superior user experience that is achieved. And also, simply the better esteem that comes out of usage of a product. And most importantly, again, is the higher level of safety that could come from a new generation product.

But on the top of it, an entrepreneurial firm tries to solve certain top level or high level programs, high level issues that a customer faces. We considered, for example, the senior citizens and entrepreneurial products for them, they try to take care of the helplessness of the senior citizens, they act as memory aids, they act as the safety props, they act as reminders,

they act as caretakers. Therefore, there are certain high level problems which a product for senior citizens tends to solve.

So, like that, likewise, every product which is segmented to a different market has got certain specific features and specific top level problems, which it must try to squarely address. For example, when companies like Nestle, Maggie and host of others tried to do, ready to eat products, what did they try to do?

They tried to solve the problems faced by people where both husband and wife are working, and there are no elders in the family to take care of the day to day family needs. Therefore, they offered ready to eat foods, they solved therefore the top end problem faced by the busy working couple.

Similarly, delivery food tech firms like Zomato and Swiggy. What are they trying to solve? They are trying to provide for those people who do not have time to go out and dine, easy availability of different types of food. They are also trying to package different kinds of foods from different restaurants at one go to a family which may have different kinds of taste.

Obviously 6 members of a family cannot go to 6 different restaurants and have their taste buds satiated. But by ordering food online, you are able to inward or converge different types of food preparations into one home through this mechanism. Therefore, there is a significant value proposition for the customer.

Similarly, when vegetables are supplied, and when cut vegetables are supplied, you can say that there is a significantly higher value proposition which is there, when cut vegetables are provided.
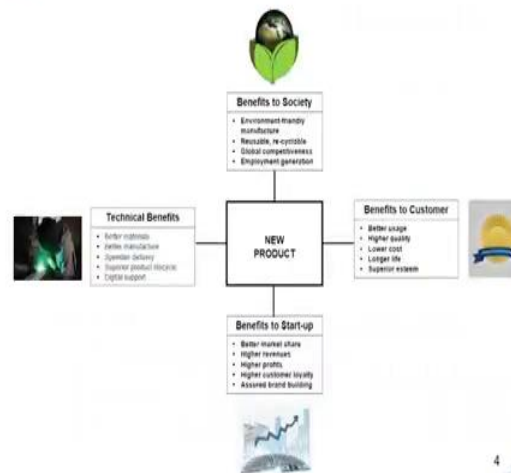
So, when we have a product which is supplied to the customer through an entrepreneur means, it has 4 types of broad benefits. The first benefit obviously is to the customer, he gets better usage, he gets higher quality, he gets it at a lower cost, he is assured of longer life and superior brand value or the esteem the value.

What does the product entail in terms of technology? All these things happened, there are better materials that are used, the manufacturing process itself is better. The product is delivered in an agile manner. There is a longer or superior product lifecycle. And there is also a digital support in today's digital world.

So, these kinds of technical benefits which are embedded in a product get translated into very significant customer benefits which we have considered. When that happens, the society also benefits because as technology improves, people tend to use recyclable materials. People tend to use reusable materials. They tend to improve the input-output ratio that is less materials for more output. There is also an effort to be globally competitive in whatever we develop and ultimately employment is generated when you have a number of startups.

So, when these things happen, a benefit to the customer due to the underlying or embedded technical benefits and that accrues to the society, the startup itself benefits. It is able to create a market or within the market is able to achieve higher market share, it is able to post better revenues, better profits, higher customer loyalty and brand building that happens

Therefore, a typical product envelope is just not meeting a particular functionality. It is more at creation of an ecosystem around a product in which the technology is superior. Therefore, it benefits the customer, it benefits the society and therefore the startup itself benefits.

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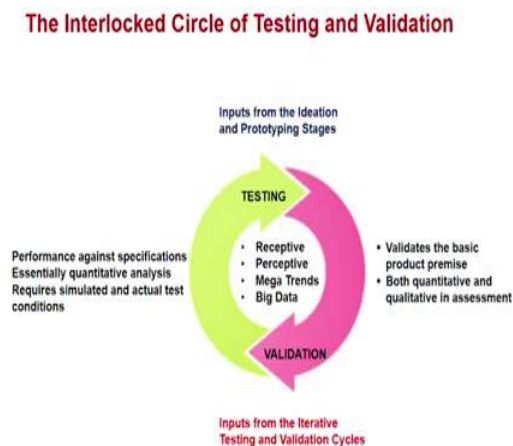


Now, this testing and validation is an interlocked system. What is the difference between testing and validation, we will shortly consider, but there are very significant inputs which come from the previous stages. There are inputs which come from the ideation and prototyping stages which go into the testing.

Then we have inputs from the testing and validation cycles which go into these specifications. How does testing happen? Actually, many people think that testing is a very routine activity, it is probably not as important as design or construction of the prototype itself.

But on the contrary, testing is the most important factor in the journey of a product from ideation stage to the commercialization stage because testing is the stage which ensures that the product is manufactured and put into place based on very stringent specifications that may have been drawn up.

It also is a way to record the design output of a particular product into measurable metrics against which the product can be tested and against which various other parameters like assurance to the customer, warranty statement, the service parameters, the entire life cycle costing or of the product can be developed.

Therefore, testing is an extremely important and it is not a routine matter as one could assume. And also, as we go through the whole manufacturing cycle, we should also understand that testing is not an end stage activity. It is actually embedded at each stage of design and manufacture. As you do these specifications. You are conscious of the materials you are using; you are conscious of the manufacturing process you are using and you know whether this product will gel the way it is being planned to.

Similarly, when you are doing the manufacturing, working process inventory is tested. The manufacturing process itself is subject to various tolerances and therefore, testing or the quality of the product is embedded into the manufacturing process. Regardless of all that, when the product comes out and is ready to be used into the market, we need to undergo a very formal process of testing and validation.
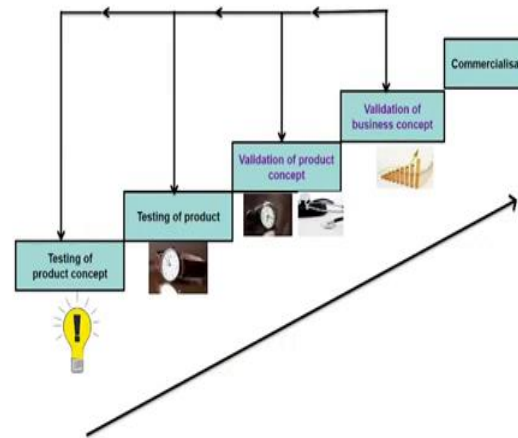
And that is very important because the basic product premise, why I am making this product? Suppose you make a clock which is visible all through the night, through very specific radiation approach, you got to really test it in dark nights, less dark nights, daylight situations and see whether this product proposition is validated, is tested first and if it is tested and proven to be correct, whether that whole idea of the product concept being luminous all through the night is validated that is also very important.

Testing is very quantitative, you got the set of specifications like the materials should be of this strength, the product should be of this dimensions, the weight should be this way. The light, for example, if you are considering a light bulb, the lumens should be of this order. If you are considering a computer, the processing should be of this speed. If you are considering a camera, the pixels capability of should be of this order like that there are very specific metrics which are associated with testing.

But when we come to the validation stage, we are not only testing the product per se, but we are validating whether the premise which is underlying the product is valid, whether the customer is buying into the validity of the product premise. Therefore, it is both quantitative and also qualitative.

Testing and validation therefore occurs at two levels in each case. If you see this staircase, we have testing of the product concept that is we talked about a luminous alarm clock which is luminescent all through the night. Now that is the product concept which we would like to test, but then you test the product that is up to what level of distance you are able to see the light in the night.

At what level of darkness can you see? Can you see it when the alarm rings? Or is any other functionality affected when you have different kind of interventions which is happening in the alarm clock? So, that is the testing of the product.

Similarly, when you have a light bulb which is attached to the ceiling fan, the concept is whether it looks glorious along with the ceiling fan. It adds to the decor of the house that is the overall product concept. And also whether the shape of the bulb which is may beep like a candle, like a round bulb or like another chandelier, whether that is going along with the overall profile of the ceiling fan that is the product concept.

But when it comes to the testing of the product, you would really like to see what is the kind of lumens, the bulb is giving. And when the fan is circulating at different speeds, do you find that the light is differentially placed in terms of its prominence in different parts of the room that is actually the testing of the product which happens.

And also the connectivity between the electrical circuits of the ceiling fan and also the electric circuits or the bulb whether is happening in the proper manner. Therefore, you have the testing of the product concept, you have testing of the product.

Then we come to the validation, again you have got two types of concepts, one, whether this product concept whether it gives an Aha moment for the customer, that is the validation of the product concept. But even if it comes with an Aha from the customer is it really going to translate itself into a good business. Therefore, there are four stages in this so called the testing and validation phase, testing of the product concept, testing of the product itself.

Similarly, validation of the product concept and validation of the business concepts, when these four sub stages happen during the testing and validation phase, you can say that the product is ready for commercialization.

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Now, what are the principles of testing? The principles of testing are very closely aligned to the product itself. Each product has its own method of testing, its own protocol for testing. For example, when you look at software, basically there are two types of testing, one is the alpha testing and another is the beta testing.

Alpha testing is testing that happens at the development centers stage, even as the code is being written and at the time of completion of the code. All the bugs which are there in the code are evaluated and then fixed based on certain automated as well as human testing procedures. But once that is done, it goes into the beta testing phase which is getting tested at the hands of the customer.

When you look at various portals or various sites, you will find that this site is available for beta testing, which means that it is available for customers at their choice to be tested. And some customers may like to test it and provide feedback, whereas, some customers may like

to stay with the previous generation of the site. Whichever way it is done, when the beta testing is done at the hands of the customer, the company gets valuable feedback from the customer. And therefore, he is able to the developer is able to input all those feedback into the program or the site.

Similarly, when you look at the software testing, there are several modules of sub testing, there is graphic user interface GUI testing, whether the whole thing is being aligned in a proper manner, so that the customer is able to appreciate the portal, whether it is being launched in the same manner in different devices, whether it is a smart phone or on a desktop or on a big projector. Similarly, whether the backend functionality is maintained, so there are different stages of testing which are available in the software field.

Similarly, when you look at the bulb, the testing is not so simple as testing the wiring through a multimeter. One has to really look at the strength of the filament and how many cycles, how many thousands of cycles the filament can stand, what is the level of heat which is generated when the bulb is put in and how many cycles of switching on and switching off it can seamlessly do.

And what is the color luminescence which can come from the bulb and what is the level of blue light which emanates from the bulb. So, these are all the factors which could be looked at.

Even a product which is as simple as an apparel or textile has close to 20 test which need to be performed like the strength of the weave, the color, the fastness of the color, whether the any of the ingredients of the color or carcinogenic, whether there are shades which are not to the color palette which has been decided. And what is the strength of the knitting that has happened, are there any loose ends, are there any metallic objects left by mistake during this stitching process.

And what is the kind of profile conformance that the apparel has got. So, there are number of parameters which need to be checked during the testing phases, validation phases. And therefore, although it is stucked away in the entire scheme of things, it is one of the most important phases in an entrepreneurial products.

And it is very important that before testing takes place, the entire specification set is frozen. This is particularly valid in startup situation because many times the startup tends to develop

on the go. They start with a particular product. And we will think about that concept a little later.

And then they keep developing the product as the feedback comes forth. So, as established to let say developing an automobile by an established automobile Engineering Center, a smart watch, which is developed by first generation enterprise is likely to be development on the go.

It is therefore important for startups to realize that the entire specification set should be frozen. Secondly, this testing should be undertaken, not only against the internal benchmarks, against the available external benchmarks as well. Because typically in any product development, a lead time of at least 1 to 2 years is inherent, whether it is a startup which does things in a very efficient and very effective manner or an established company which does things in a very measured and cautious manner. There is going to be a lead time.

By the time the product comes out as a prototype, it is quite likely that you have external benchmarks which have not been anticipated at the time of development Therefore, it is very important for a company to test products not only against its own specifications, but in a broad manner against the competitive external benchmarks which are available as a measure of additional assurance.

For industrial products, for example, earthmoving equipment or for tracks or for buses, testing needs to be done not only by the company and its internal experts, but it also has to be done by external regulators. Because such industrial products have got very important role in economy and they can cause lot of productivity enhancements or they can cause lot of emission and safety issues in the environment. Therefore, testing has to be done at the hands of internal and external experts when it comes to the testing of industrial products.

And in when it comes to products, which are extremely consumer oriented. You require testing definitely at the hands of experts who have designed it, but also at the hands of the customers who are going to use it. For example, you think of a chair, which has got different methods of lumbar support, different height parameters. Obviously, it has to be tested not only by the experts but also different customers of different profiles, body profiles, different height, so that this chair with all its adjustments is very easy to operate and meets a number of personality profiles.

Therefore, for consumer products an additional layer of testing at the hands of the users is very important. At times for testing, it is important to simulate the usage conditions. Typically, a product is designed to last as we say a lifetime but actually there will be a fit for purpose design that is one would expect that product would run without any issue for let us say 3 to 5 years, let us say as a benchmark.

Then is it possible for a company to test a product for 3 to 5 years, is not possible at all. A truck, for example, is expected to run for thousands of kilometers each year. And at the end of the thousands of kilometers of run, it is likely to have certain wear and tear.

It is impossible for a company to do that kind of testing in real time. Therefore, testing is always done at factory level or at the development lab level through simulation. When we talk about simulation, we simulate the actual conditions that could take place on the road, and then put our product through those kinds of steps.

For example, there are things like engine dynamometer, there is a thing called a chassis dynamometer, where you run an engine, engine power pack, you run a chassis that is the vehicle and find out the kind of speeds they are encountering. And when there is resistance, how do they break, what kind of fuel economy is being turned out, what kind of noise levels are coming out.

Therefore, whatever be is expected to be done on the road, is simulated and those simulations can take place 24 by 7. Therefore, valuable data can be obtained upfront mimicking thousands and thousands of kilometers of actual field run. The other one is what we normally hear as torture track, torture track is very specially fabricated or constructed test track in which it has got all kinds of gradients, it has got all kinds of ups and downs, it has got all kinds of soils. While Indian roads themselves may be thought of as torture tracks in certain seasons of the monsoon, etcetera.

But torture tracks which are constructed scientifically help a company to simulate these kinds of adverse running conditions or operating conditions very effectively. Similarly, you have for components, various vibration test modes, you can see how the pressures come and how the pressures get relieved. For switches you can have continuous 24 by 7 switching methodologies. Therefore, prototype testing is also innovative in the sense that simulation of the actual user conditions takes place at the hands of the engineers in the design centers.

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### Principles of Validation

- Validation interlinks empathy, ideation, prototyping and testing phases, in terms of product functionality, customer experience, and business potential

- Even if testing is not done at the actual hands of users, validation must be carried out with actual users

- Additionally, a panel of experts may be formed to bring additional sharpness to the validation process

- As contrasted with testing, which is focused on performance versus specifications, validation establishes the nexus between product and business. For industrial products such as trucks, a comprehensive process of homologation serves as a good validation programme.

- Testing is more in the Quality domain while validation is more in the marketing domain, in fact in the entire design thinking team's domain. For consumer products, an additional layer of testing at the hands of users is very much desirable

But then how does principles of validation differ from principles of testing? Principles of testing as I said is very quantitative, very rigorous against a set of specifications and it is a kind of go no go gauge, if it meets the specifications it passes, if it does not meet the specifications, it does not pass.

There are no gray areas. That is a quite black and white kind of analysis. Whereas in the principles of validation, we are linking the empathy ideation, prototyping and testing phases in terms of a set of quantitative and qualitative functions, which cover the product functionality, which cover the customer experience and which covers the business potential.

So, looking at the alarm clock, which lights up also the night, let us say by design or by default, somebody has done it with a black color. So, although it may be functionally excellent and it may have the kind of luminescence when it happens when it lights up when customer sees in the night. Obviously, the black color is something which is antithetic to the whole concept that has been developed of being visible in the night times.

Therefore, the customer experience is likely to be negative. So, what are we trying to seek in this alarm clock and finally, what have I got? So, the empathy with which you have developed a product gets tested during the validation phase? And when the validation phase says that both quantitatively and qualitatively this product meets the criteria, then it is available for exploitation of the business potential.

I would also like to state that even if testing is not carried out at the hands of the real users, validation at least must be carried out with the actual users. That is because only through them you can get the qualitative feel of the product properly described.

Additionally, we can also co-opt a panel of experts to make sure that this product gets validated in the appropriate manner. A panel of experts is important because they give a detail third eye approach to the product, something which the startup might have thought about when the product started getting developed. Therefore, at a broad concept level, testing establishes the nexus between the specifications and the product performance. Whereas validation establishes the nexus between the product concept and potential business.

Therefore, there is kind of two level hierarchy which is very important in this testing and validation phase which is very critical to business success. For industrial products such as trucks, there is another layer, which is what is called the homologation, which means that you not only have to meet the requirements of a particular customer or you not only have to meet what the technology says it can deliver, but also it should meet the regulatory requirements of the country in which this product is going to be put.

Similarly, is the case with the pharmaceuticals or the meds, these are two product categories were meeting the requirements of the regulatory authority is extremely important. And it is also done on a product by product basis. It is just not done on an overall basis. And this process is called homologation, which is part of the testing and validation cycle and it is a variable specialized term used for certain products where regulatory approvals are mandated before a product can be put in the marketplace.

Generally testing is seem to be more in the quality domain, whereas validation is seem to be more in the marketing domain, but whatever it is, it is the kind of quality assurance for the product. And if a company is using the concept of design thinking, taking the product and an end to end seamless basis from empathizing with the customer need to the final delivery solution, it is a kind of one seamless circle of development that happens.
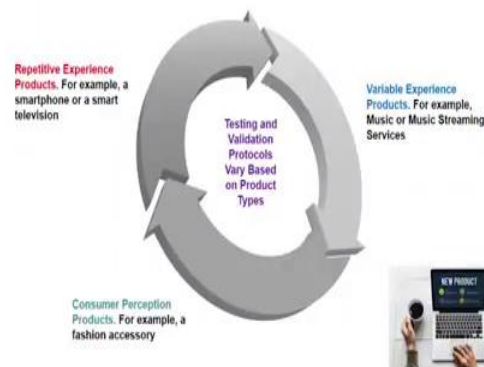
Now, when we talk about testing and validation, we can have two types of hierarchy. The first type of hierarchy is about the types of products. Now, we cannot say that all products are the same. Different products have got different characteristics and therefore, the testing and validation cycles differ, I would say some products are repetitive experienced products. Now, when we talk about a computer or a alarm clock or a camera, I would say they are repetitive experienced products that is, they act as standalone products.

A computer has to display the image in a particular milliseconds or nanoseconds of time, it has to have certain functionalities and whatever be the content which comes in, the computer has to perform in the same manner. So, this is called a repetitive experienced product. A watch is another classic example of a repetitive experienced product. The second type of products are the variable experienced products, which means that their performance is dependent not only on them, but also on a number of other conditions.

We can talk about an automobile. It is designed to be repetitive at one level, but also it is likely to be variable in experience, depending upon the, is also likely to be different depending upon the type of fuel you are able to use, the type of road conditions you use. Therefore, there is a variable experience that comes out of the product. So, these are variable experienced products.

But as a product, certain products are services or variable experience in all ways like for example, you look at a streaming service, while the concept is the same that you subscribe to a streaming service and it streams in the music or it is streams in the films. But the

experience, the customer gets out of the streaming service is dependent on the content that comes through the streaming service.

Therefore, there is a variable element which is inbuilt into the very idea of the product. Then the third one is the consumer perception products. For example, you think of a beverage which is tea or coffee, the product may be made as per the specifications, the variability in the product can be minimized through appropriate package design and things like that.

But still the way, a consumer feels the tea is likely to be different depending upon the type of tea or for the same tea, different consumers have different experiences in experiencing Therefore, it is very consumer specific, although there is a broad generic category like a beverage how the beverage is tasted or expressed about is quite different between the consumers.

Therefore, to summarize, we have got three types of products. One is the repetitive experienced product, where the specifications determine what the product is going to be in at the hands of the customers, how it is going to be perceived.

Second is the variable experienced product, where the overall ecosystem also determines how the product is perceived. And the third one is the consumer perception product, where the consumer depending upon his or her mindset, depending upon his or her personality looks at the product in a different way, a fashion accessory for example.

So, depending upon the three types of products, one can relate that whatever we have discussed earlier about the testing and validation cycles and the methodologies they have to be obviously different. And needless to say if it is a repetitive experience product, you would need to have very significant level of testing based on specifications.

If it is a variable experienced product, you need to have specifications covering not only your product, but also the ecosystem inputs that go into the product. And if it is a consumer perception product, obviously, you need to understand the consumer psychology in to a far greater extent than you would otherwise care to understand. And similarly, the level of consumer involvement becomes highly different, highly variable depending upon the kind of products which you are testing.

Likewise, you have another type of classification that is related to the nature of the startup itself. Because startups have got certain approaches in terms of developing a product,

fundamentally products tend to be fuzzy ideas. Fuzzy ideas means the technology is under development. What it delivers is hazily known, but not completely known. And despite the best design thinking you may have that is of empathizing with the customer, ideating as much as possible, finding out a solution for the product issue.

It is quite possible that the products tend to be fuzzy and only when the development cycle is complete. You get to see the product coming out live and in the manner which you have perceived. A digital watch, where it has been developed for the first time that it would have smartphone like functionality but also have a watch like functionality is a fuzzy idea when the idea is thought about.

Only when the development cycle is complete, one is able to see that a digital watch functions in this manner. It measures the activity in this manner, it creates its own community of wellness oriented users. So, these are all the developments which happen, so a fuzzy idea gets converted.

Similarly, when you want to have a health parameter, in a digital watch, it is a fuzzy idea, but how exactly it gets converted and how effective it is happens to be frozen only when the development cycle is completed.

Secondly, technology could behave differently in the real world. When we talk about technology, particularly things like sensors which are very much part of every new kind of product which is being developed, the accuracy with which you measure the sensor movements of the body, for example could vary depending upon the sensor technology. When you are measuring the steps, you got to differentiate between body movements which mimic steps and actual steps.

Similarly, the sensor should have the ability to differentiate between what happens between stair climbing, and let us say rapid jumping. So, how does the technology, the technology of sensors, differentiate between the two?

And to be able to bring fuzzy ideas into the logical conclusion, to be able to deploy the best methods of sub technologies, you need to have resources. Unfortunately, startups do not have all the resources for full-fledged product development. So, herein lies the dilemma of startup product development, that the resources are limited, but the ideas are exotic and esoteric, and the technology is sun rise, but not fully proven. So, the whole product plan tends to be a very dynamic document, a dynamic development as far as startups are concerned.