



# Grand Challenges for Engineering

An ASU-UNSW joint course made possible by the PLuS Appliance

Never Stand Still

Faculty of Engineering

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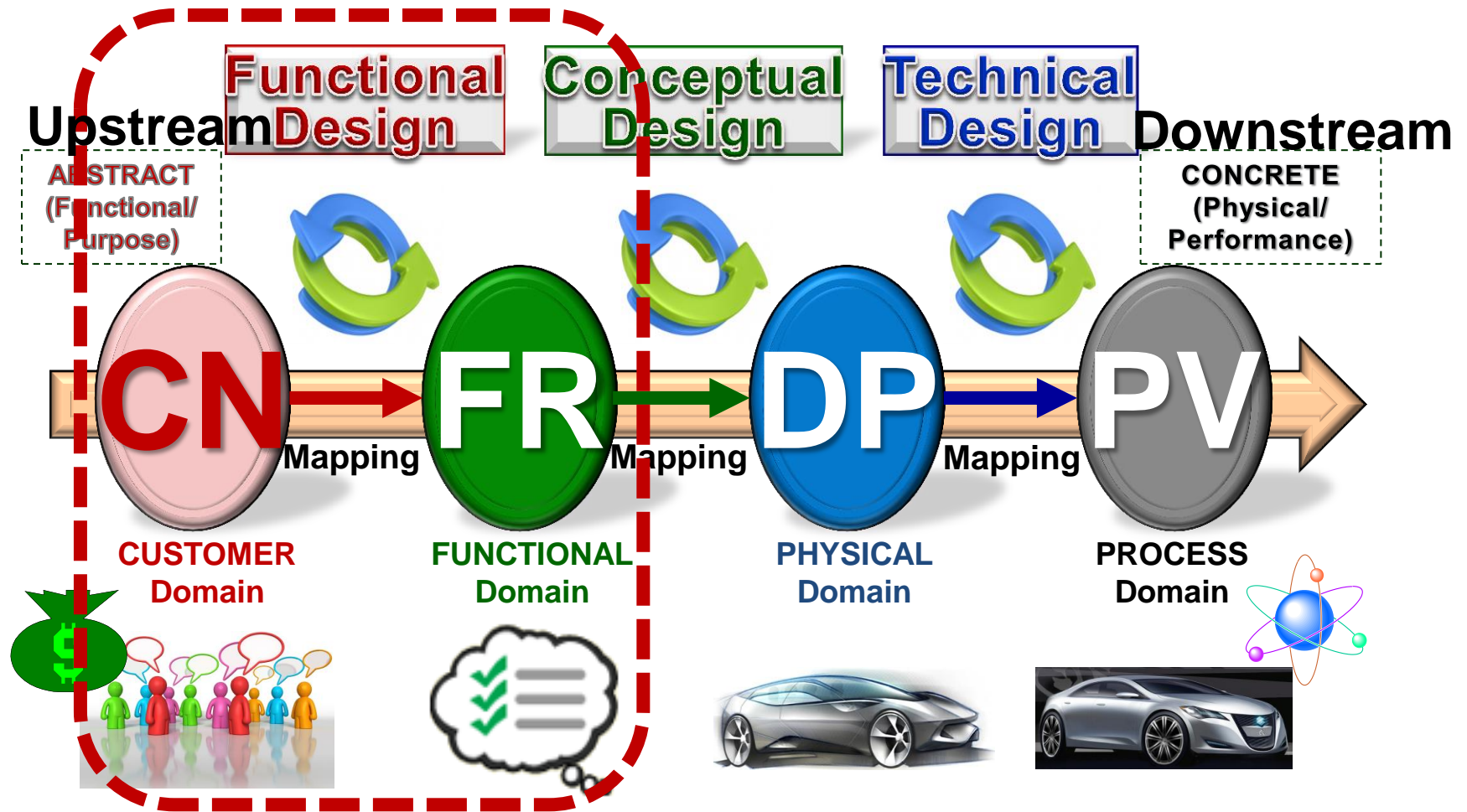
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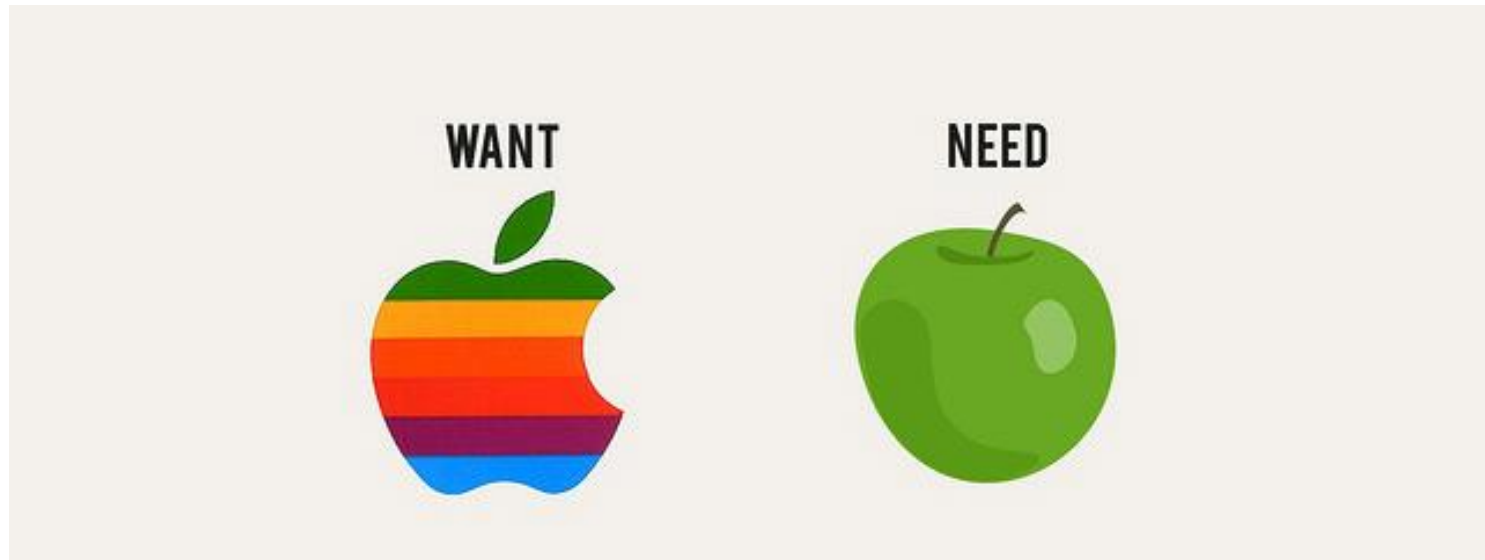
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# The “functional design” stage in design



# Difference between “need” and “want”



- You need a sandwich, but you want a lobster
- You need a Toyota car, but you want a Mercedes
- You need a Nokia phone, but you want an iPhone
- You need a McCafe, but you want a Starbucks
- You need a paper bag, but you want a LV bag

# Complete process of functional design

- **Explore the Customer Domain**
  1. **Describe** target customers
    - Stakeholder involvement and customer portrait.
  2. **Solicit** voices of the target customers (i.e., CN)
    - Contextual inquiry, ethnography, lead user, crowdsourcing, etc.
  3. **Extrapolate** the solicited CNs to discover an innovation opportunity
    - Market competitions, emerging social trends, lifestyle changes, SET factors, etc.
- **Explore the Functional Domain**
  4. **Assign** functional requirements (FR) to seize the opportunity
    - Propose and represent FRs based on the solicited CNs
  5. **Classify** the assigned FRs to determine the innovation priority
    - The Kano Customer Satisfaction Model
  6. **Organize** the assigned FRs to frame a unique design problem
    - Complete, minimal, and independence principles
- **Map between Customer and Functional Domain**
  7. **Map** CNs in the customer domain to FRs in the functional domain
    - Use Quality Function Deployment to build a House of Quality

# Need can be transformed to want!

**NEED**



**WANT**



“My love from the star”

[https://en.wikipedia.org/wiki/My\\_Love\\_from\\_the\\_Star](https://en.wikipedia.org/wiki/My_Love_from_the_Star)



# “Needs” vs. “wants” in innovation

## Maslow's hierarchy of human needs

Give a few examples of products for each of needs:

Self-actualization

Esteem

Love/belonging

Safety

Physiological



**WANT**

What happens  
you move up  
this pyramid?

**NEED**

# Products designed for diverse needs



# Uncover new market demands

Market (Demand) Side

**BLUE-OCEAN  
Strategy**

**Stimulate  
“the wants  
of the few”  
to uncover  
new  
market  
demands**

**The Maslow Hierarchy  
of Human Demands**



Technology (Supply) Side

**RED-OCEAN  
Strategy**

**Satisfy  
“the  
Needs of  
the Many”  
to uncover  
new  
market  
demands**





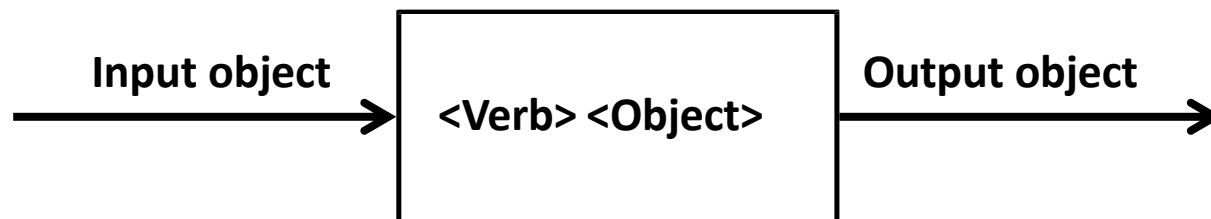
# Formulate engineering design problem

## Given the customer need of “cure cancer”

- It can be formulated as a biological problem
  - Design an experiment to understand how cancer is developed
- It can be formulated as a pharmaceutical problem
  - Design a new drug to detain the cancer development
- It can be formulated as a policy making problem
  - Design an insurance policy to reduce the cost of treatment
- It can be formulated as a public health problem
  - Design a public campaign to discourage smoking
- It can be formulated as an engineering problem
  - Design a scanning machine to identify, image stage-1 cancers
  - Design a big-data platform to analyse risk of developing cancer
  - Design a medical device to remove cancer completely

# Formulate an engineering problem by means of functional requirements (FR)

- General representations of function
  - Function = <Verb><Object>
  - Function  
=<Verb><Object1>to/from/with/through<Object2>
  - Function = <verb><object><in the context>
- Graphical representation of function



# Examples of functional requirements



<support><person>



<contain><water>



<transport><child>



<carry><cosmetics>



<carry><book>



<carry><laptop>

# Functions can be decomposed



FR = <control><GUI>

FR<sub>1</sub> = <move><pointer>

FR<sub>2</sub> = <select><item>

FR<sub>3</sub> = <scroll><items>

FR<sub>4</sub> = <open><menu>



FR = <support><user>

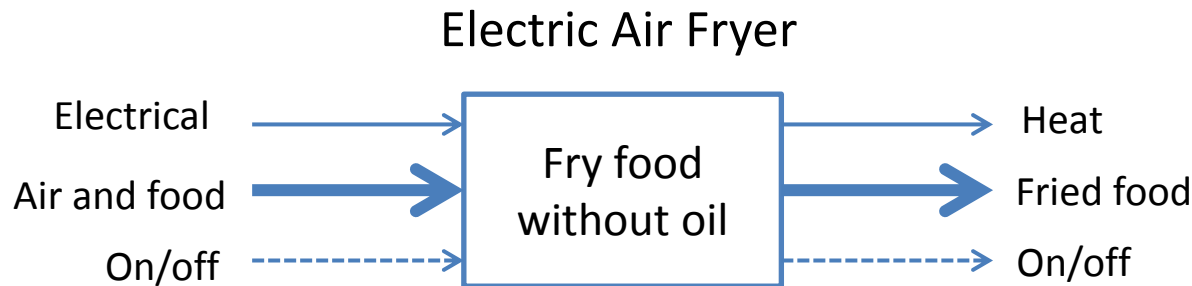
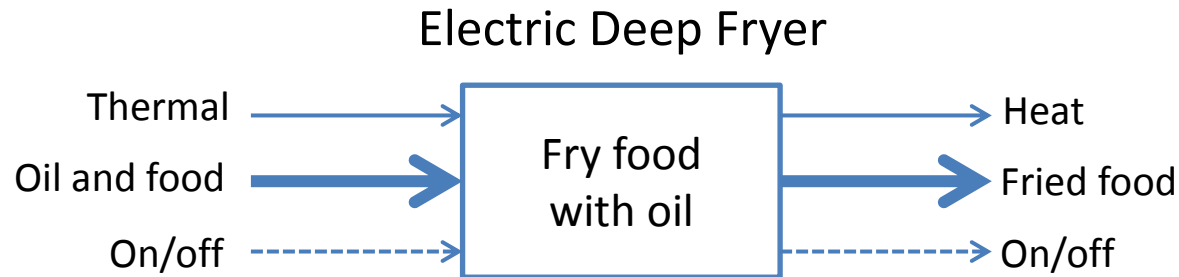
FR<sub>1</sub> = <support><foot>

FR<sub>2</sub> = <support><arm>

FR<sub>3</sub> = <support><back>

FR<sub>4</sub> = <support><main body>

# Example of E-M-S functional modelling





# Function is by assignment!



This is an artefact to “tell time”.  
Can other artefacts be used to “tell time”?

This is an artefact to “show off”.  
Can other artefacts be used to “show off”?



This is an artefact to punish boyfriend who made mistakes!

# Similarities among these products?



Product: smartwatch

Problem: monitor bio signals



Product: Jogging stroller

Problem: stable transport



Problem: yoga ball chair

Problem: exercise in office



Purpose: perform exercise while multitasking

People: a young mother who has a full-time job



# Choose a good FR is most critical!

## R.S.I



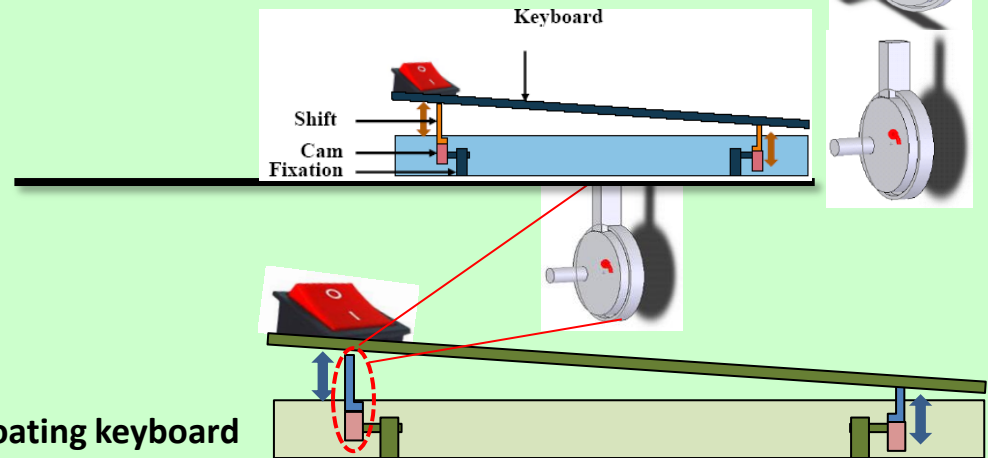
Traditional Ergonomic Thinking



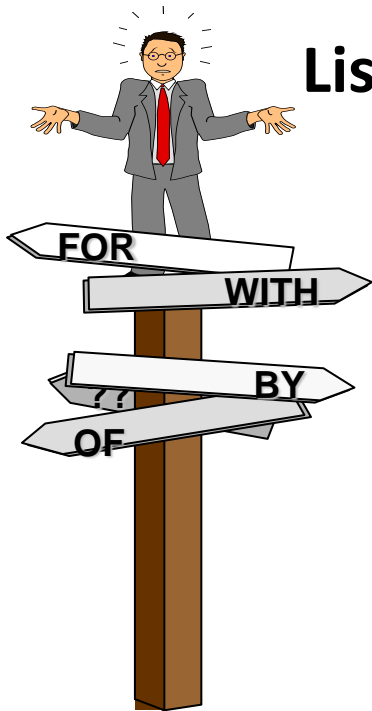
Creative Functional IDT  
**Problem Purpose**



An innovator can assign different functional requirements (FR) as their design target to satisfy the same customer voices

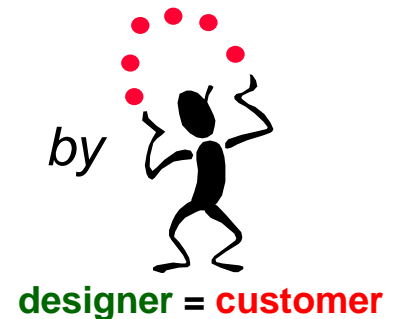
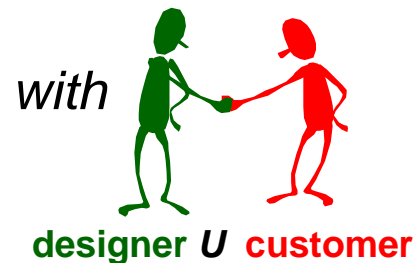
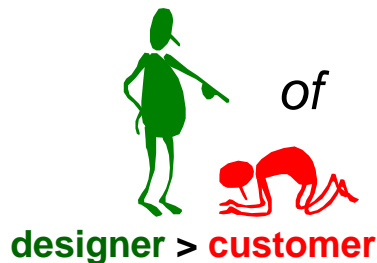


# The myths about “design-for-customer”



**Listen to, but don't be dictated by, your customers**

- Who is your real customers, anyway?
  - An individual, or a community of individuals
  - Airplane, toy, pet food, degrees, etc.?
- Does customers really know they want?
  - Past and present needs versus future wants
- Should you listen to customers after all?
  - Yes, they can help you to choose proper CNs
  - No, they should not dictate your FR choices



# Traditional surveys didn't work

- Problems with traditional market surveys
  - The Theorem of Impossibility (by Kenneth Arrow)
    - No procedure for combining individual preference rankings that can lead to a consistent (rational) group ranking

Customers express their preferences via ordinal ranking of discrete alternatives

Individual Customer	Preference Rankings
I	$a > b > c$ , and $a > c$
II	$b > c > a$ , and $b > a$
III	$c > a > b$ , and $c > b$

Democratic decision making (social choice) by simple preference aggregations

Customer	Decisions		
(when asked)	a vs. b	b vs. c	c vs. a
I	a	b	a
II	b	b	c
III	a	c	c
Group Result	$a > b$	$b > c$	$c > a$



# Modern approaches to solicit VoC

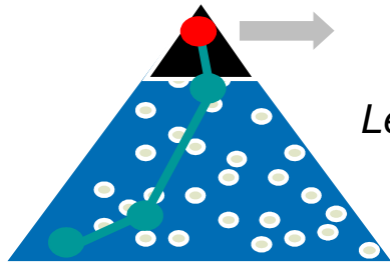
- Modern methods are available in marketing research and are used in new product development
  - Focus group
  - Leader user theory
  - Context inquiry
  - Ethnographic observations
  - Crowdsourcing
  - Qualitative data analysis
- Most of these VoC methods assume that you have already built some prototype products or that you already know who and where are your targeted customers
  - This is often not the case for true breakthrough innovations

# VoC method of contextual inquiry

- Contextual inquiry is a semi-structured interview method that occurs in the context, based on observations, to guide designers towards smarter questions
- Contextual inquiry is a user-centred design method
  - The leading design firm, IDEO, is the pioneer of this approach.
- A typical contextual inquiry process takes 2-3 hours
  - Introduction: the designer introduces him/herself to the user and outlines the design scope
  - Interview: the designer observes and discusses with the user
  - Summary: the designer summarized what was learning and seek for comments, clarifications, and suggestions from the user
- It is about asking smart questions in the field

# Engage lead users in design

Karsten Nebe – Off-Road-driver and usability expert



*Leading edge*



**Lead-User**



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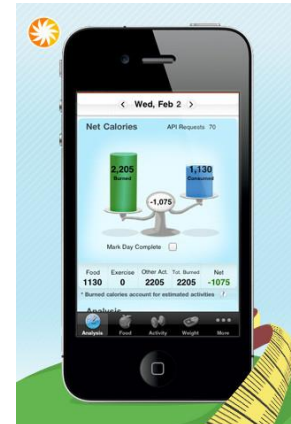
(c) Karsten.Nebe@googlemail.com

- Karsten Nebe uses a laptop computer for his special GPS software while off road driving
- He desperately needed a fast, intuitive operating concept
- He already modified laptops for this special onboard need
- The prototype is used permanently and is going to be improved on a continuous basis

Source: Halbinger, Fujitsu, Innovation Leadership Summit 2009, Aachen

# Five WHY method

1. Why do you exercise?
  - Answer: because it's healthy
2. Why is it healthy?
  - Because it raises my heart rates
3. Why is that important?
  - So that I can burn more calories
4. Why do you want to do that?
  - Because I want to lose weight
5. Why losing weight?
  - I feel social pressure to look fit



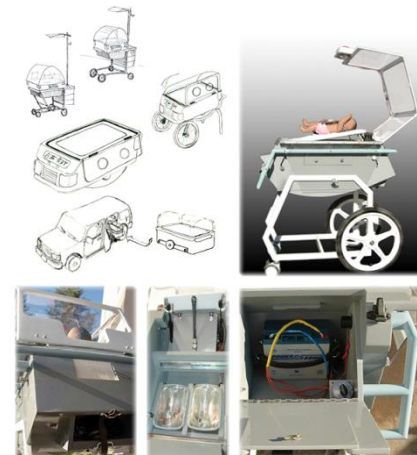
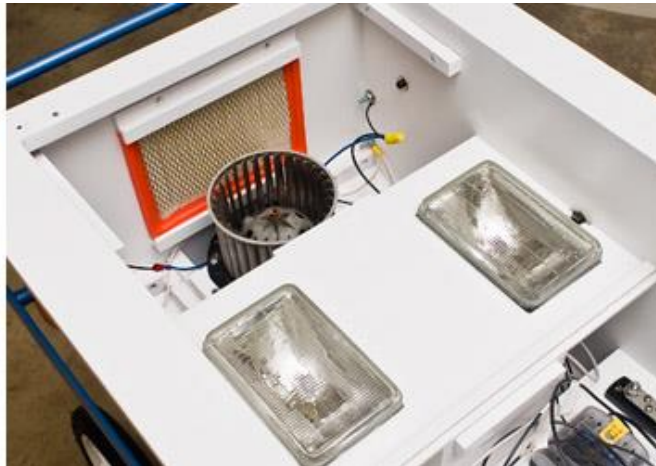
Why stop at 5 WHYs???





# Why not, What-If, and How

- Why aren't people in the developing countries use incubators?
  - Answer: the incubators are prone to breaking and the local hospitals didn't have the parts and know-how to fix them
- What if we can provide incubators that were easy to maintain?
  - Answer: car computer parts are readily available in the developing countries
- How can we make an incubator out of car parts?
  - Easy to use, inexpensive, **using parts from car shops**, reliable, etc.



Source: A More Beautiful Question by Berger W



# What is Ethnography?



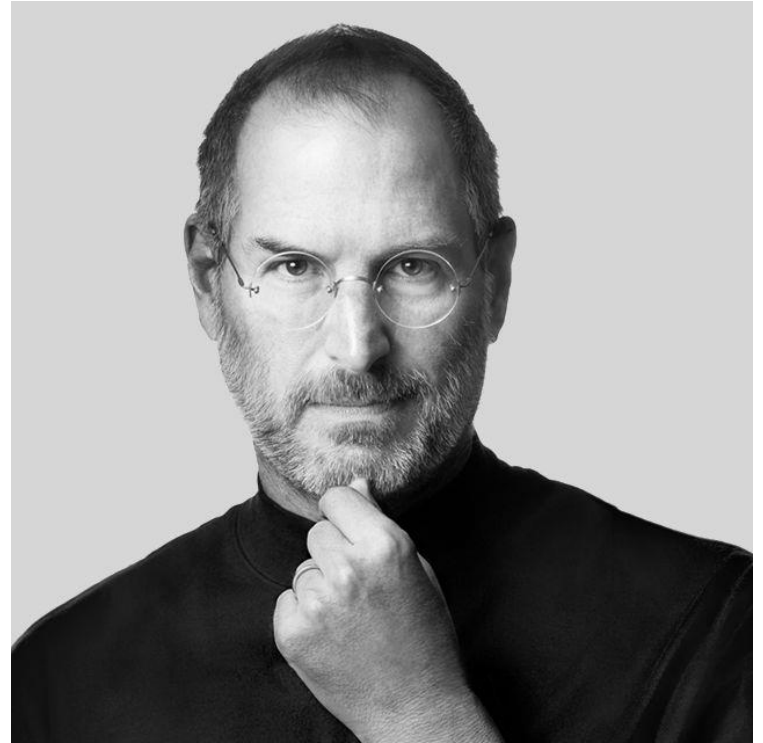
Ethnography documents and understands how people live in their daily lives

- It focuses on a few telling cases
- It begins with no hypothesis
- It focuses on questions
- No detail is too small to be missed
- Every finding should be personalized if not unique
- It focuses on the constructivism than constructinism
- It involves continuous dialoguers

# Should you listen to you customers?



**“What people say, what people do, and what they say they do are entirely different!”**



**“Customers don't know what they want until you show them”**

# The secrets behind Apple store



What comes to your mind if you were asked to “design a retail store to display and sell the products”?



What comes to your mind if you were asked to “design a playground where customers can play, interact, and tweak the products”?



# VoC Method of crowdsourcing

- Crowdsourcing is a new form of the user-centered innovation approach (e.g., the power of the many)
  - Who knows voice-of-customer better than would-be users?
- Creative people often like to work on innovation for free
  - The incentive is fulfilment and recognition, rather than money
  - Many computer games are built with these implicit purposes
- Crowdsourcing can discover user requirements early
  - It enables you to solicit user requirements even before you actually build the product for your customers
- The current trends toward online commerce and social networking are making crowdsourcing an increasingly popular and powerful tool for soliciting VoC
  - Customer reviews and online discussion forums
  - Visit [www.whynot.net](http://www.whynot.net) to see some examples

# Customer reviews on Amazon

**Customer Reviews**

24,767 customer reviews for a single product

4.5 out of 5 stars

5 star 72%  
4 star 18%  
3 star 6%  
2 star 3%  
1 star 4%

Share your thoughts with other customers

Write a customer review

See all 24,767 customer reviews

**Top Customer Reviews**

★★★★★ No big improvement in the 2015 model  
By Desert Rat **TOP 1000 REVIEWER** on July 1, 2015

Configuration: With Special Offers | Connectivity Technology: Wi-Fi Only | Color: Black | **Verified Purchase**  
Review updated September 17, 2015


As a background, I am a retired Information Systems professional and I am writing this review from the perspective of being a long-time Kindle user. I have all the current e-readers and Fire devices from Amazon including the basic Kindle, the 2013, 2014 and new 2015 Paperwhite, the Fire HD6, Fire HD7, Fire HDX7 and Fire HDX8.9. This review is for the 2015 All-New Kindle Paperwhite. The attached picture shows the 2014 Kindle on the left and the new 2015 Kindle on the right. Here is the summary of my initial impressions of the 2015 model versus the 2014 model.

I am somewhat disappointed in the 2015 version as there is not a huge improvement over last year's model. The Paperwhite made many improvements from its original first generation 2012 model to its second generation 2013 model, especially in the display and processor area. The 2013 model came with 2 GB storage, a wonderful display, a great battery and was the e-book "workhorse." The second generation 2014 model changed by only increasing storage to 4 GB. The third generation 2015 model increased the display resolution but reduced the battery life slightly.

WHAT COMES IN THE BOX: A Paperwhite device, a quick-start guide and a short USB cord. Amazon still does not supply a power adapter.

SIZE: It's the same identical size as the older Paperwhites. The weight has been reduced slightly from 7.3 to 7.2 ounces, a fraction of an ounce, most likely because of a smaller battery. The good news is that all cases that fit the other Paperwhites will fit the 2015 version!!

DISPLAY: The resolution has been bumped up to 300 ppi, equivalent to the Voyage. [Read more](#)



87 Comments | 6,363 people found this helpful. Was this review helpful to you?   [Report abuse](#)

- Rating
- Preference aggregation
- Recommendation
- Reviewer's credibility
- Text-based review
- Photo and video
- Comments and Q&A
- Peer evaluation



# VoC Method: qualitative data analysis

- Qualitative Data Analysis (QDA) is a widely used research method in social sciences
  - It converts qualitative data into quantitative data
- Systemic process of QDA
  - Collect raw data of product reviews
    - Amazon, product forum, Youtube, etc.
  - Transcribe data into texts
  - Segment the whole text into individual text units (e.g., logic propositions of “subject-predicate” pairs)
    - The basic unit is a short phrase or sentence
  - Categorize the segmented units into different design domains
    - Customer, functional, physical, and process domains
  - Assign an applicable category code to every unit
    - VoC: customer profile, customer need, customer expectation, etc.

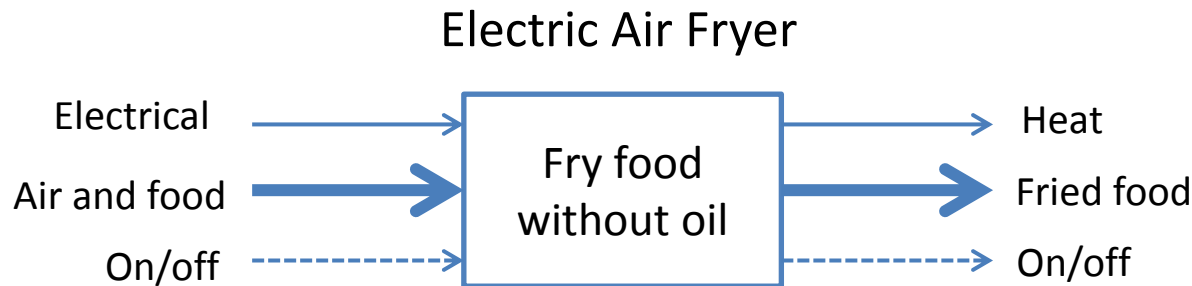
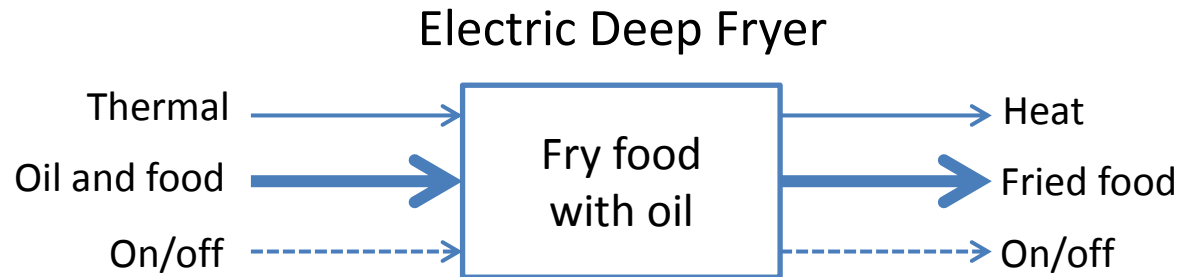
# VoC method of focus group

- Qualitative research that seeks customers' attitudes and perceptions about different products
- A focus group comprises 6-9 customers who don't know each other
- The primary benefit of focus group is group dynamics and interactions between peer customers
- The focus group is lead by a moderator
  - The moderator sets the context, asks question, creates an open environment, etc.
  - A skilled moderator is needed to make sure that no one takes over and imposes his/her opinions on others

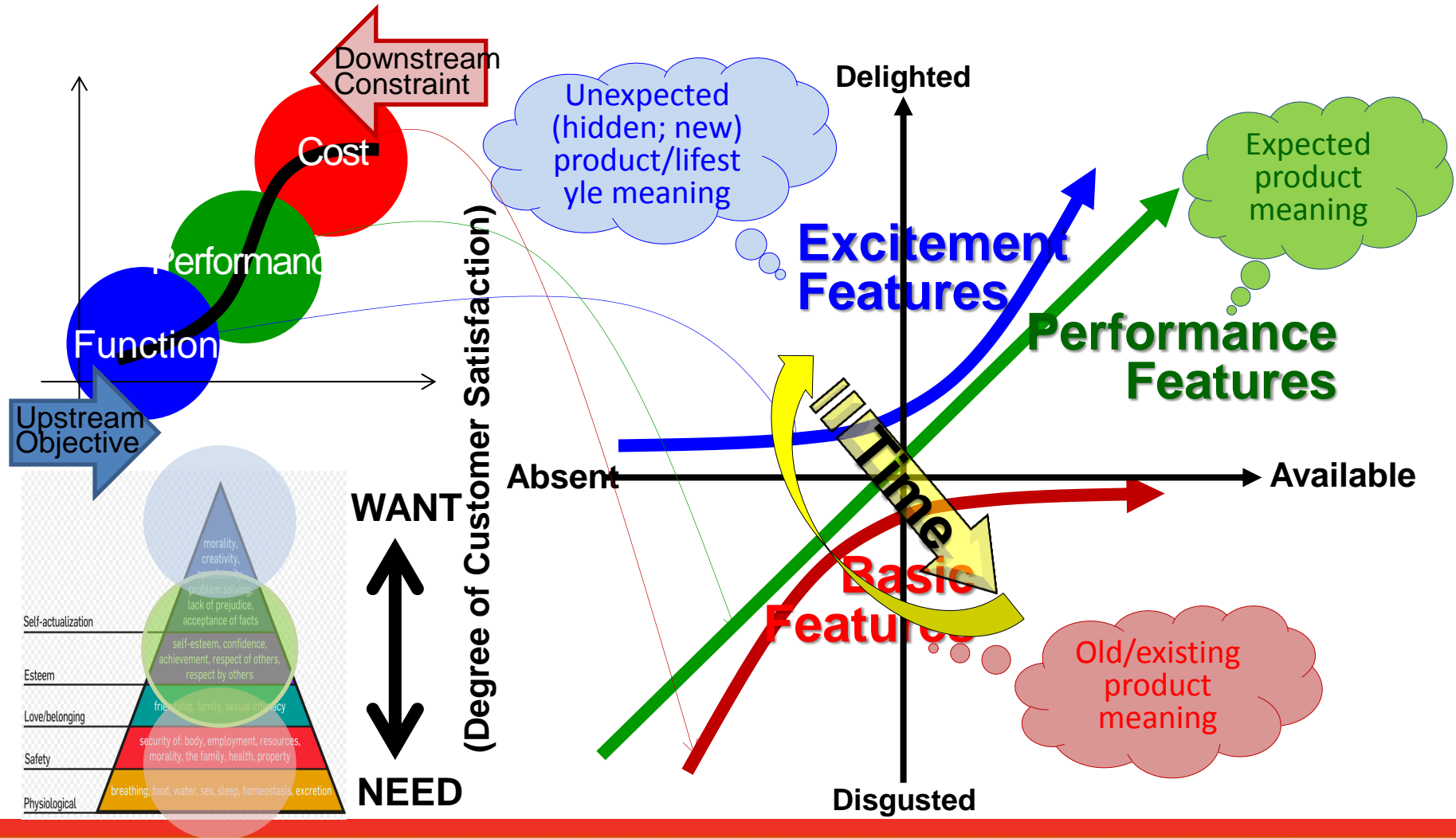
# VoC method of leader user theory

- Lead users are the users of a product whose needs are still unknown to the public and who would benefit greatly if their needs become satisfied
- Fundamental principles of lead user theory
  - “Identification of functionally novel products should be done at the leading edge of markets”
  - “Evaluation of commercially viable products should be done at the mainstream edge of markets”
- Lead users create user-oriented innovation when develop expects to benefit by using it
  - 77% of scientific instruments and 67% of process machineries are first developed and built by lead users
  - On average, it takes 3-5 years to transfer the first user-oriented innovation to commercial products in the market
  - Innovations created by lead users are characterized by creation of new functions, automation of existing functions, etc.

# Example of E-M-S functional modelling



# The Kano Customer Satisfaction model





# Focus on the exciting features

