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# Philosophy of Engineering Practice

At its core, Engineering is about **DESIGN**

The practice of **design** often involves non verbal **drawing/s** and **models**, and is as much about **art** and **creativity** as about **science** and **mathematics**.

*'a rich mix of theory and experimentation, intuition and craftsmanship, mathematics, drawing and luck.'*

Samuel Florman (1996)  
'The Introspective Engineer'



"What you mean the specs are being changed again?!?"

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## Philosophy of Engineering Practice

*'There is **never** just **one possible design**. A goal may be reached by many, many different paths, some of which are better than others but **none of which is in all respects the best way**.*

*An engineering design is inevitably influenced by **past technologies**, **personal preference** of the designer, **intuition** about what is appropriate and will fit the requirements, and also **cultural** and **social** factors.*

***Design is a social process** involving interaction between the design team, the client and others.'*

Eugene Ferguson (1992)

'Engineering and the mind's eye'

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"Bob, don't turn the bumper into a horsey!"



## Traditional Design; the Artisan Engineer

Product design modified over very long period by **trial and error** to meet needs of **user**. Design often from **experiential folk knowledge** which resided **collectively** with little knowledge of theoretical/scientific underpinnings. Designer answerable directly to user and changes could be made quickly.



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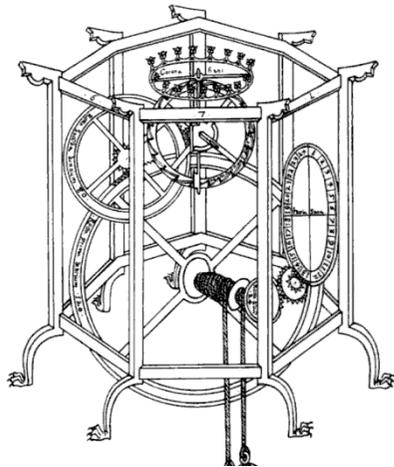
"Ok, you invented the wheel, but what have you done for me lately?"

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## Modern Design; the Artisan Engineer

Modern engineering uses **drawing** and (physical or computational) **models**; these are **simplifications of reality**, hence fallible and rely on **judgement**. Removes much of the trial and error, allows freedom to change several parts at once.



Giovanni de'Dondi's Astrarium (drawn 1364; completed 1381) included gear mechanisms not used by mechanical engineers for another four centuries.

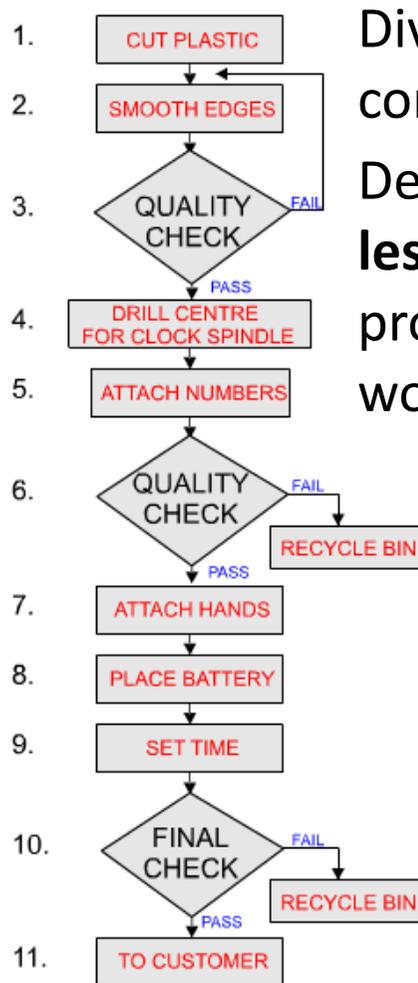


Reconstructions by Don Unwin (Whipple Museum, Cambridge) & Peter Haward (Science Museum, London)





# Industrial Society Design; Division of Labour



Division of design process into drawing, modelling, installation, commissioning, manufacture. Separation from **user**.

Designers have **less feel** for how product may work in context.

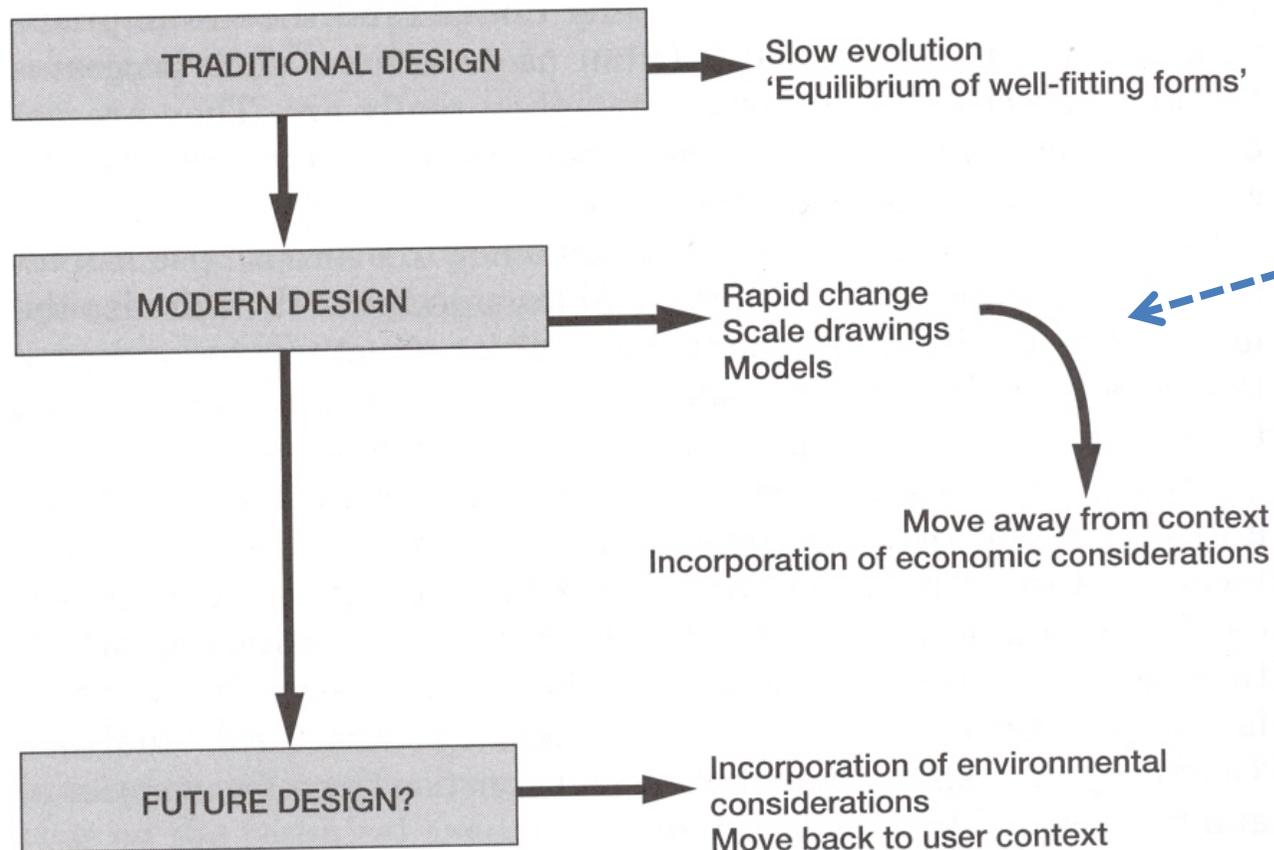
Citizen watch assembly line in a clean room environment (USA)



Manufacturing process for a clock manufacturing line



## Evolution of design methods (Beder, 1998)



Greater remove from user is associated with **technically based 'problem solving'** approach with **singular 'fixes'** rather than **multi-faceted prevention** e.g. dammed water feeding into leaking pipes



# Engineering Design and Innovation

## Linear Model of Innovation:

'technology push' →

→ 'market pull'



Driven by R&D led 'technology push' or consumer led 'market pull'  
 -based on forecast demand and actual demand respectively

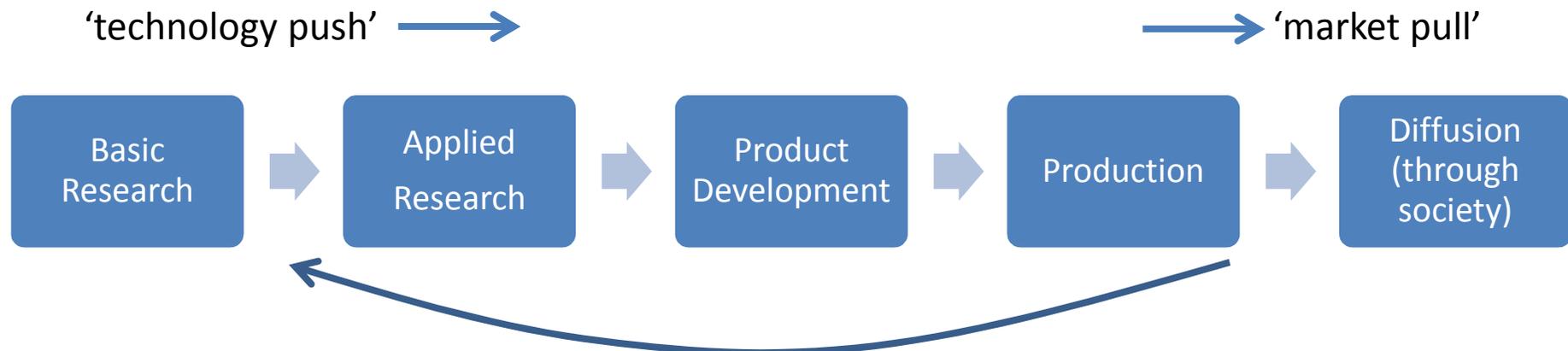
### Features:

- Simple, easy to understand
- Used to leverage Research & Development (R&D) funding
- Easy to measure (financial) inputs and generate statistics (e.g. OECD); hence persistent



# Engineering Design and Innovation

## Linear Model of Innovation:



e.g. Steam engine –invented/built long before scientific principles known (developed by W.J.M. Rankine from 1850's)

### BUT:

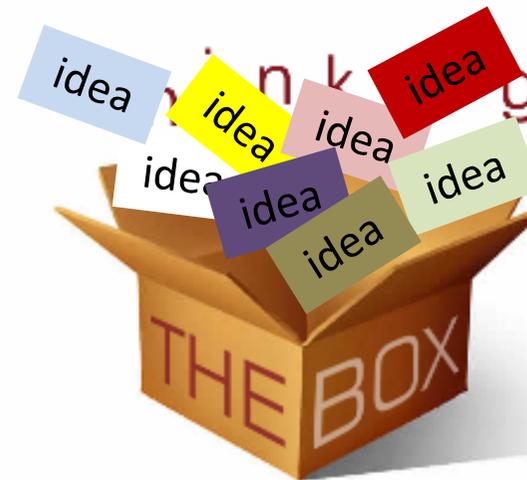
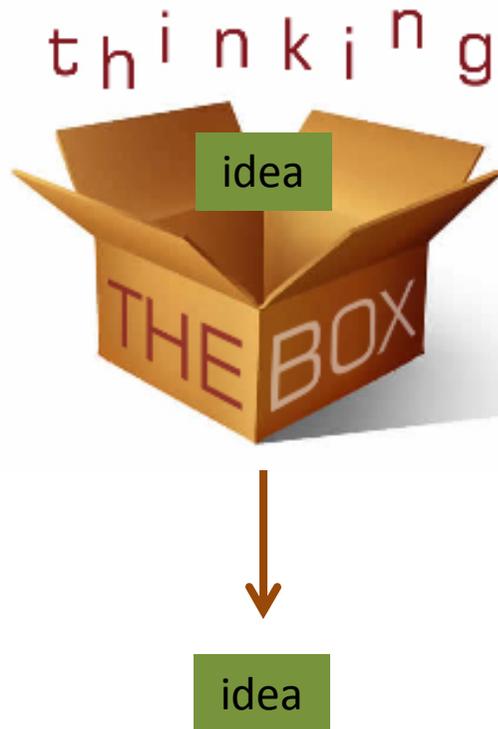
- Largely accepted as not being realistic; innovation is inherently complex, not linear
- 1967 US Dept. of Commerce Charpie Report: Research comprises 10% of costs of innovation; other steps are more important

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# Non linearity of creativity/innovation

Linus Pauling (Nobel Prizes in Chemistry & Peace): *“The best way to get a **good idea** is to get a **lot of ideas**”*



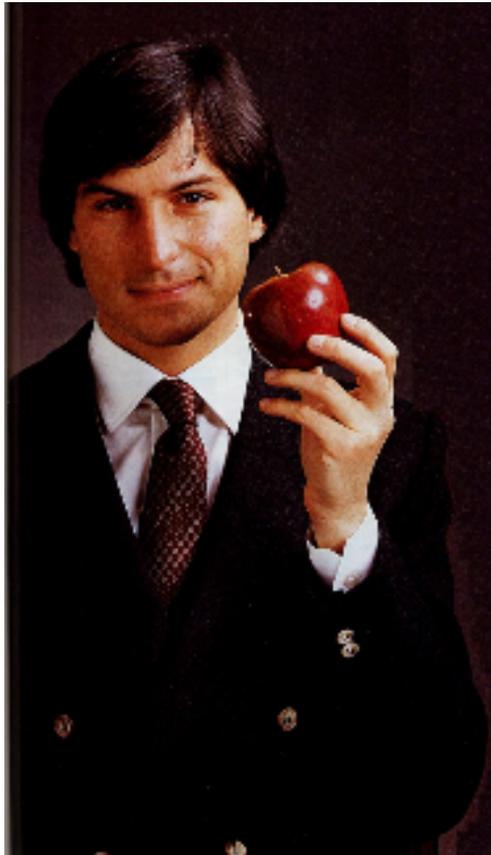
Not looking for the **‘best’** idea, but to promote **chaos** & hence stimulate creativity to generate more **new ideas**





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## Non linearity of creativity/innovation



Steve Jobs, inventor  
(1955-2011)

*“When you start looking at a problem and it seems really **simple**, you **don’t really understand** the **complexity** of the problem. Then you get into the problem, and you see that it’s **really complicated**, and you come up with all these convoluted solutions. That’s sort of the middle, and that’s where most people stop.*

*..But the really great person will keep on going and find the key, the underlying principle of the problem - and come up with an **elegant, really beautiful solution that works.**”*

Steve Jobs, 1994

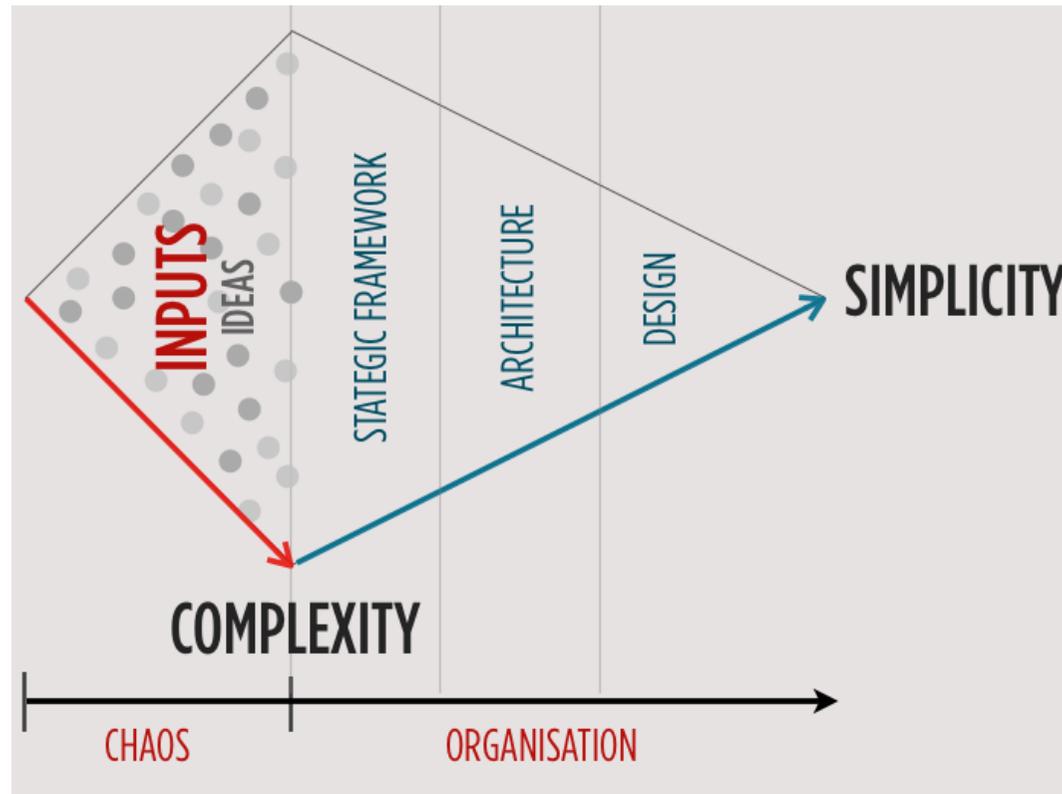
*“If I had never dropped in on that single **calligraphy** course in college, the Mac would have never had multiple typefaces or proportionally spaced fonts.”*

Steve Jobs, Apple founder and college dropout

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# Non linearity of creativity/innovation



Matthieu Mingasson, (User Experience (UX)) Designer  
<http://design.activeside.net/>



# Non linearity of creativity/innovation

Itself a social  
process

Engineering/  
Design/  
Problem Solving/  
Innovation Process

Social Impact/  
Societal Response

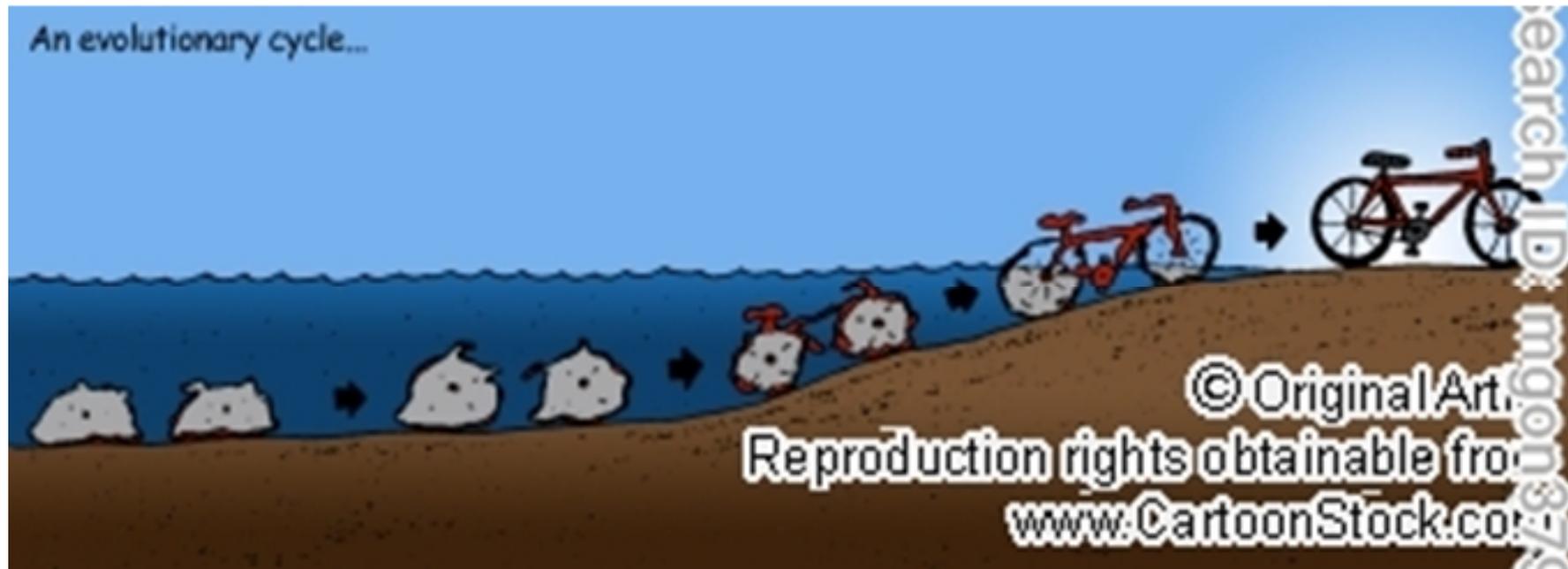
*Iterative series of non-predictable and non-linear feedback and feedforward loops*

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# Non linearity of creativity/innovation

e.g. Development of the Bicycle



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# Non linearity of creativity/innovation

e.g. Development of the Bicycle



from 1870: Development of 'ordinary' bicycle (later called 'Penny farthing')



1817: Baron Karl von Drais' walking machine

1880's: League of American Wheelmen campaigned for better paved roads across USA



# Non linearity of creativity/innovation

e.g. Development of the Bicycle



- Developed 1870, heyday in 1880's
- First to be called a 'bicycle' ('ordinary bicycle')
- Solid rubber tyres and large front wheel provided a much smoother ride than wooden/metal predecessors
- Wheels grew larger as makers realized it increased speed with each rotation with leg length only limit
- Popular among young well to do men (cost half years average pay)

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## Non linearity of creativity/innovation

e.g. Development of the Bicycle



- However, high centre of gravity made them prone to "taking a header"

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# Non linearity of creativity/innovation

e.g. Development of the Bicycle



## Hard tyred 'Safety' Bicycle

- Metal became strong enough to make chain, gears and sprocket light enough for human power
- Safer and more demure

### **BUT:**

- Far bumpier ride
- Slower



### **HENCE:**

Popular with women, clergy, older men  
but less attractive to high flying young men

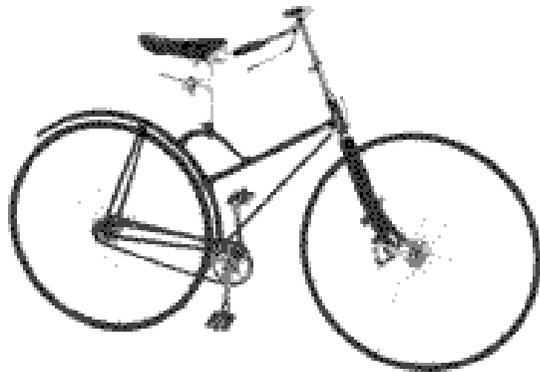
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# Non linearity of creativity/innovation

e.g. Development of the Bicycle



## Social Consequences

- Women became more mobile, freer.
- Encouraged change in fashion trends; 'common sense dressing' became popular



Bicycle suit vs conventional clothing (Punch, 1895)



# Non linearity of creativity/innovation

## The Pneumatic-tyred Safety Bicycle

**1888:** John Dunlop, a Belfast based vet made an inflated tyre with canvas, bonded together with liquid rubber for his young son's tricycle, who was prescribed cycling as cure for a heavy cold. He patented the idea calling it the 'pneumatic' tyre.



Women's pneumatic safety bicycle (1890's)

A comfortable safety bike was now available –but still not a hit among younger men! However, this bike soon started to win races. It had both safety and speed, and the rest is history...

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# Non linearity of creativity/innovation

21<sup>st</sup> C: As a form of transport, the bicycle has come full circle..



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## Non linearity of creativity/innovation

2010's: Mass produced Electric Vehicles to become the norm??



**Nissan Leaf**  
*ex 2011*



**Renault Fluence Z.E.**  
*ex 2012*