



## FRUGAL APPROACH FOR DESIGNING REHABILITATION PHYSICAL SYSTEM

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1. Frugal Innovation.
2. PRODIP.
3. Constrain-Based Thinking.
4. Frugal approach for designing rehabilitation physical systems.
5. Conclusions.
6. Bibliographic.



Frugal innovations are products that creatively use the often-limited resources at hand to produce high-quality solutions at affordable prices for the target customers (AGARWAL, 2021).

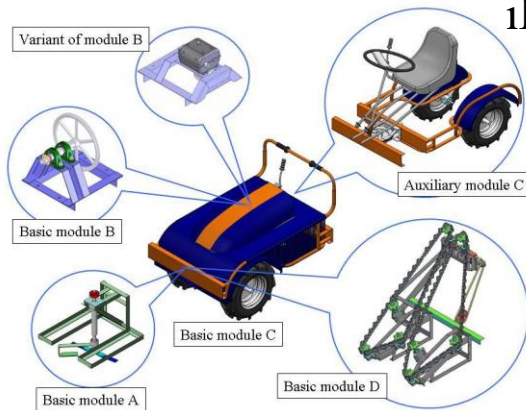
*UE LifeSciences*



iBreastExam



TATA NANO

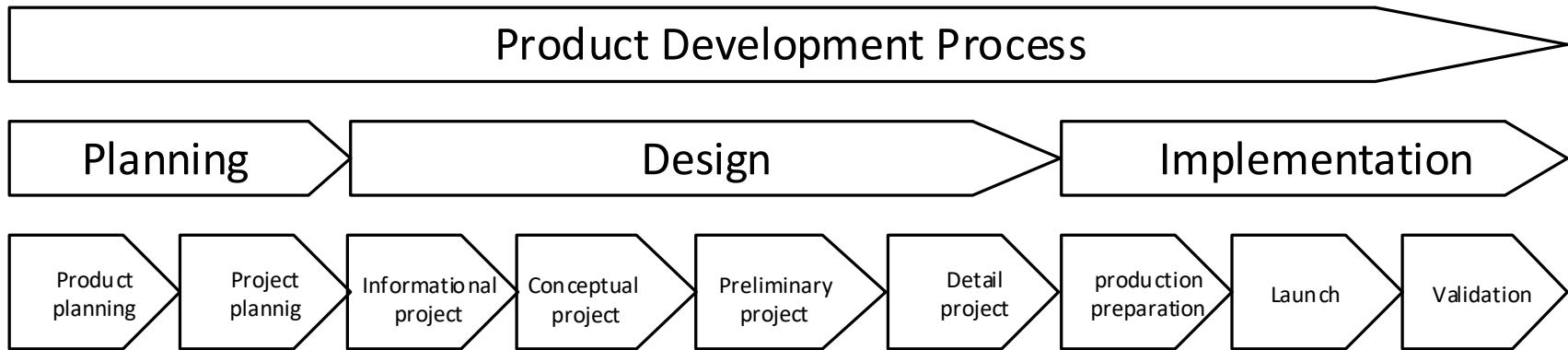


Frugal Tractor



SMART: Frugal Methodology (SIEMENS)

## PRODIP

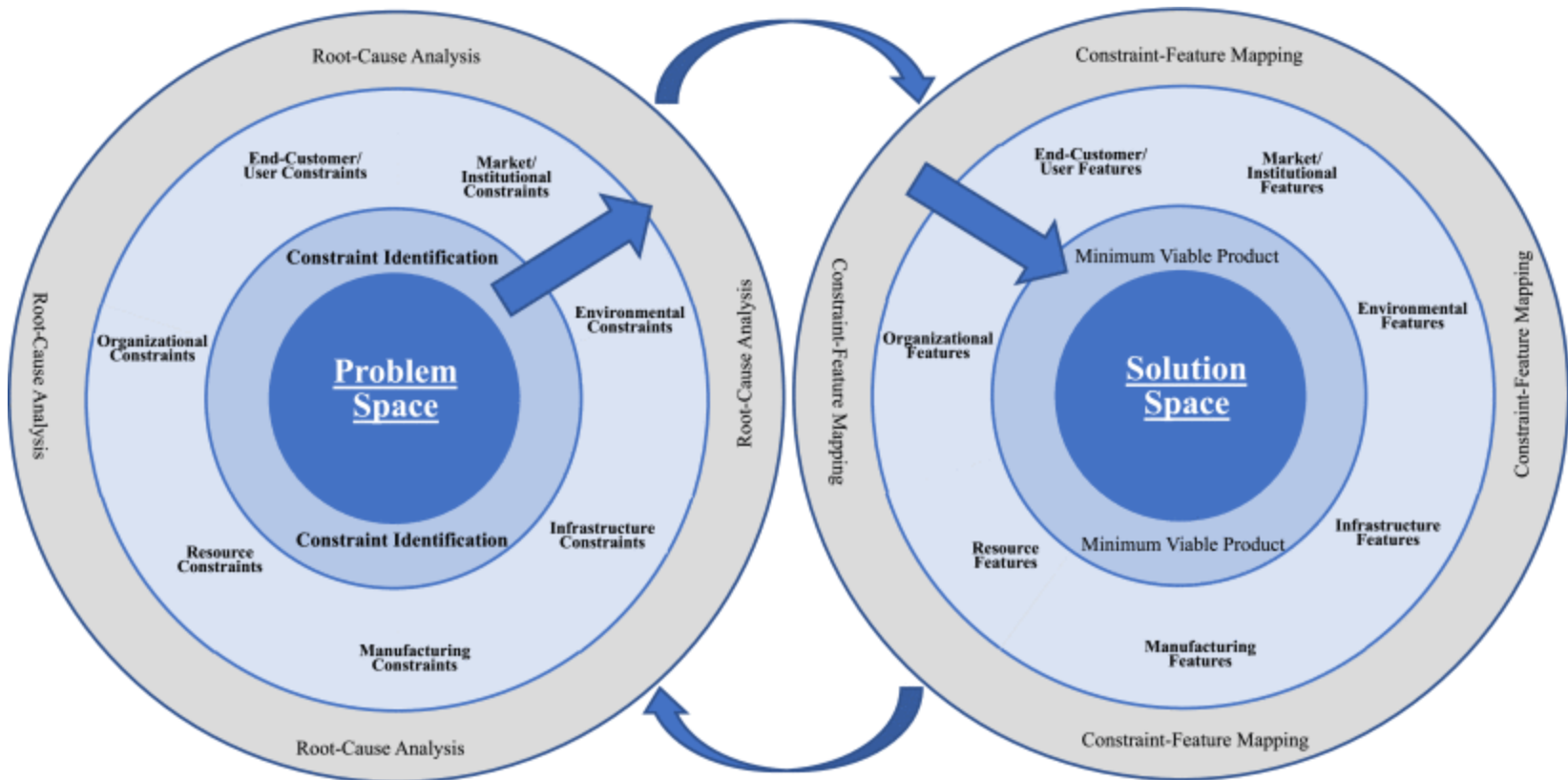


(BACK et al. (2008) and. ROMANO, (2003))

New product development (NPD) is a process or roadmap that guides a new product from ideation to product launch.

# Constrain-Based Thinking.

“Constraint is any factor that places limits or boundaries on creative problem solving.” Even in processes that aim to construct something different, constraints appear on an environmental or individual level and can influence structure and outcome.



# Frugal approach for designing rehabilitation physical systems.

## Mapping of constraints to frugal features for physical rehabilitation products

The world report on disability published by the World Health Organization (WHO) presented that 1 in 7 individuals suffers from disability and 2% to 4% have severe difficulties in functioning. Disability has a higher incidence in low and middle income countries, which include many in Latin America (SCHIAPPACASSE et al., 2019)

Constraint-Feature mapping

Effect

Cause

No physical rehabilitation in patients

Resource Constraints  
 Physiotherapists and required therapy experience not available  
 Rehabilitation equipment unavailable

Work with local healthcare workers  
 Easy-to-use, simple, intuitive products

Manufacturing Constraints  
 Manufacturing challenges  
 Challenge of building a low cost new team

Reduce number of parts  
 Local Partnerships  
 Scalable

Energy Efficient  
 Portátil con tamaño pequeño

Infrastructure Restrictions  
 Inaccessible health services/poor health infrastructure  
 Low internet bandwidth

Environmental/Market/Institucional Constraints  
 Government regulations

Robust  
 Local partnerships

User Restrictions  
 Taboos, culture.  
 Fear of pain from using the product.  
 Low levels of disposable income  
 Low user awareness  
 Lack of health plan  
 Equipment difficult to use

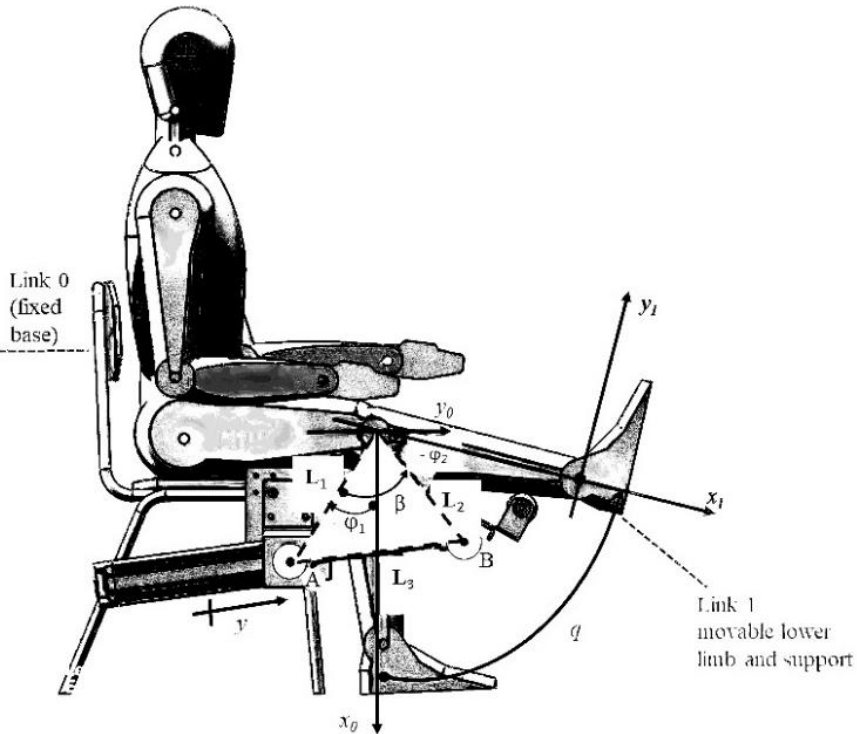
Low cost device  
 Less intimidating  
 Painless and comfortable  
 Transportable

# Frugal approach for designing rehabilitation physical systems.

User Requirements	Weight	(JARRETT; MCDAID, 2017)	(GONÇALVES <i>et al.</i> , 2020)	(KOÇAK; GEZGIN, 2022)	(GONÇALVES; RODRIGUES, 2019)	(CIOBANU <i>et al.</i> , 2018)	(GOERGEN, 2020)
Price	1,6	3	4	4	4	3	4
Transportability	1,5	4	4	4	4	3	4
Complexity	1,4	4	4	4	4	4	4
Supplyability	1,4	3	3	3	3	3	3
Usability	1,3	3	4	4	4	3	5
Robust	1,2	3	3	3	3	3	5
Connectivity	1,2	3	3	3	3	3	3
Aesthetics	1,2	4	4	4	4	4	3
Applicability	1,2	3	3	3	3	3	4
safety of use	1,1	4	4	4	4	4	4
Value of the utility function		44,5	47,4	47,4	47,4	46,1	51,1
Ordering of conceptions		6 <sup>th</sup>	Second	Third	Fourth	5 <sup>th</sup>	First

## QFD

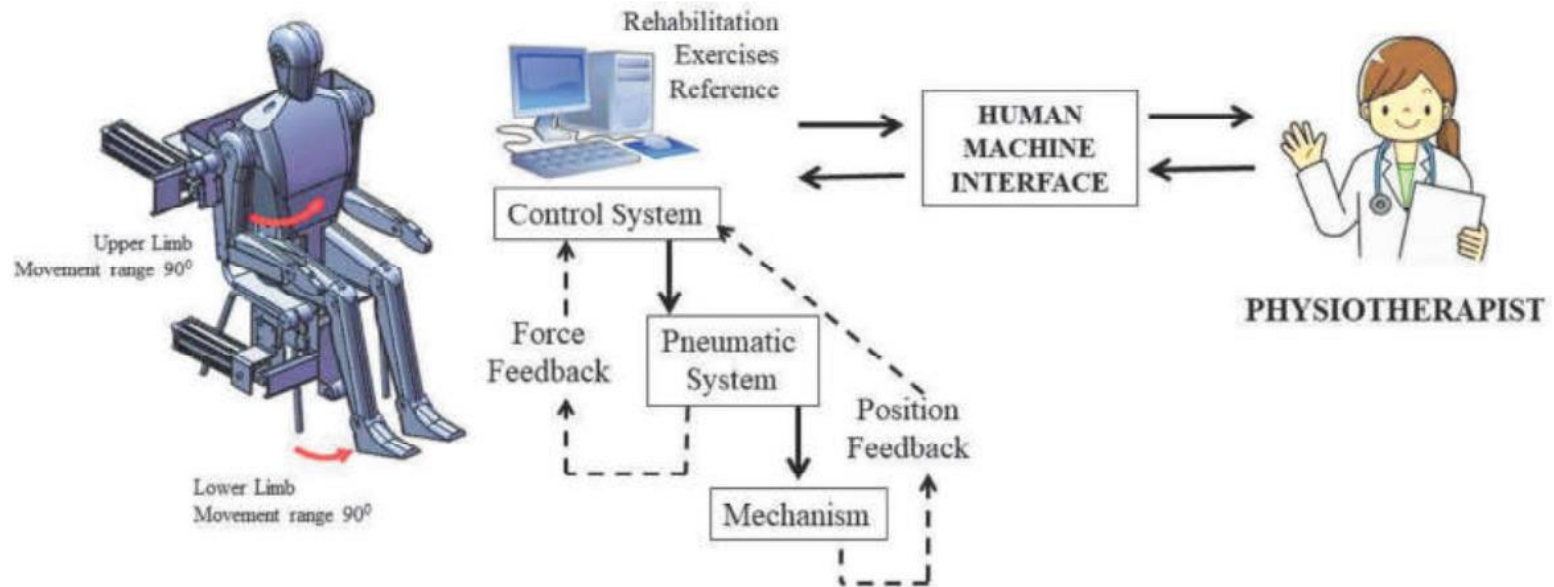
# Frugal approach for designing rehabilitation physical systems.



$$y(q) = \sqrt{L_1^2 + L_2^2 - 2|L_1||L_2|\cos(q - \Delta\varphi)} - L_3 \quad (1)$$



# Frugal approach for designing rehabilitation physical systems.

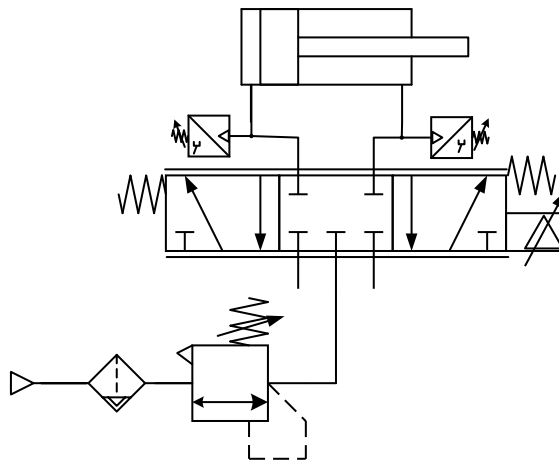


**Fig. 6.** The pneumatically driven robotic workbench for rehabilitation of lower limb

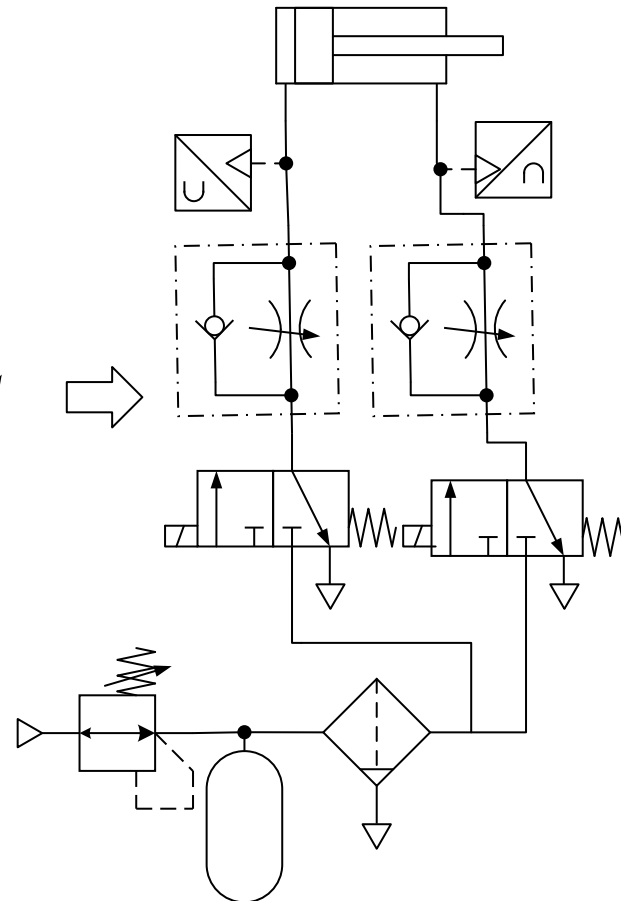
$$y(q) = \sqrt{L_1^2 + L_2^2 - 2|L_1||L_2|\cos(q - \Delta\varphi)} - L_3 \quad (1)$$

# Frugal approach for designing rehabilitation physical systems.

Original  
a. Pneumatic System



b. Pneumatic System Proposal



# Conclusions

1. The future work has as a goal to build a rehabilitation bench using valves on-off ( On-off pneumatic valves).
2. Other configurations will be studied to analyze the price of components vs. energy consumption, to conclude which configuration best meets the Frugal and Sustainable approaches.
3. This article presents the initial stage of the user requirements definition process for frugal innovations. This work combines the PRODIP reference model and the Constraint-Based thinking method on the way to develop a special methodology for the development of frugal mechatronic products for industry 4.0 and 5.0.

CONCLUSIONS



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**THANKS !!!**

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