

7 Ferramentas Básicas da Qualidade

PME3463 Introdução à Qualidade

Escola Politécnica da Universidade de São Paulo

Departamento de Engenharia Mecânica

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7 Ferramentas Básicas da Qualidade

- Kaoru Ishikawa (1915-1989):
 - “95% do problemas relacionados à qualidade na indústria podem ser resolvidos com sete ferramentas básicas da qualidade!”
- Sete Ferramentas Básicas
 1. Diagrama de Ishikawa (causa-e-efeito)
 2. Lista de verificação (check sheet)
 3. Carta de controle
 4. Histograma
 5. Diagrama de Pareto
 6. Diagrama de dispersão
 7. Estratificação (ou Fluxograma)

ISO 13053-1:2011

Quantitative methods in process improvement -- Six Sigma -- Part 1: DMAIC methodology

ISO 13053-1:2011 describes a methodology for the business improvement methodology known as Six Sigma. The methodology typically comprises five phases: define, measure, analyze, improve and control (DMAIC).

ISO 13053-1:2011 recommends the preferred or best practice for each of the phases of the DMAIC methodology used during the execution of a Six Sigma project. It also recommends how Six Sigma projects should be managed and describes the roles, expertise and training of the personnel involved in such projects. It is applicable to organizations using manufacturing processes as well as service and transactional processes.

The screenshot shows the ISO website's product page for ISO 13053-1:2011. The page features the ISO logo and the text 'International Organization for Standardization' and 'When the world agrees'. The navigation menu includes 'Standards', 'All about ISO', 'Taking part', and 'Store'. The breadcrumb trail is 'Store > Standards catalogue > Browse by ICS > 03 > 03.120 > 03.120.30 > ISO 13053-1:2011'. The main title is 'ISO 13053-1:2011' with a 'Preview' button. Below the title is the subtitle 'Quantitative methods in process improvement -- Six Sigma -- Part 1: DMAIC methodology'. A callout box states: 'This standard was last reviewed and confirmed in 2016. Therefore this version remains current.' The description reads: 'ISO 13053-1:2011 describes a methodology for the business improvement methodology known as Six Sigma. The methodology typically comprises five phases: define, measure, analyse, improve and control (DMAIC). ISO 13053-1:2011 recommends the preferred or best practice for each of the phases of the DMAIC methodology used during the execution of a Six Sigma project. It also recommends how Six Sigma projects should be managed and describes the roles, expertise and training of the personnel involved in such projects. It is applicable to organizations using manufacturing processes as well as service and transactional processes.' The 'Buy this standard' section shows the price 'CHF 138' and a 'Buy' button. The 'Format' dropdown is set to 'PDF' and the 'Language' dropdown is set to 'English'. The 'General information' section includes: 'Current status: Published', 'Publication date: 2011-09', 'Edition: 1', 'Number of pages: 32', 'Technical Committee: ISO/TC 69/SC 7 Applications of statistical and related techniques for the implementation of Six Sigma', and 'ICS: 03.120.30 Application of statistical methods'. The footer includes 'Customer care' with contact information and 'Opening hours: Monday to Friday - 09:00-12:00, 14:00-17:00 (UTC+1)'. There is also a 'Got a question? Check out our FAQs' link.

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Current status: Published, Publication date: 2011-09

Edition: 1, Number of pages: 32

Technical Committee: ISO/TC 69/SC 7 Applications of statistical and related techniques for the implementation of Six Sigma

ICS: 03.120.30 Application of statistical methods

ISO 13053-2:2011

Quantitative methods in process improvement -- Six Sigma -- Part 2: Tools and techniques

ISO 13053-2:2011 describes the tools and techniques, illustrated by factsheets, to be used at each phase of the DMAIC approach. The methodology set out in ISO 13053-1 is generic and remains independent of any individual industrial or economic sector. This makes the tools and techniques described in ISO 13053-2:2011 applicable to any sector of activity and any size business seeking to gain a competitive advantage.

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International Organization for Standardization
When the world agrees

Standards | All about ISO | Taking part | **Store**

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ISO 13053-2:2011

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<input checked="" type="checkbox"/> PDF	English
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Pacotes do R

- **Scrucca, L. (2004). qcc: an R package for quality control charting and statistical process control. R News 4/1, 11-17.**
- **Emilio L. Cano, Javier M. Moguerza and Andres Redchuk (2012) Six Sigma with R. Springer, New York**
- **Emilio L. Cano, Javier M. Moguerza and Mariano Prieto Corcoba (2015) Quality Control with R. Springer, New York**

1 – Diagrama de Ishikawa

- Diagrama de causa-e-efeito ou diagrama de espinha de peixe.
- Serve para analisar os fatores (causas) que estão relacionado com um problema ou oportunidade de melhoria (efeito).
- Serve para organizar e documentar ideias e conceitos. Pode ser realizado juntamente com um processo de Brainstorming.
- Desenvolvido da saída (efeito) para as possíveis entradas (causas).

Etapas na elaboração de diagrama de Ishikawa

Selecione um problema ou oportunidade de melhoria (efeito)



Identifique as principais causas organizando em categorias (6M)



Identifique as causas associadas a cada categoria (espinhas)



Detalhe as causas até nível apropriado



Construa o diagrama de Ishikawa



Avalie as causas comprovadas e documentas indicando-as no diagrama

Principais categorias de causas (6M)

Mão-de-obra (*Man*)

- recursos humanos, capital intelectual

Máquina (*Machines*)

- instalações, equipamentos, capital fixo

Materiais (*Materials*)

- matérias primas, insumos, consumíveis

Método (*Methods*)

- processo, metodologias, procedimentos, tecnologia

Metrologia (Measurements)

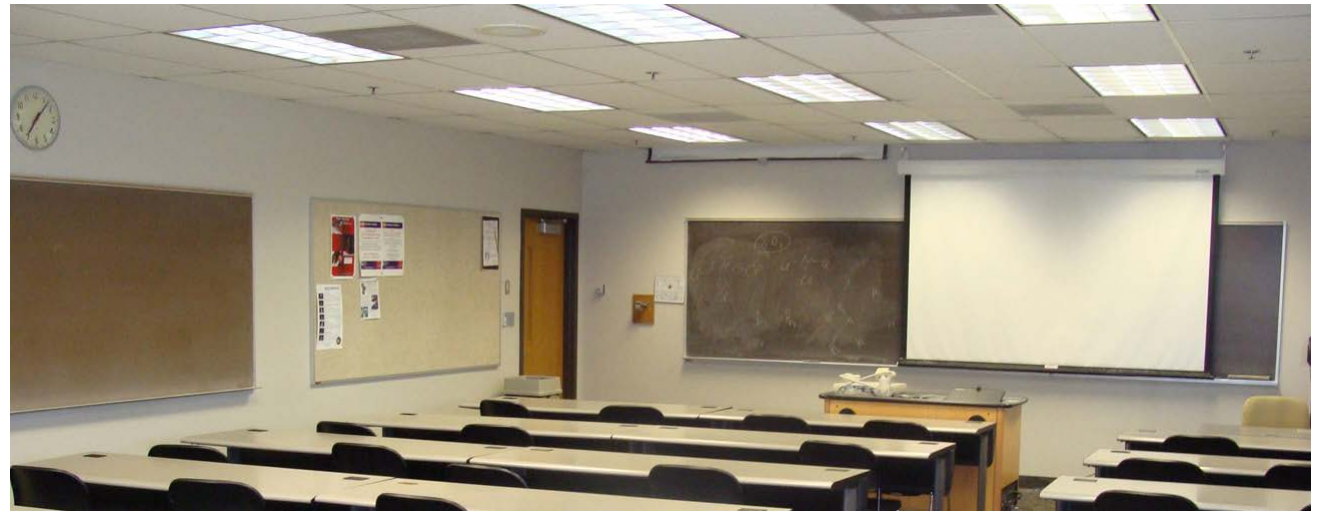
- medições, inspeção, avaliação quantitativa

Meio ambiente (Mother Nature
– environment)

- natureza, clima, ambiente sócio-político, externalidades

Exemplo

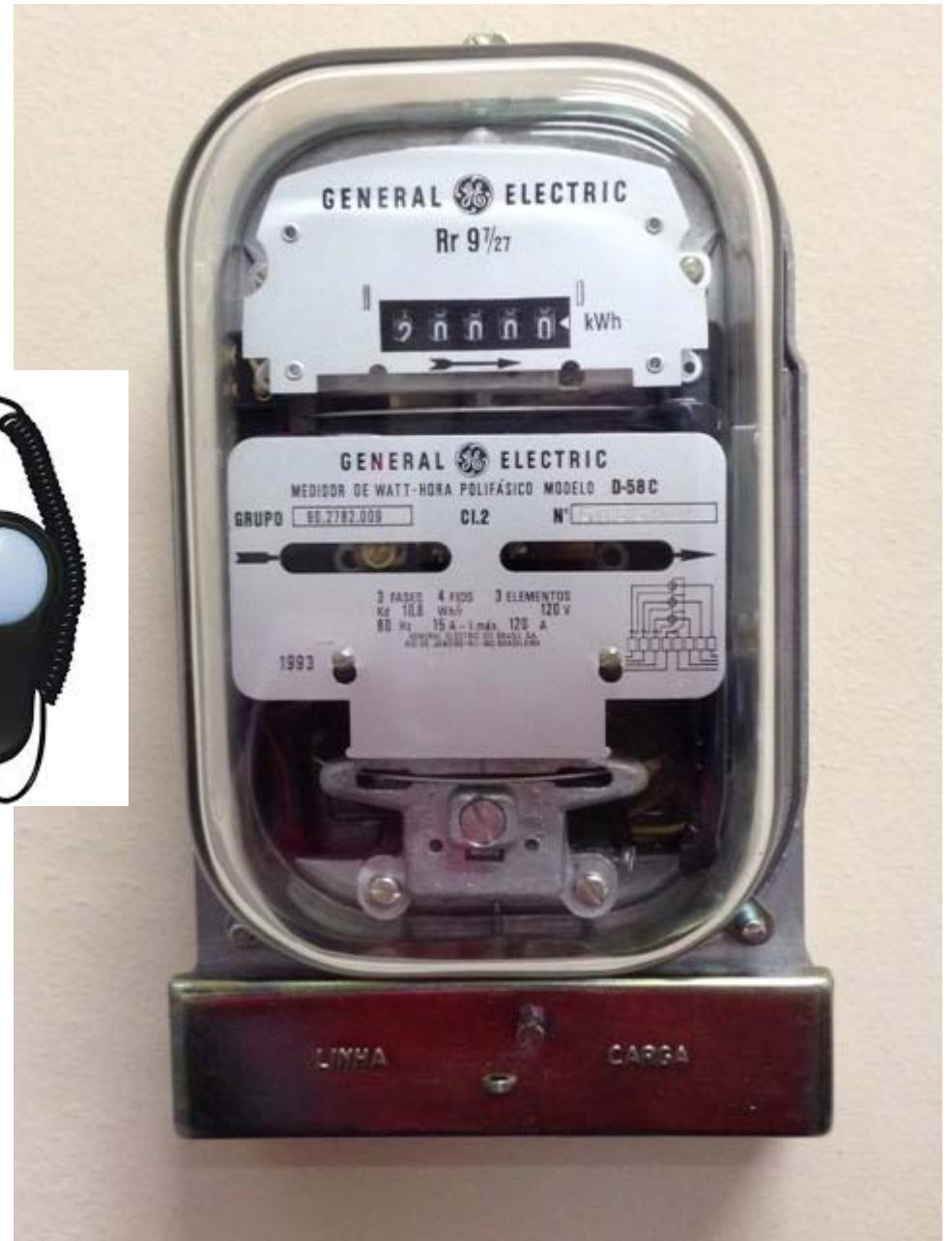
- Descrição do Problema
 - Iluminação na sala de aula A1A
- Aspectos
 - atividades nas mesas
 - monitores de computador
 - bancadas de ensaio
 - utilização da lousa
 - projeção de transparências
- Pessoal envolvido
 - Usuários: alunos e professores
 - Suporte: instalação, manutenção, segurança e responsáveis
 - Manutenção: limpeza e conservação
- Utilização
 - Aulas expositivas
 - Aulas de simulação em computador
 - Aulas de laboratório



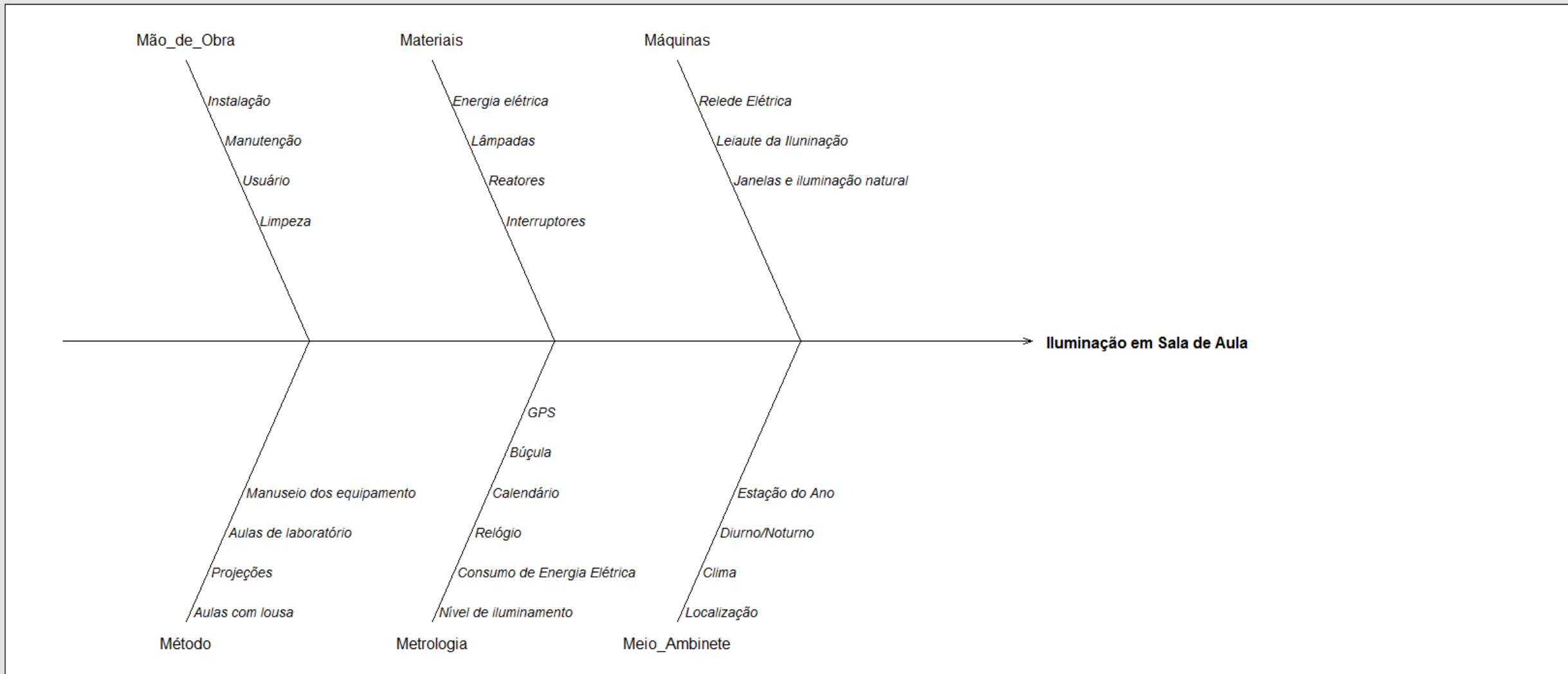
NR 17 – ERGONOMIA

Iluminação no Local de Trabalho

- 17.5.3. Em todos os locais de trabalho deve haver iluminação adequada, natural ou artificial, geral ou suplementar, apropriada à natureza da atividade.
- 17.5.3.1. A iluminação geral deve ser uniformemente distribuída e difusa.
- 17.5.3.2. A iluminação geral ou suplementar deve ser projetada e instalada de forma a evitar ofuscamento, reflexos incômodos, sombras e contrastes excessivos.
- 17.5.3.3. Os níveis mínimos de iluminamento a serem observados nos locais de trabalho são os valores de iluminâncias estabelecidos na NBR 5413, norma brasileira registrada no INMETRO.
- 17.5.3.4. A medição dos níveis de iluminamento previstos no subitem 17.5.3.3 deve ser feita no campo de trabalho onde se realiza a tarefa visual, utilizando-se de luxímetro com fotocélula corrigida para a sensibilidade do olho humano e em função do ângulo de incidência.
- 17.5.3.5. Quando não puder ser definido o campo de trabalho previsto no subitem 17.5.3.4, este será um plano horizontal a 0,75m (setenta e cinco centímetros) do piso.



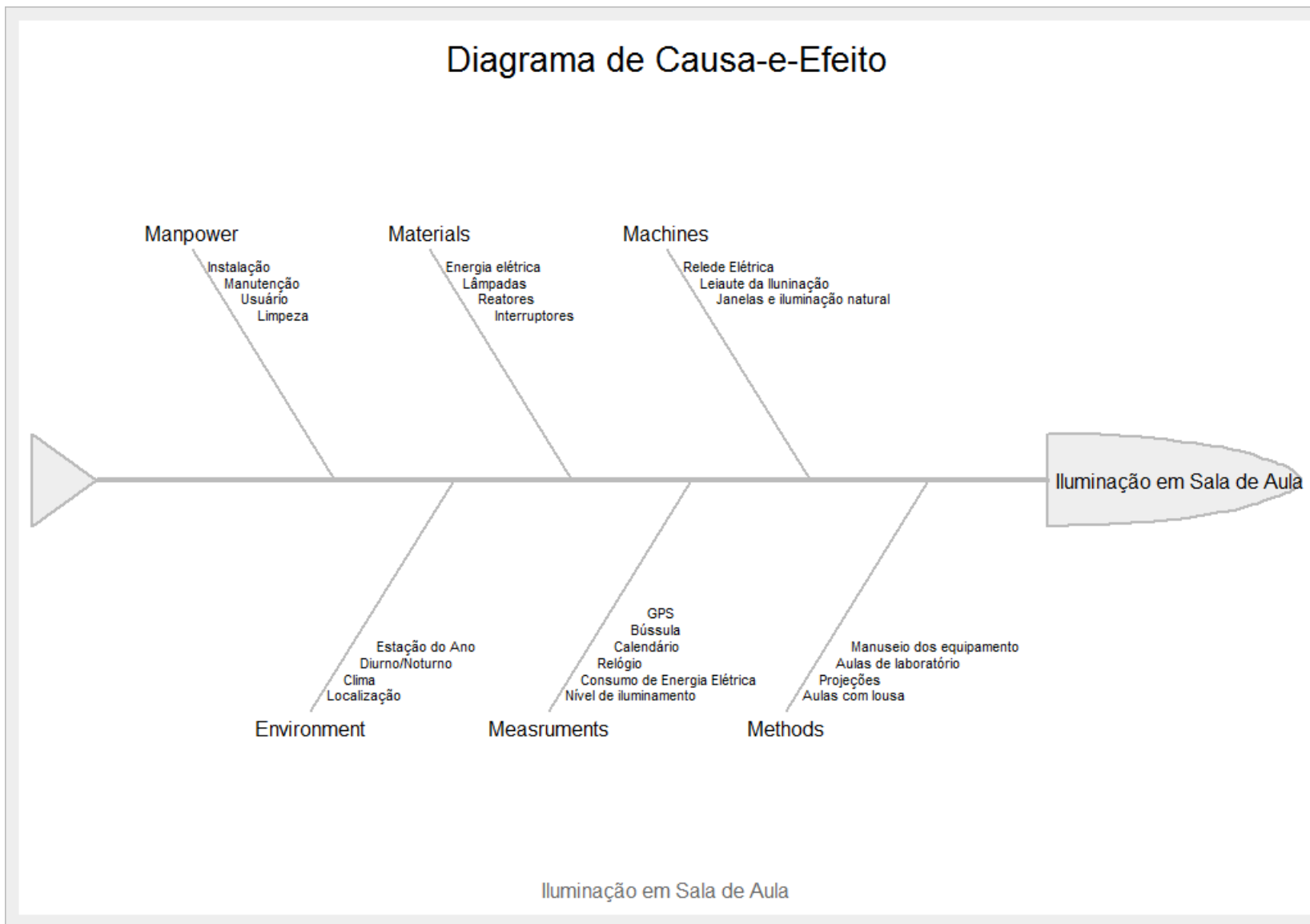
Cause-and-Effect diagram



Fonte:

Exemplo de Diagrama de Ishikawa produzido com Pacote qcc do R

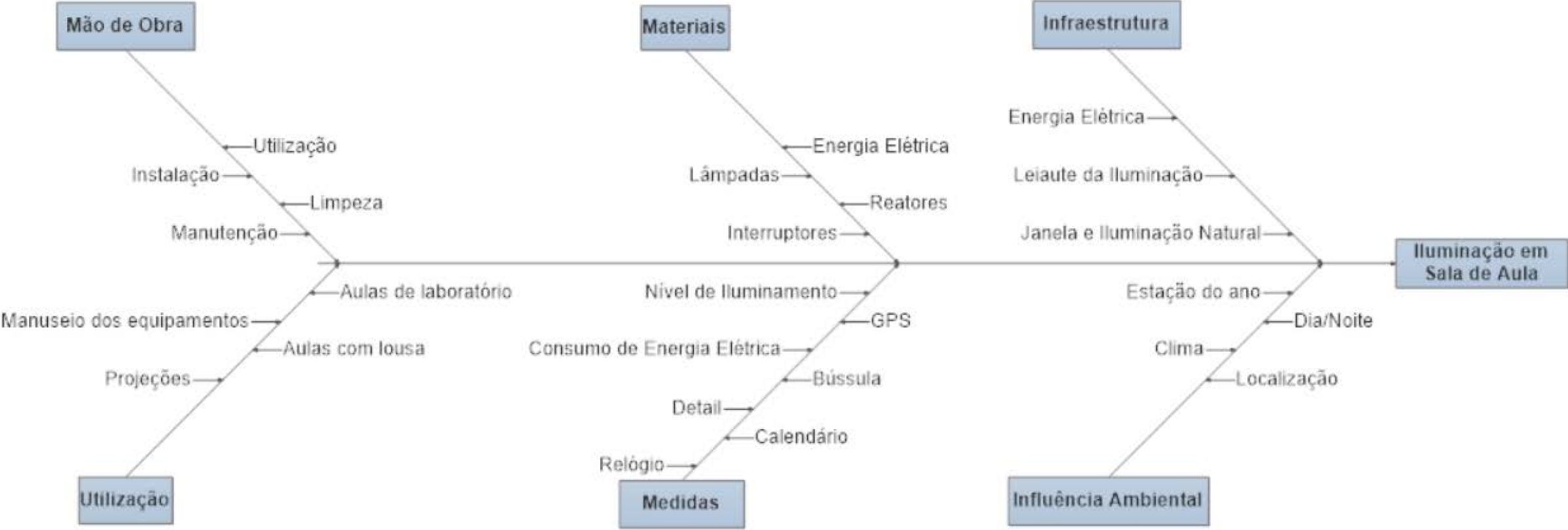
Diagrama de Causa-e-Efeito



Fonte:

Exemplo de Diagrama de Ishikawa produzido com Pacote SixSigma do R

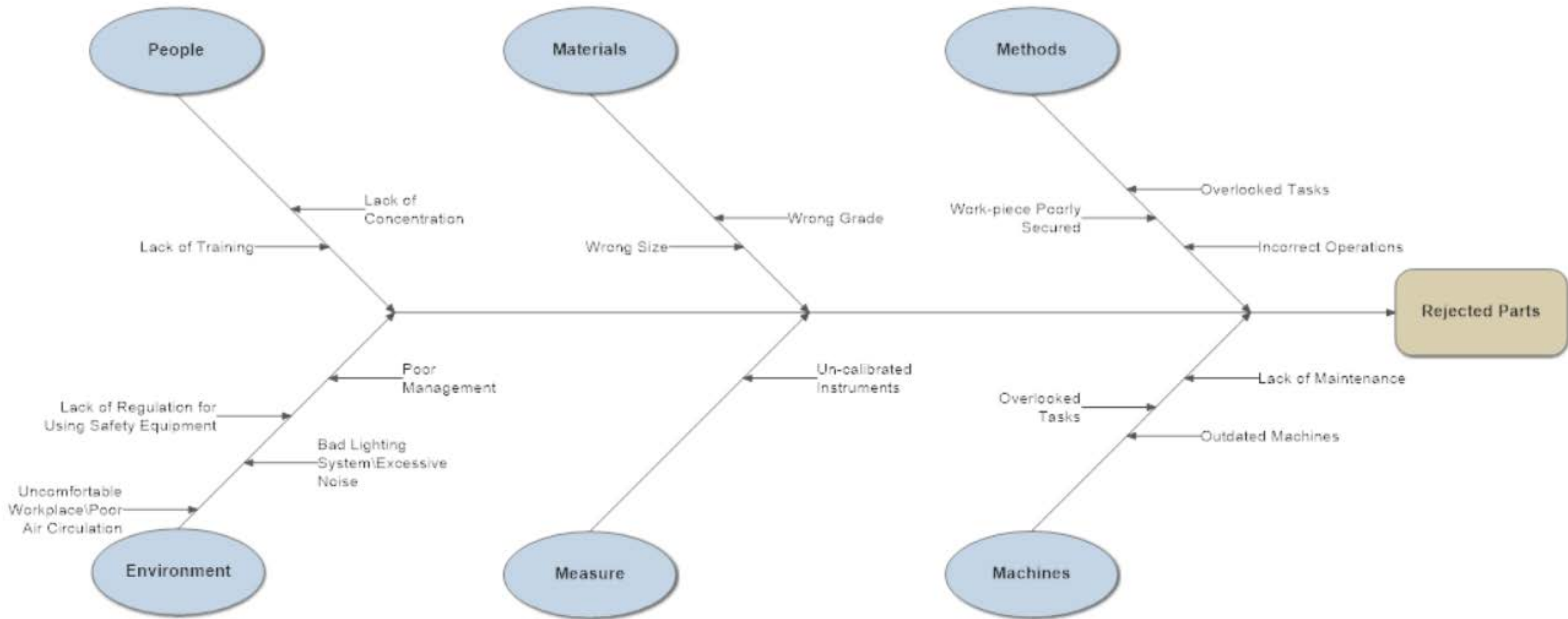
Iluminação em sala de aula



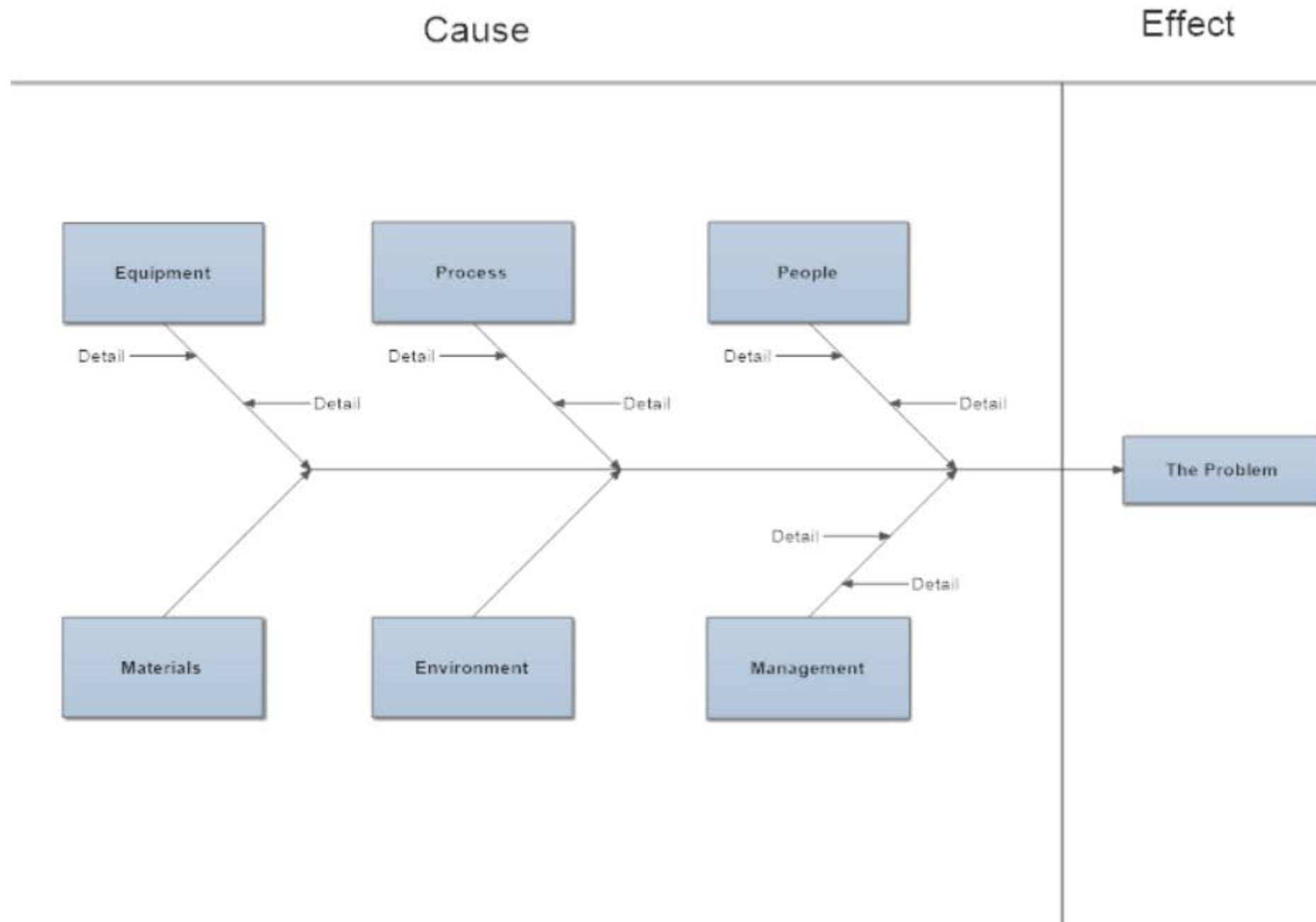
Fonte:
Exemplo de Diagrama de Ishikawa produzido pelo SmartDraw <https://www.smartdraw.com/>

Outros exemplos

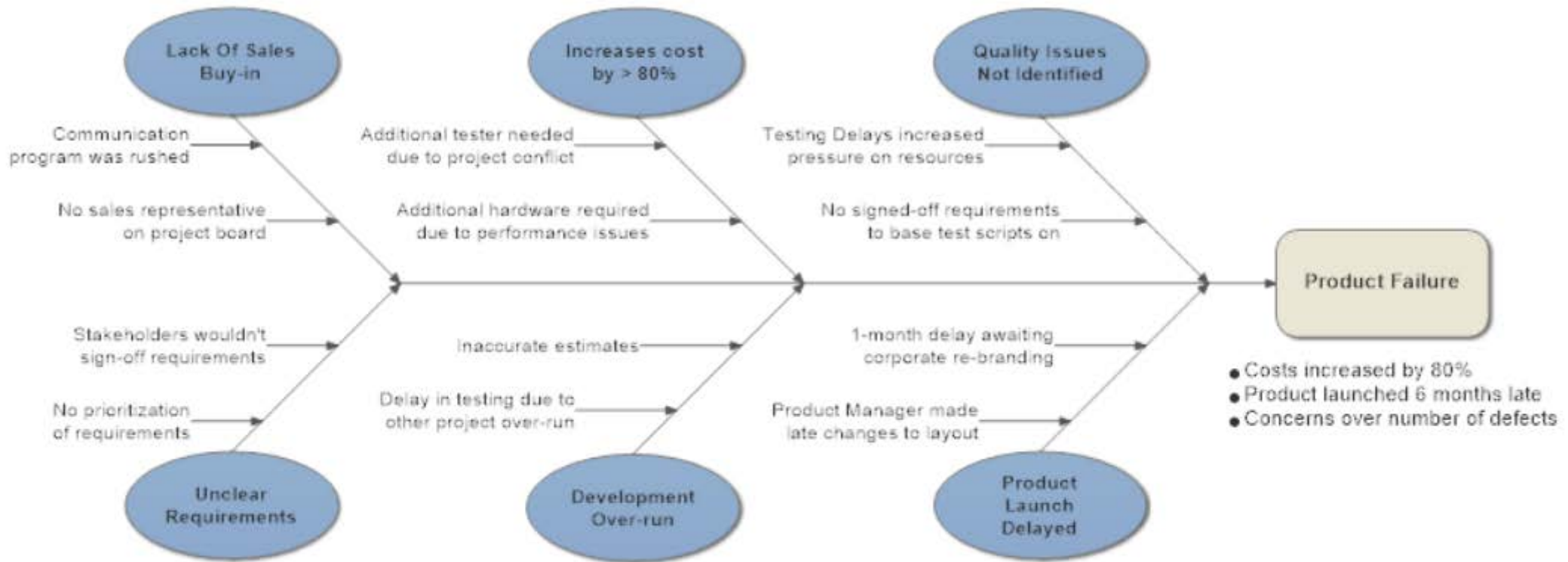
Possible causes for producing the low quality machine parts



Fonte:
Exemplo de Diagrama de Ishikawa produzido pelo SmartDraw <https://www.smartdraw.com/>



Fonte:
Exemplo de Diagrama de Ishikawa produzido pelo SmartDraw <https://www.smartdraw.com/>



Action Plan:

- Carry out review of testing approach and procedures (QA Manager)
- Source suitable requirements and estimating training for development team (HR)
- Arrange meeting with Sales to revitalize product support (Project Manager)
- Revisit project communications to ensure clear project message has been given (Project Manager)

2 – Lista de Verificação

- Tabela para coletar e resumir informações
- Contagem de ocorrência de eventos: ocorrências, consultas, falhas, defeitos, não-conformidades, etc
- Fácil utilização, visualização e interpretação
- Coleta de dados de forma padronizada
- É um Registro da Qualidade, portanto deve ser devidamente identificada, datada, e assinada por responsável

Etapas na elaboração da Lista de Verificação

Elabore uma lista de verificação específica para cada aplicação



Considere os requisitos administrativos e técnicos para Registros da Qualidade



Realize a coleta de dados – a entrada de dados deve ser simples e segura



Complete a lista com estatísticas básicas e gráficos simplificados



Avalie os resultados

Exemplos de listas de verificação

Last Name | First Name | Middle Initial

Street

City | State | Zip

<u>Numero</u>	<u>Data</u>	<u>Horario</u>	<u>Local</u>	<u>Posicao</u>	<u>Iluminamento</u>	<u>Utilizacao</u>

Comments:

yes no

Signature

Name

Title

Date

Fonte:

Exemplo de Lista de Verificação produzido pelo SmartDraw <https://www.smartdraw.com/>

Requirements Feature Matrix

	Product Features															
Customer Requirements																

Relationship: Strong Moderate Weak

Fonte:
Exemplo de Lista de Verificação produzido pelo SmartDraw <https://www.smartdraw.com/>

Data Stratification	
Factors	Examples
Who	
What	
When	
Where	

Fonte:

Exemplo de Lista de Verificação produzido pelo SmartDraw <https://www.smartdraw.com/>

MP3 PLAYER - REQUIREMENT FEATURE MATRIX

Customer requirements	Product Features																		
	Size	Weight	Price	Number of records	Bundled software	1 year warranty	NiMH Battery	Backlit LCD	Click	FM Tuner	Stopwatch	Large buttons	Earphones	Guide	Memory	Padded case	Waterproof	Armband	Belt-clip
Small size	●														○	○			
Light weight		●					○								○	○			
Affordable			●				○								○				
Versatility					●			○	○	○					△		△	△	
Upgradeable					●										●				
Reliable						●													
Large storage capability															●				
Good sound quality					○								●						
Durable																●	○		
Easy to use							●				●		●						
Long battery life						●													
Attractive	○			●			○				○					△	△	△	△
Easily portable	○	●															○	●	●

Relationship: ● Strong ○ Moderate △ Weak

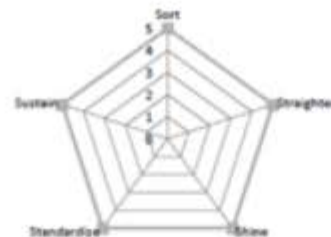
Fonte:

Exemplo de Lista de Verificação produzido pelo SmartDraw <https://www.smartdraw.com/>

5S Audit

Area		Audit Date	
Manager		Supervisor	

Category	Score
Sort	
Straighten	
Shine	
Standardize	
Sustain	
Total Points	
5S Score	
Previous Score	
% Change	



No.	Check Item	Description	Score					
			0	1	2	3	4	5
SORT	1	Materials or part	Does the inventory or in-process inventory include any unneeded materials or parts?					
	2	Machines or equipment	Are there any unused machines or other equipment around?					
	3	Jigs, tools, or dies	Are there any unused jigs, tools, dies or similar items around?					
	4	Visual control	Is it obvious which items have been marked as unnecessary?					
	5	Written standards	Has establishing the 5S left behind any useless standard?					
Sub Total								
Sort Average								

No.	Check Item	Description	Score					
			0	1	2	3	4	5
STRAIGHTEN	1	Location indicators	Are shelves and other storage areas marked with location indicators and addresses?					
	2	Item indicators	Do the shelves have signboards showing which items go where?					
	3	Quantity indicators	Are the maximum and minimum allowable quantities indicated?					
	4	Demarcation of walkways and in-process inventory areas	Are white lines or other markers used to clearly indicate walkways and storage areas?					
	5	Jigs and tools	Are jigs and tools arranged more rationally to facilitate picking them up and returning them?					
Sub Total								
Straighten Average								

No.	Check Item	Description	Score					
			0	1	2	3	4	5
SHINE	1	Floors	Are floors kept shiny clean and free of waste, water and oil?					
	2	Machines	Are the machine wiped clean often and kept free of shavings, chips and oil?					
	3	Cleaning and checking	Is equipment inspection combined with equipment maintenance?					
	4	Cleaning responsibilities	Is there a person responsible for overseeing cleaning operations?					
	5	Habitual cleanliness	Do operators habitually sweep floors, and wipe equipment without being told?					
Sub Total								
Shine Average								

No.	Check Item	Description	Score					
			0	1	2	3	4	5
STANDARDIZE	1	Improvement memos	Are improvement memos regularly being generated?					
	2	Improvement ideas	Are improvement ideas being acted on?					
	3	Key procedures	Are standard procedures clear, documented and actively used?					
	4	Improvement plan	Are the future standards being considered with a clear improvement plan for the area?					
	5	The first 3 5S	Are the first 3 5S (sort, set locations and shine) being maintained?					
Sub Total								
Standardize Average								

No.	Check Item	Description	Score					
			0	1	2	3	4	5
SUSTAIN	1	Training	Is everyone adequately trained in standard procedure?					
	2	Tools and parts	Are tools and parts being stored correctly?					
	3	Stock controls	Are stock controls being adhered to?					
	4	Procedures	Are procedures up-to-date and regularly reviewed?					
	5	Activity boards	Are activity boards up-to-date and regularly reviewed?					
Sub Total								
Sustain Average								

Grand Total Score	
Grand Average	

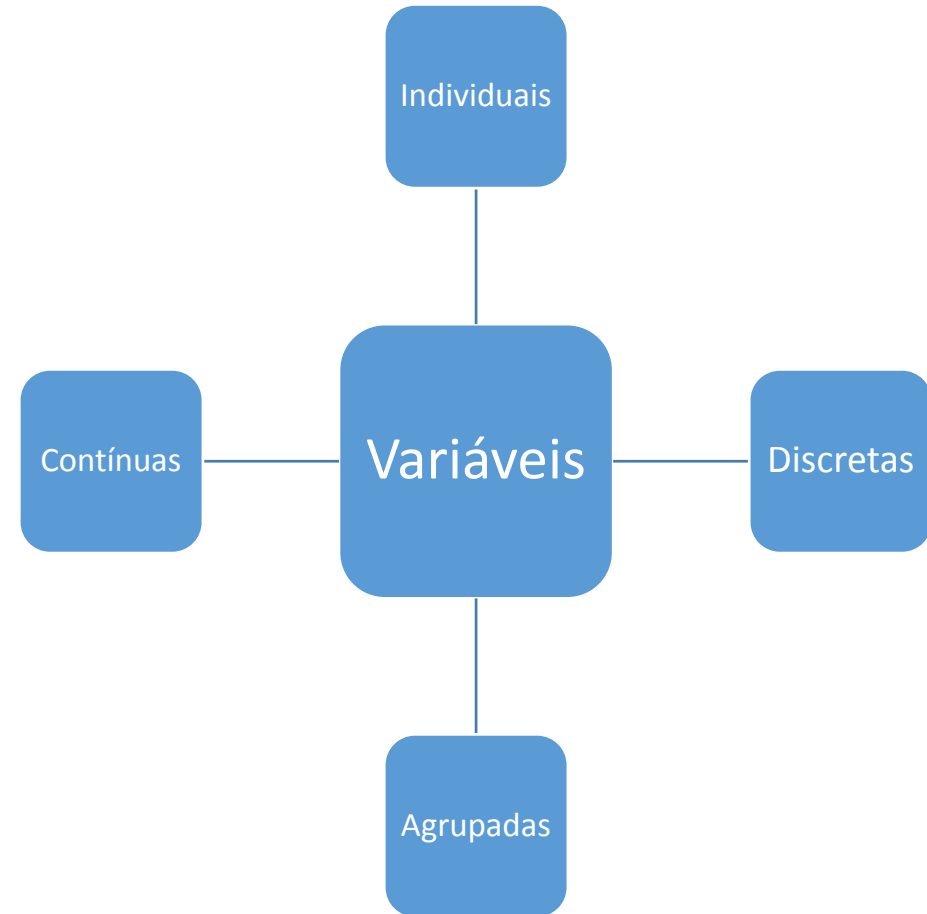
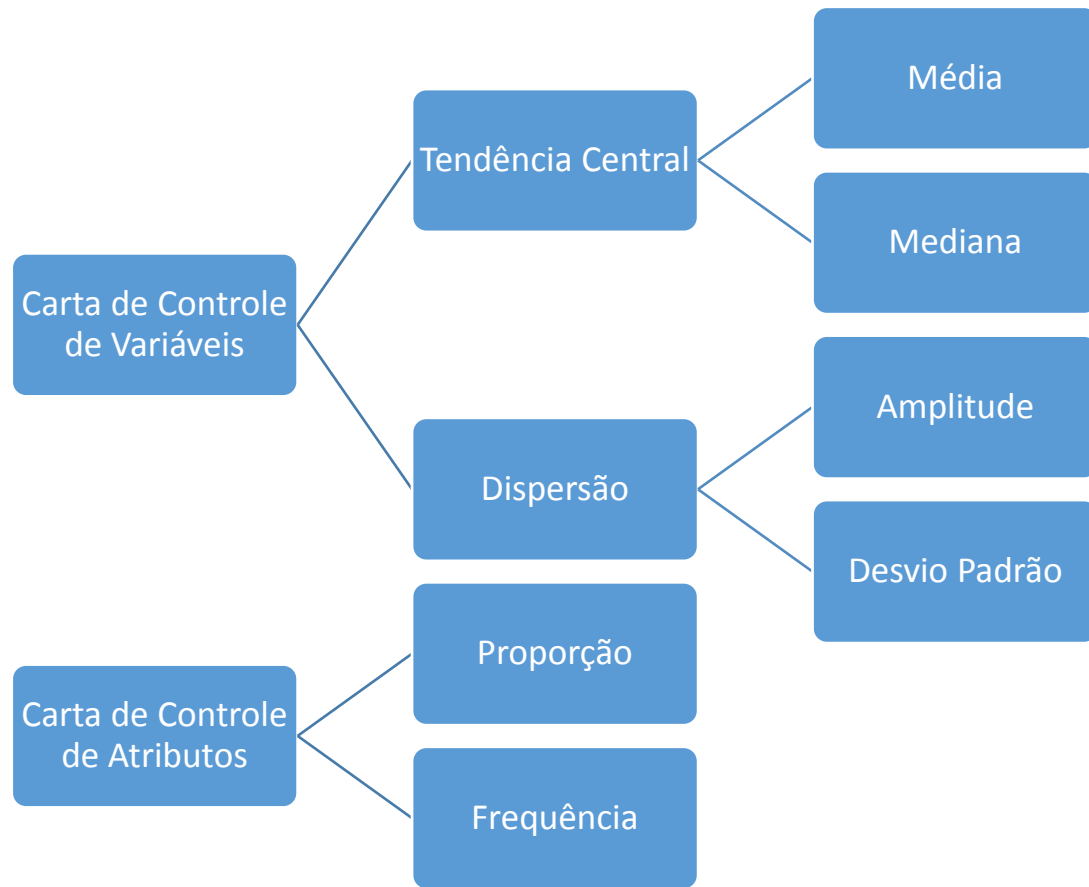
Fonte:

Exemplo de Lista de Verificação para Auditoria de 5S produzido pelo SmartDraw <https://www.smartdraw.com/>

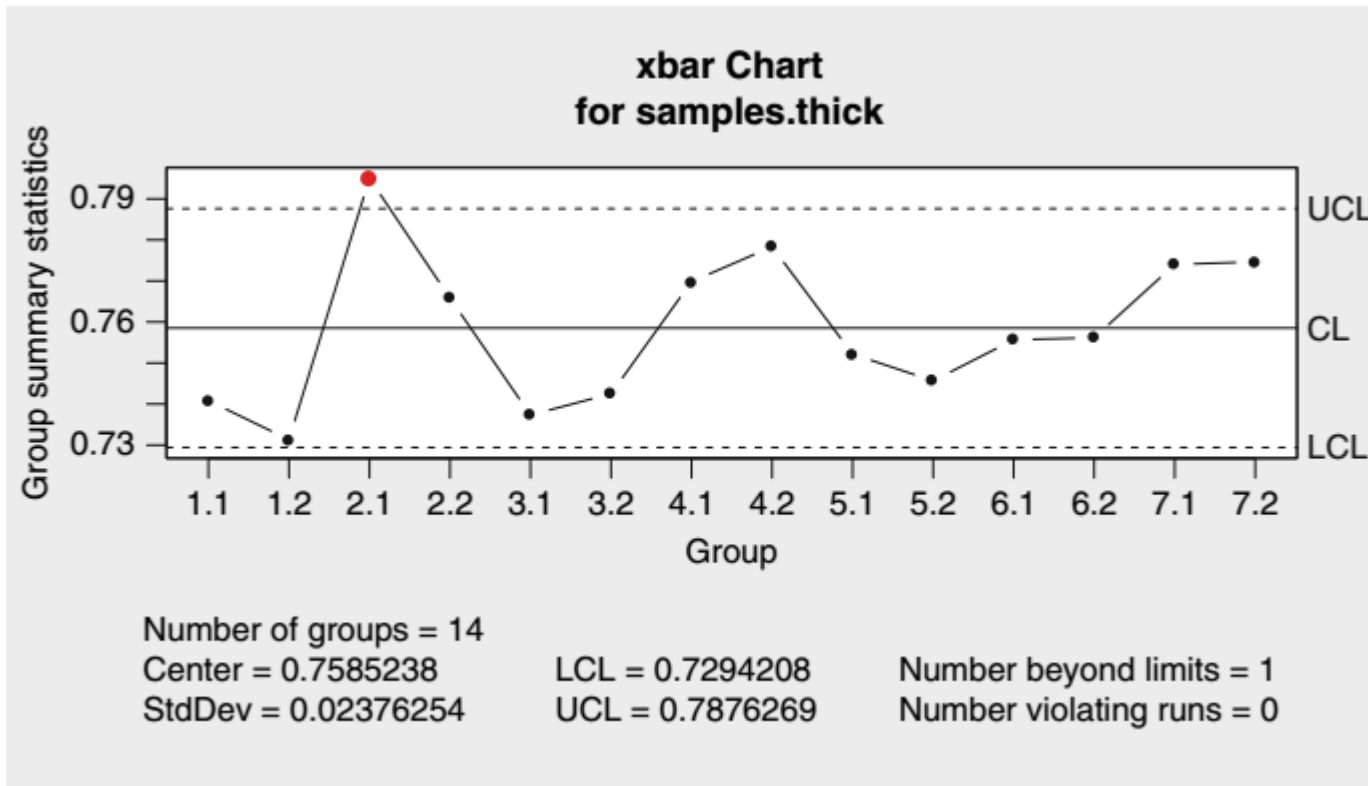
3 – Carta de Controle

- Desenvolvidas por Walter Shewhart (1891-1967)
- Registra a evolução das variáveis ao longo do tempo (produção)
- Utilizada para avaliar estabilidade de processos
- Controle Estatístico de Processos - CEP
- Comumente utilizada em conjunto com Análise de Capacidade
- Detecta causas especiais (desgastes, desajustes, modificações, ações indevidas)
- Aplicáveis à variáveis com distribuição próximas da normal

Tipos de Cartas de Controle



Carta de Controle da Média \bar{x}



- Linha de centro

$$CL_{\bar{x}} = \mu$$

- Limite superior da carta

$$UCL_{\bar{x}} = \mu + 3 \frac{\sigma}{\sqrt{n}}$$

- Limite inferior da carta

$$LCL_{\bar{x}} = \mu - 3 \frac{\sigma}{\sqrt{n}}$$

4 - Histograma

- Apresentação gráfica das frequências de eventos ou valores contidos em faixas
- Apresenta a distribuição de frequências
- Permite observar a tendência central, dispersão, simetria e forma da distribuição de valores da amostra
- Pode ser construída para variáveis qualitativas ordinais ou para variáveis quantitativas, discretas ou contínuas

Etapas na elaboração do Histograma

Colete o número suficiente de elementos (tamanho da amostra $\gg 9$)



Escolha o número de faixas e a largura das faixas (\sqrt{n} , $\log_2(n)$, Scott - 1079, Freedman & Diaconis - 1981, Sturges - 1926)



Compute a frequência de observações em cada faixa



Construa o gráfico de barras da frequência por faixa



Acrescente a curva de proporções acumuladas

Histograma

- Tamanho da amostra: n

- Amplitude:

$$R = \max(x_i) - \min(x_i)$$

- Número de faixas:

$$k \approx \sqrt{n} \qquad k \approx \log_2(n)$$

- Largura de faixa:

$$\Delta \approx \frac{R}{k}$$

- Limites das Faixas:

$$\min(x_i); \min(x_i) + \Delta; \min(x_i) + 2\Delta; \dots; \min(x_i) + (k - 1)\Delta$$

- Frequência:

$$f_i = \text{cont}(x_i) \quad |\{ \min(x_i) + (i - 1)\Delta \leq x_i < \min(x_i) + i\Delta \}$$

- Proporção (frequência relativa):

$$p_i = \frac{f_i}{n}$$

Exemplo Histograma: v.a. discreta

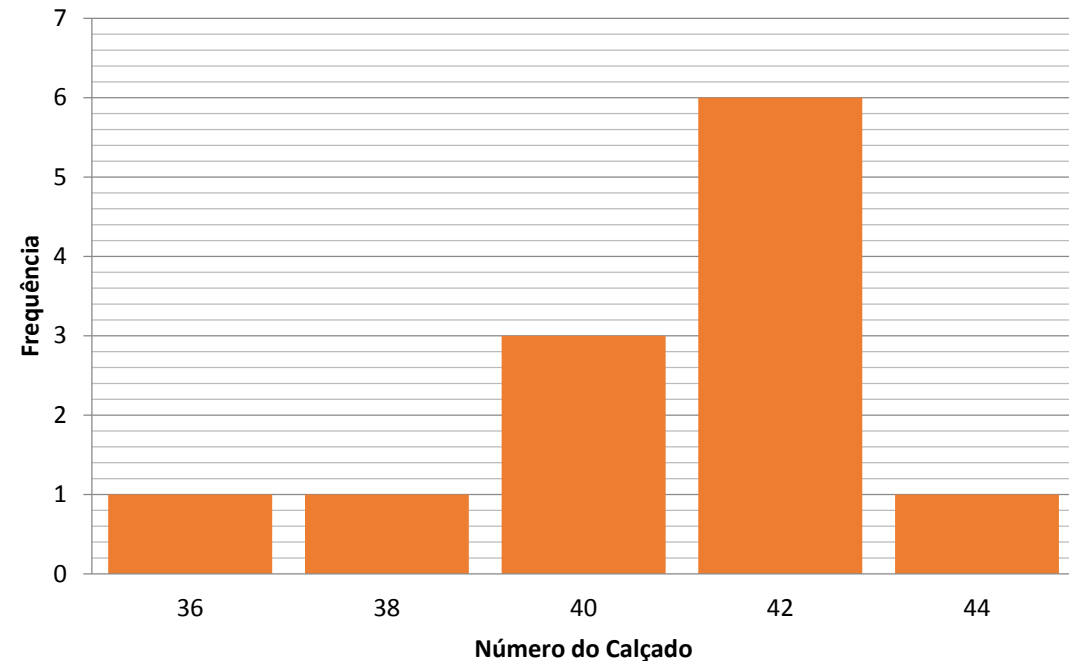
- Número do calçado dos alunos:

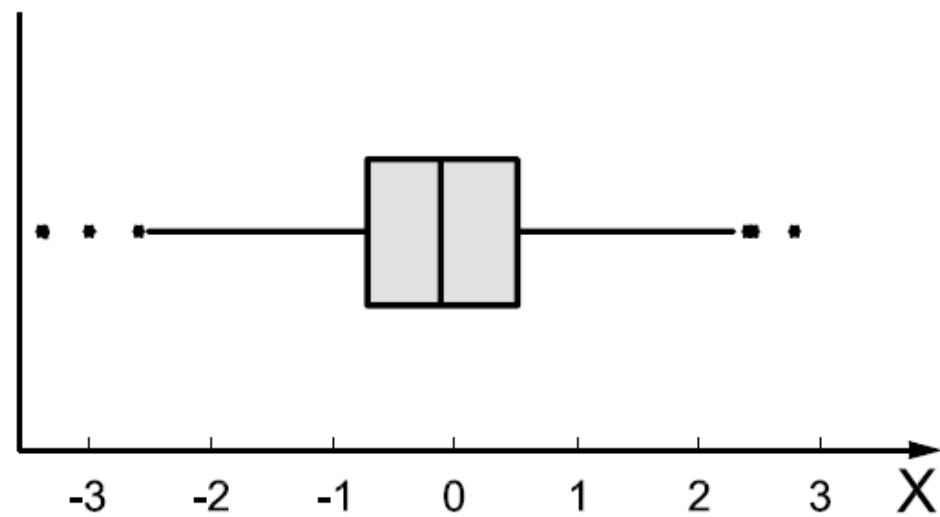
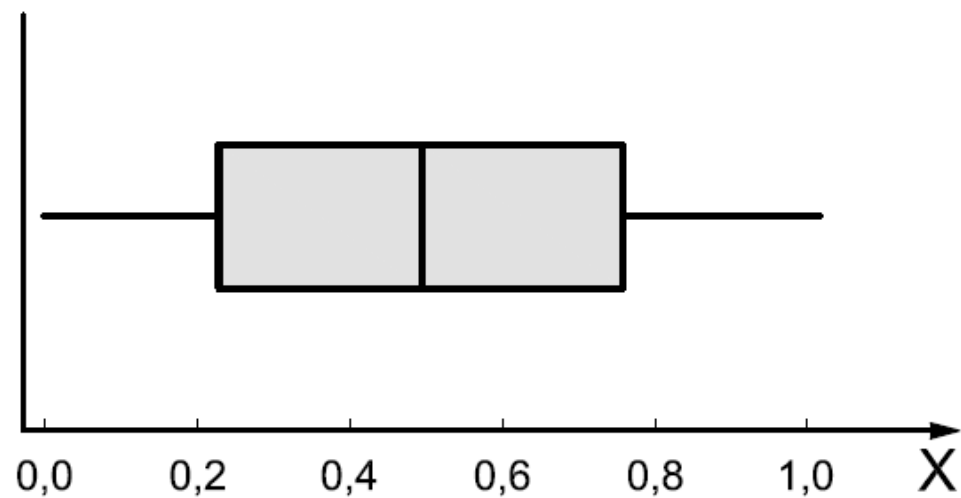
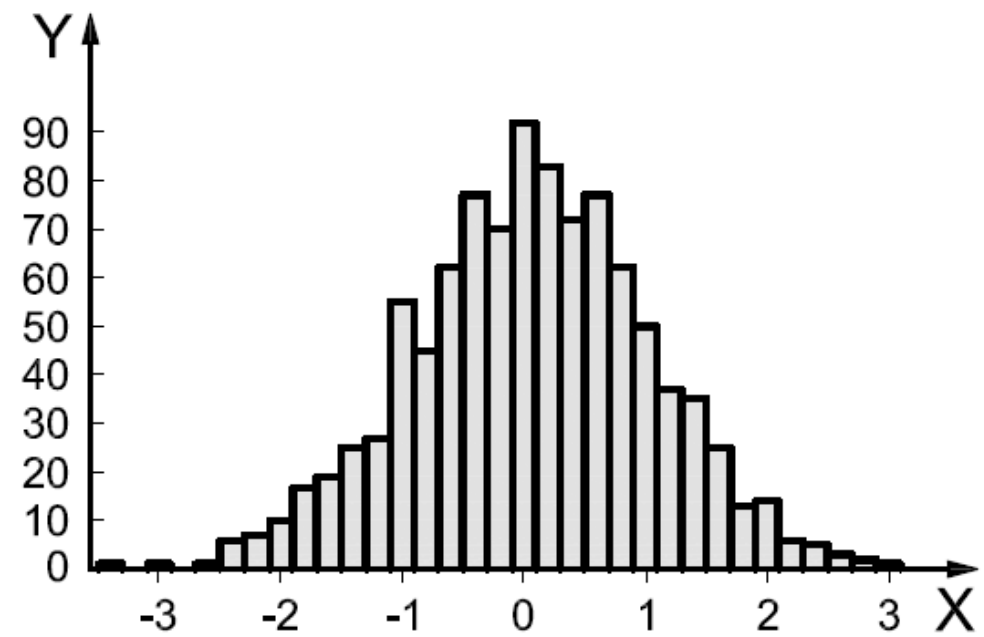
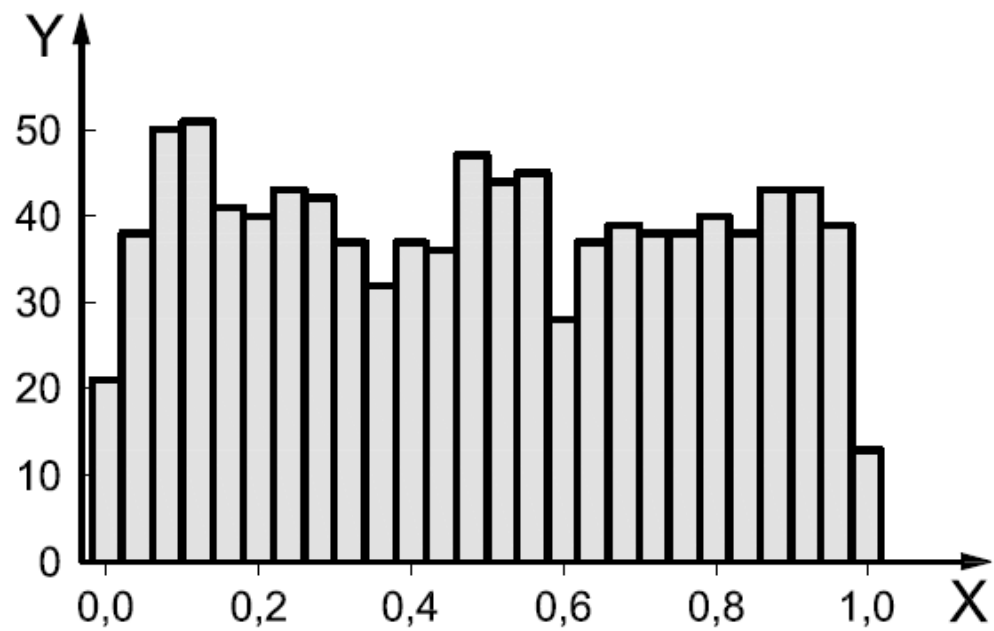
i	x_i
1	36
2	40
3	40
4	38
5	42
6	39
7	41
8	41
9	41
10	42
11	44
12	41
13	39
Xmax =	44
xmin =	36
R =	8

$$n = 13 \rightarrow k \approx \sqrt{13} = 3,61 \approx 4 \rightarrow \Delta \approx \frac{A}{k} = \frac{44 - 36}{4} = \frac{8}{4} = 2$$

X	f_i
34	0
36	1
38	1
40	3
42	6
44	1

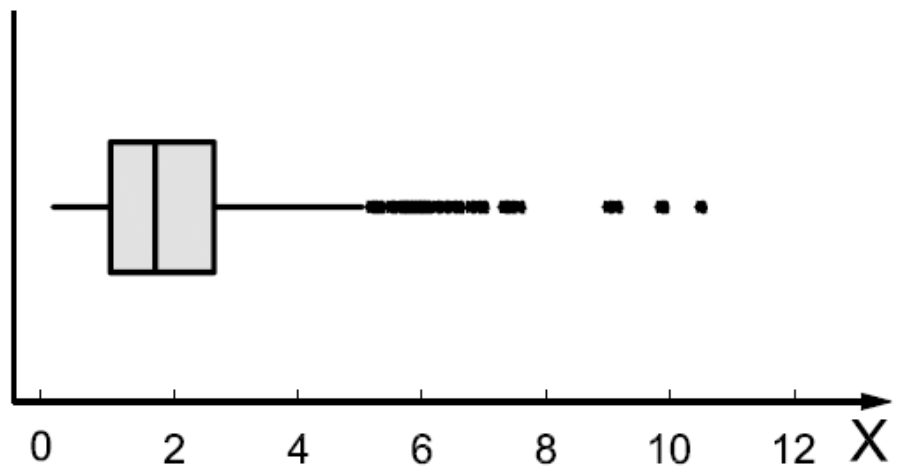
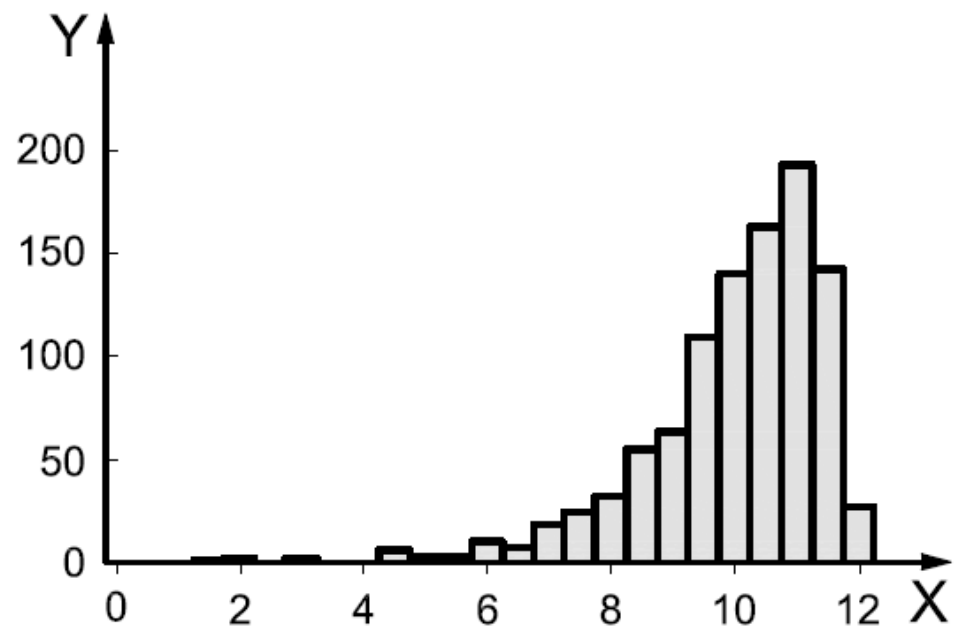
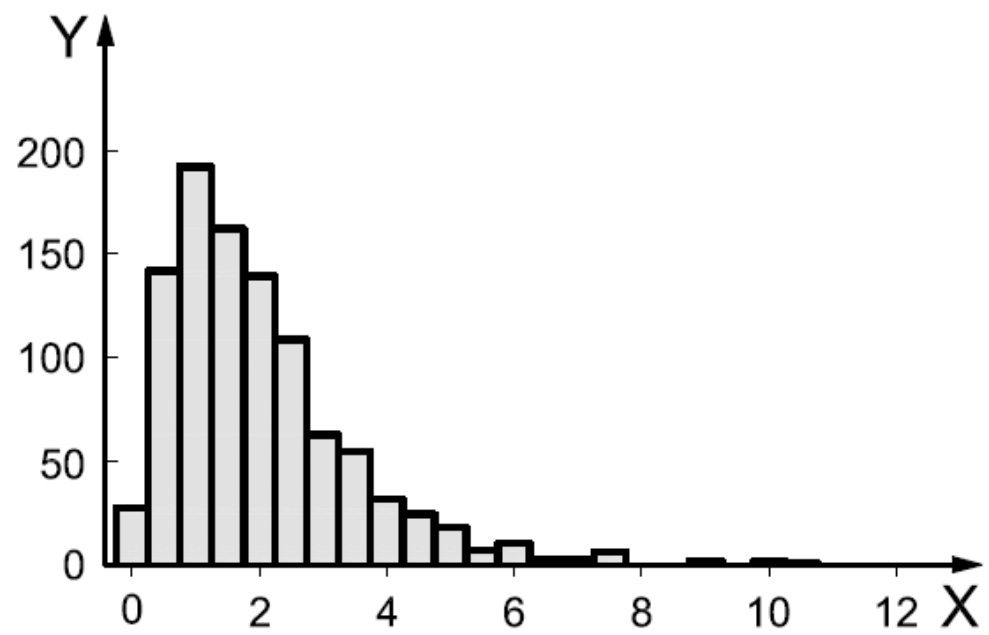
Histograma



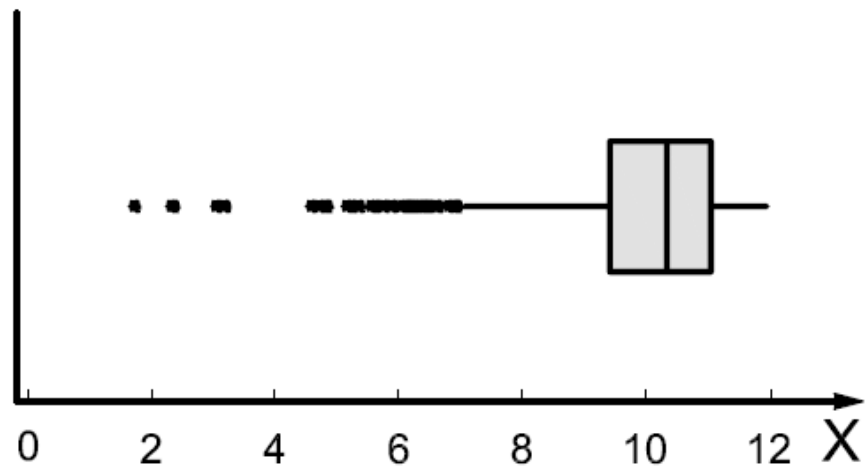


a) Uniform distribution

b) Bell-shaped distribution

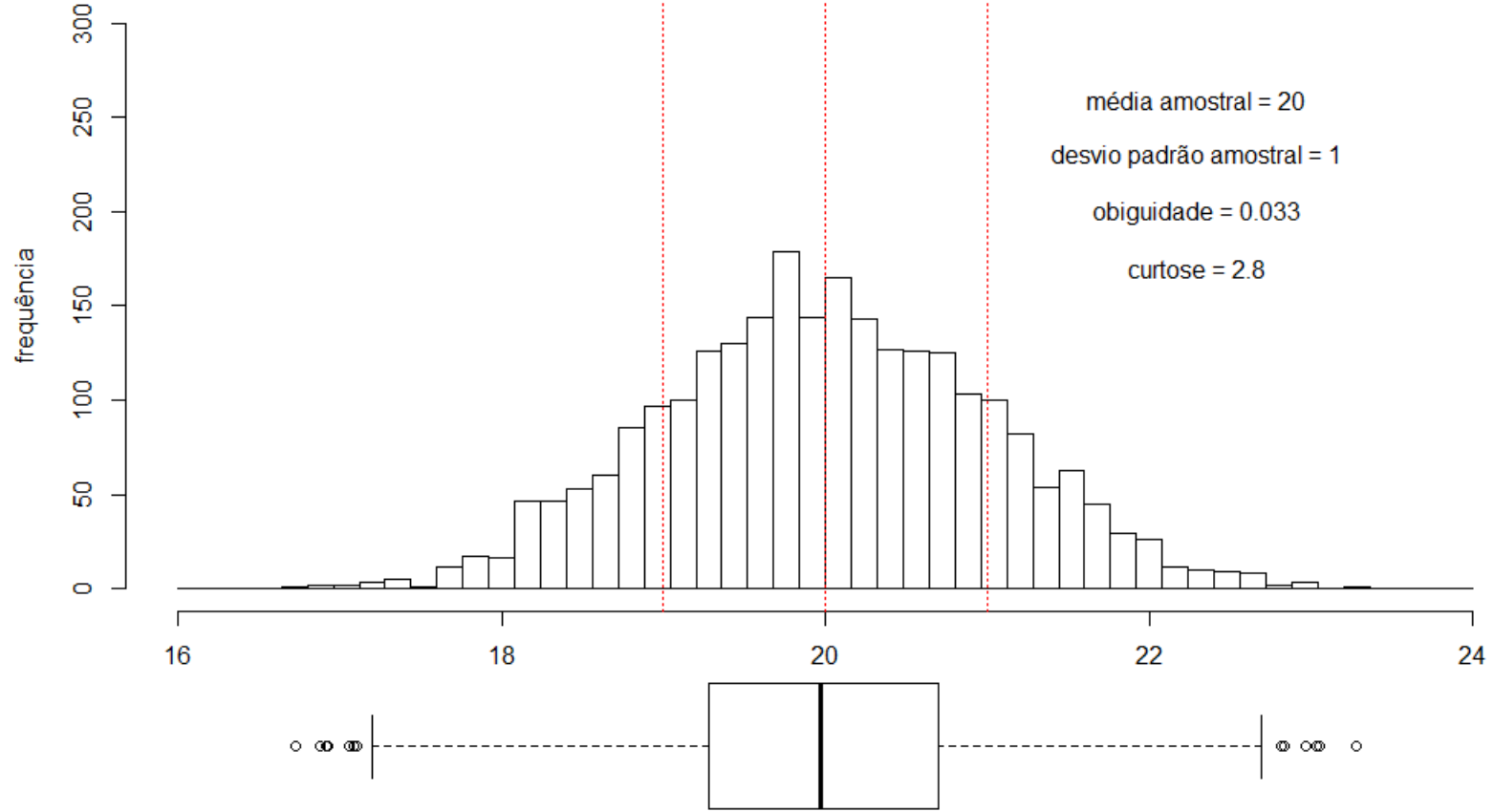


c) Right-skewed distribution

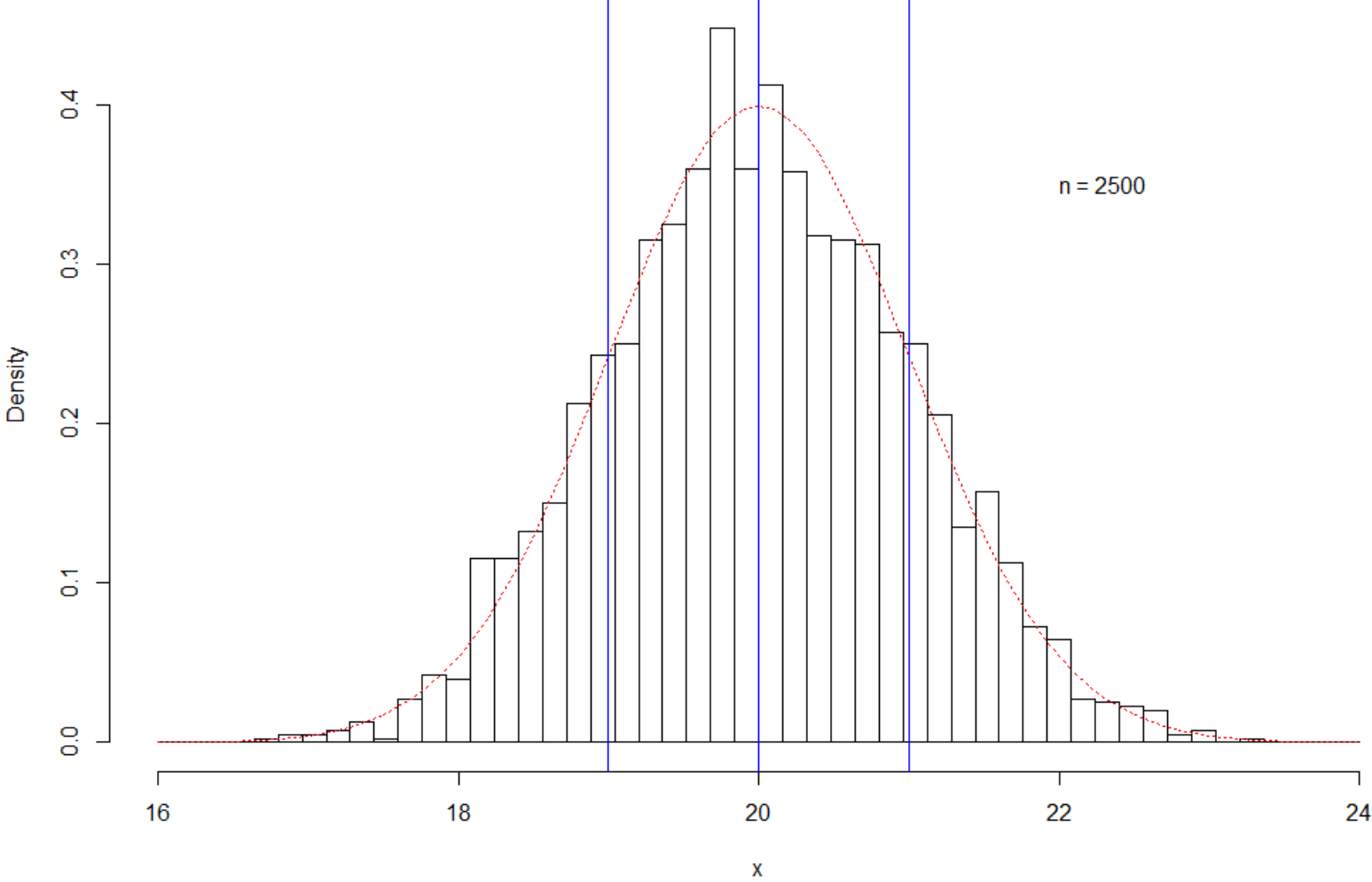


d) Left-skewed distribution

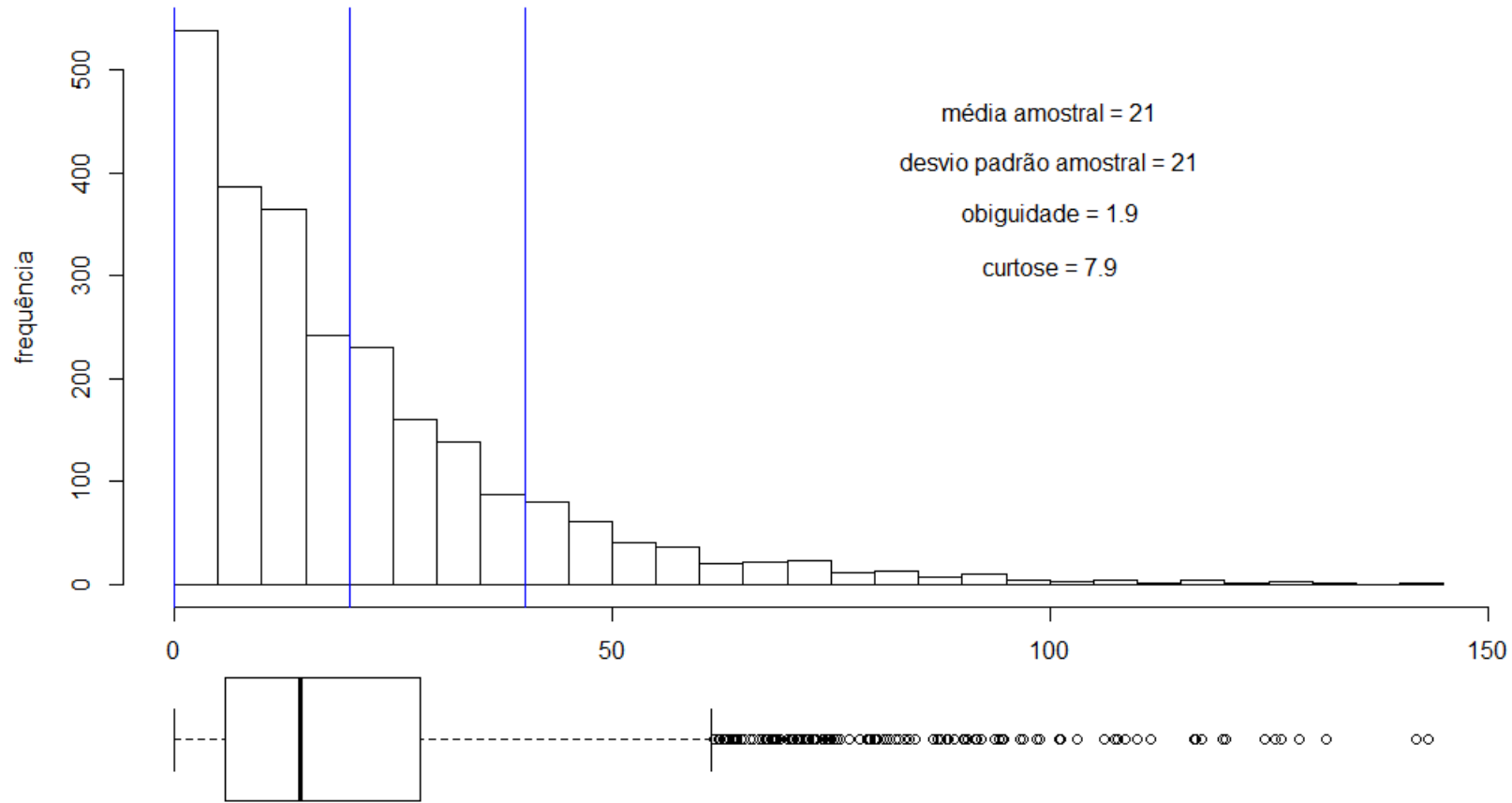
Distribuição Normal



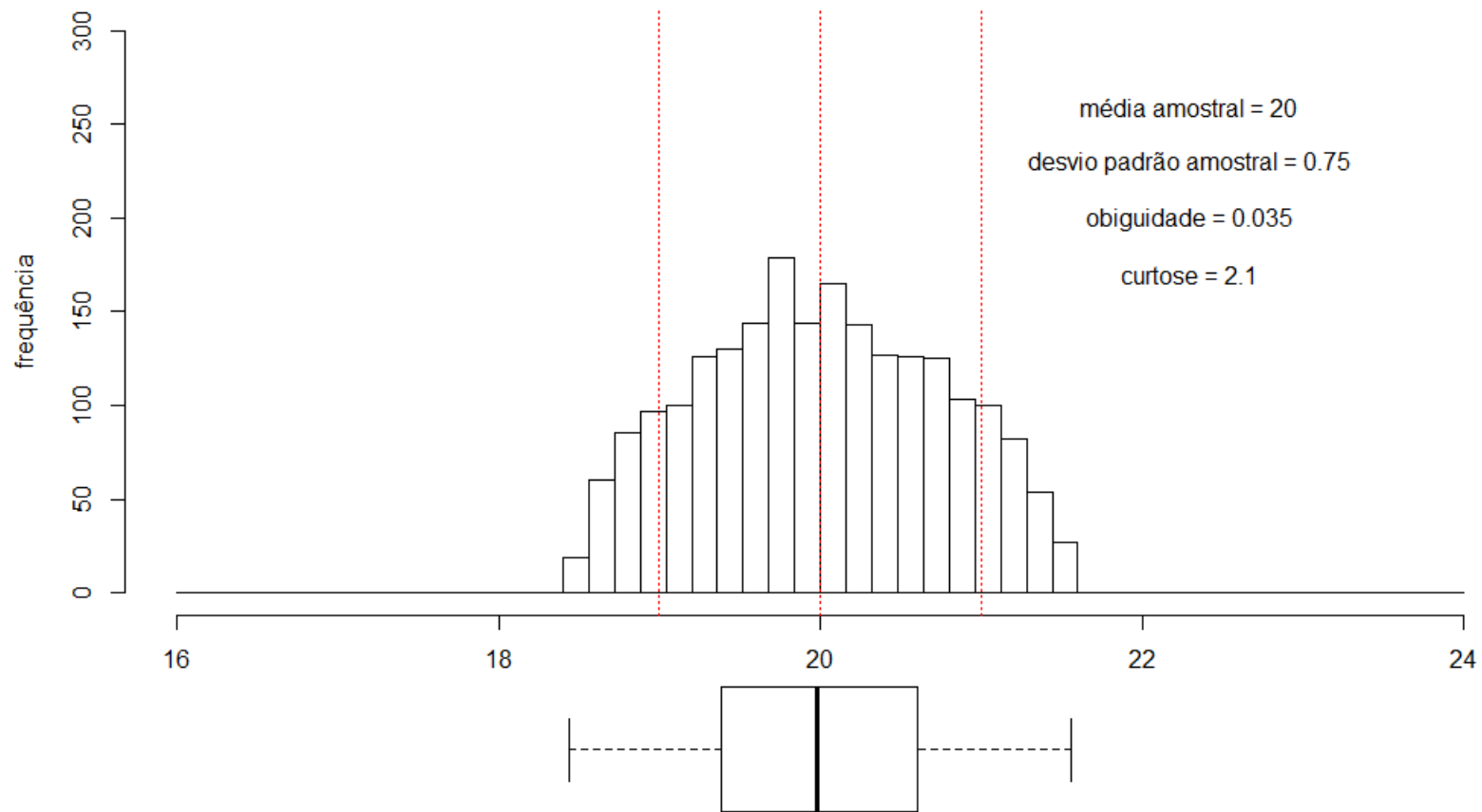
Distribuição Normal



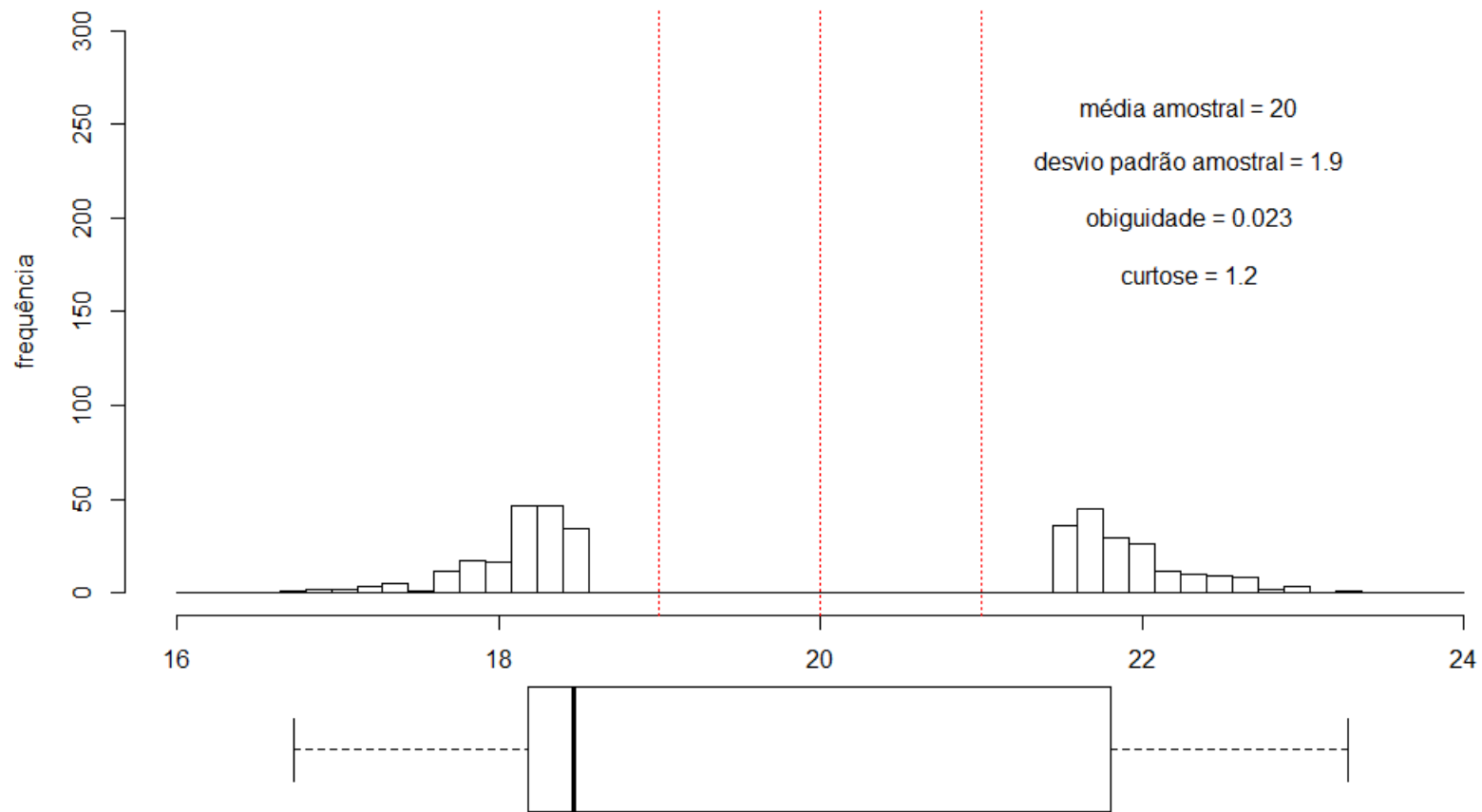
Distribuição Exponencial - Leptocurtica com calda à direita



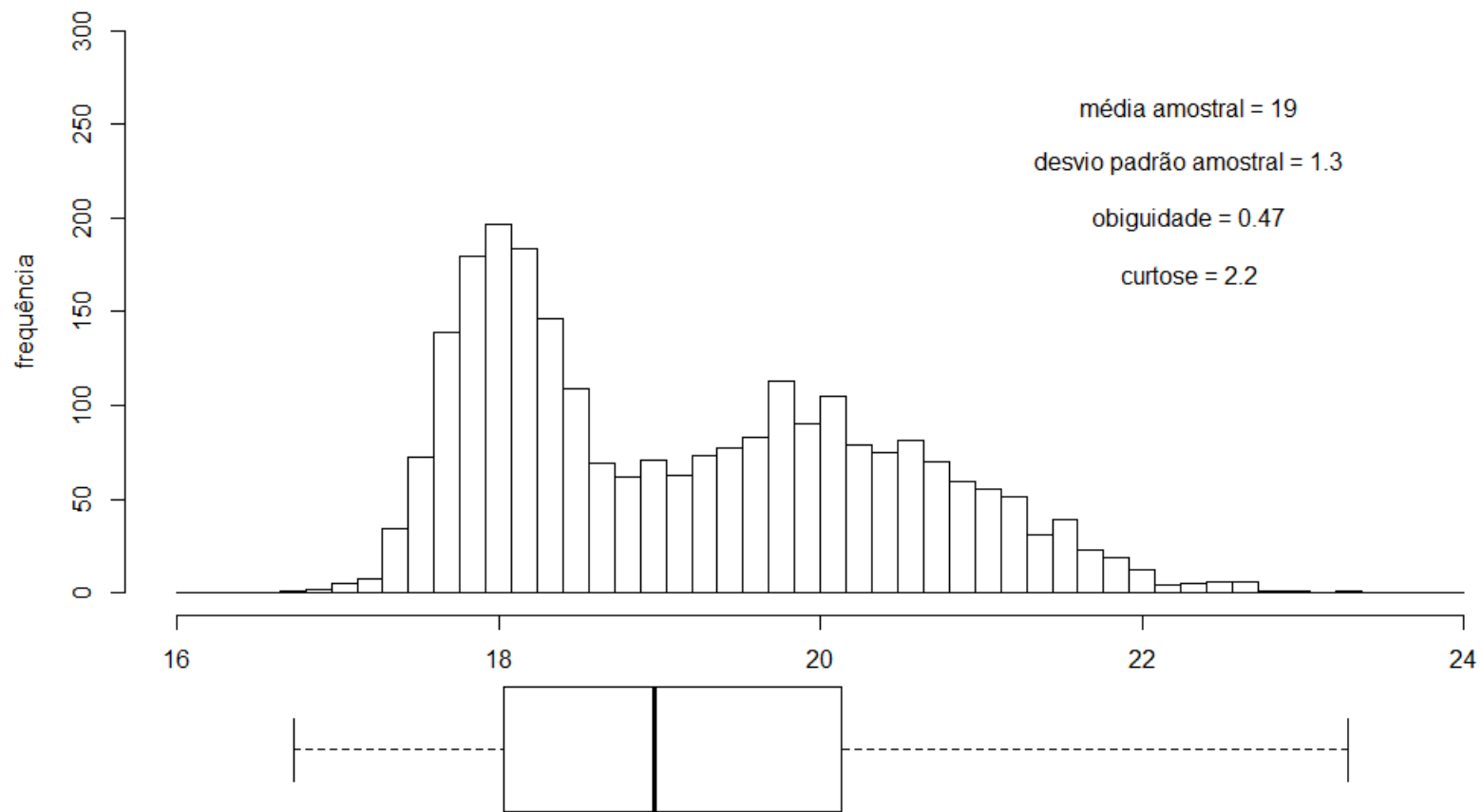
Distribuição Normal Aparada



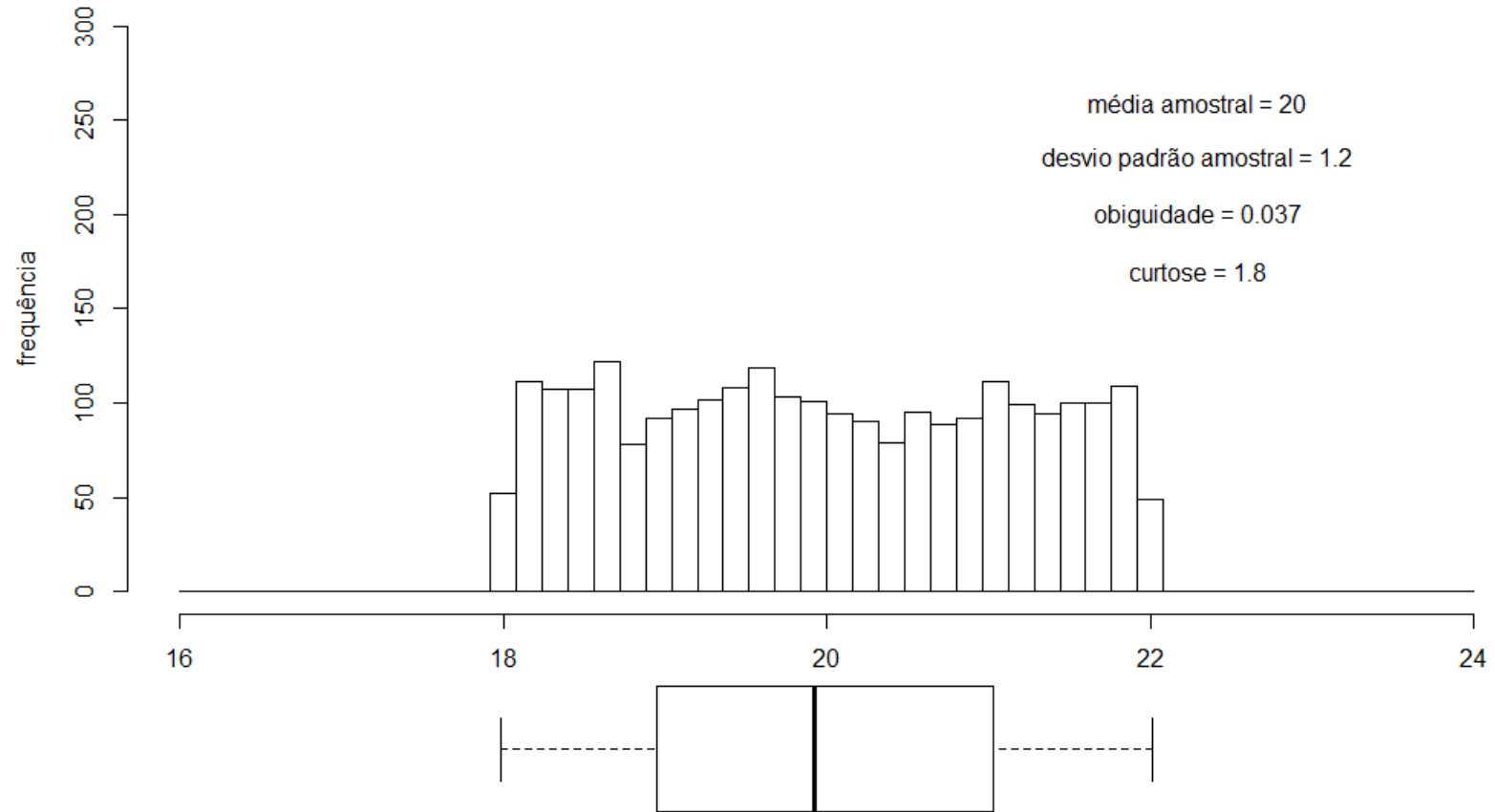
Distribuição Normal Refugio



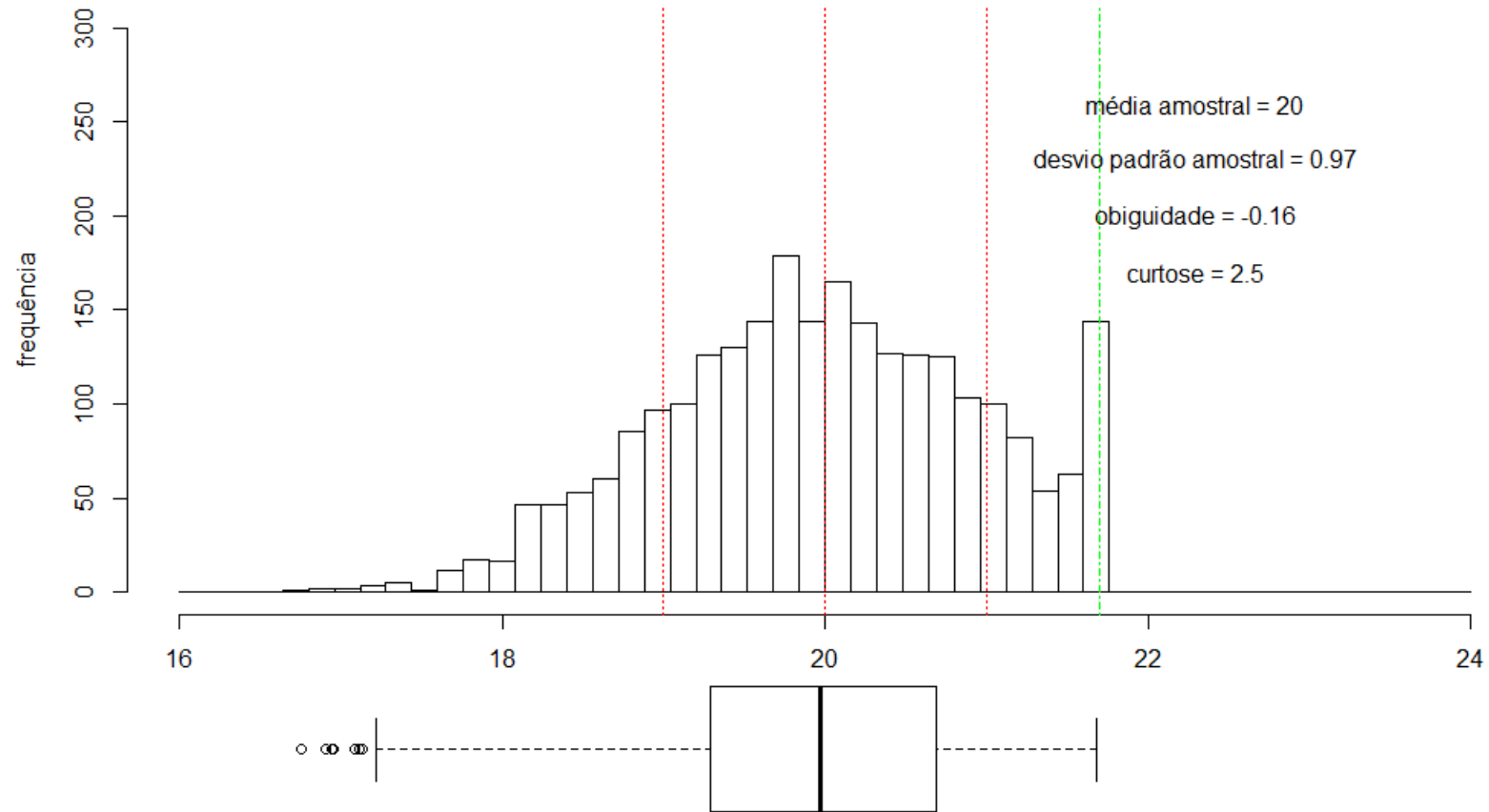
Distribuição Bimodal



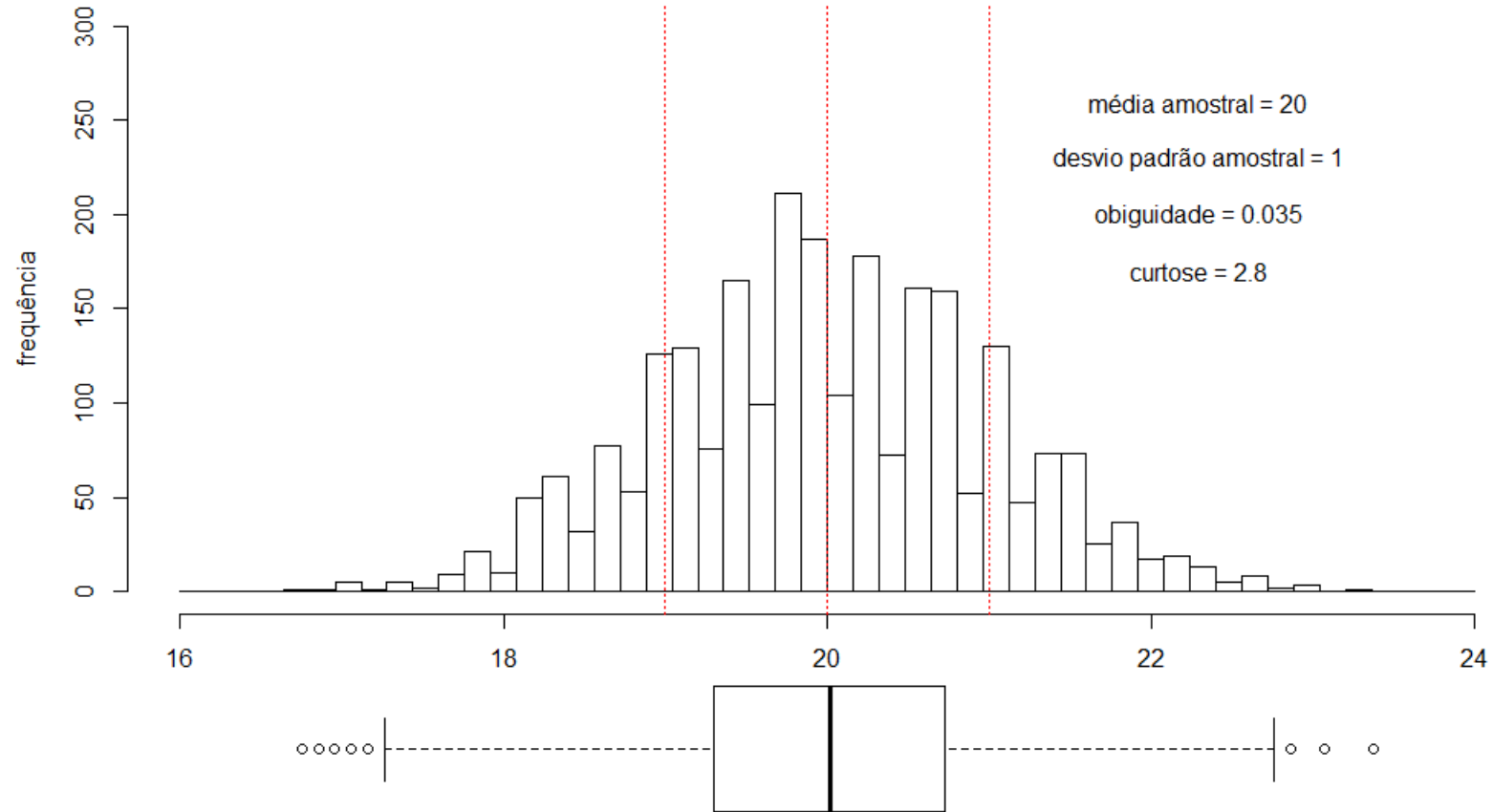
Distribuição Uniforme



Distribuição Mista = Contínua + Discreta



Distribuição Pente

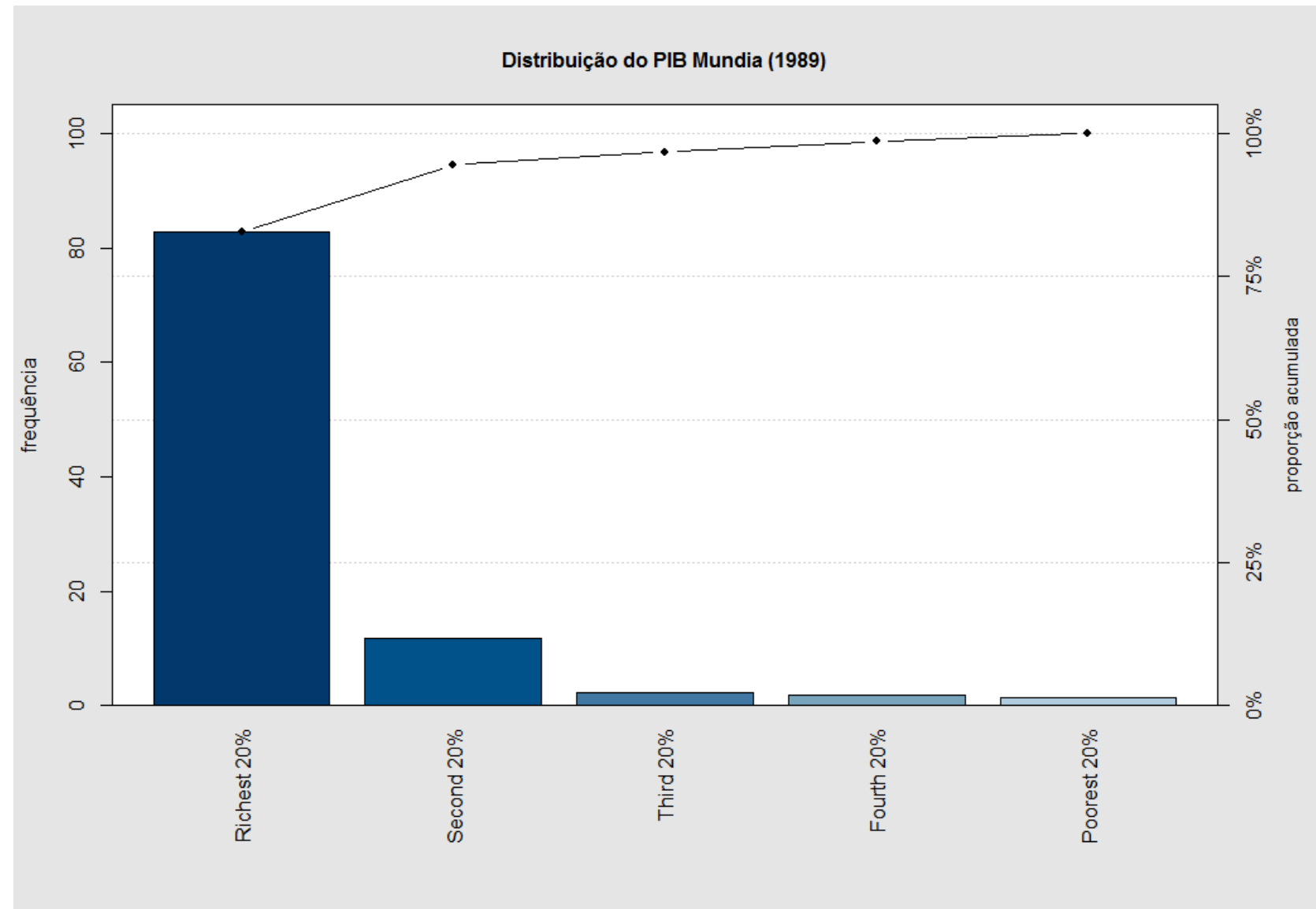


5 – Diagrama de Pareto

- Vilfredo Pareto (1848-1923), engenheiro e economista italiano
- Princípio de Pareto (Lei dos 80/20)
- Para muitos eventos, aproximadamente 80% dos efeitos derivam de 20% das causas.
- Pareto publicou em 1896 um artigo “Cours d'économie politique”, onde mostrou que aproximadamente 80% das propriedades rurais da Itália pertenciam a 20% da população.

Distribuição do PIB Mundial (1989)

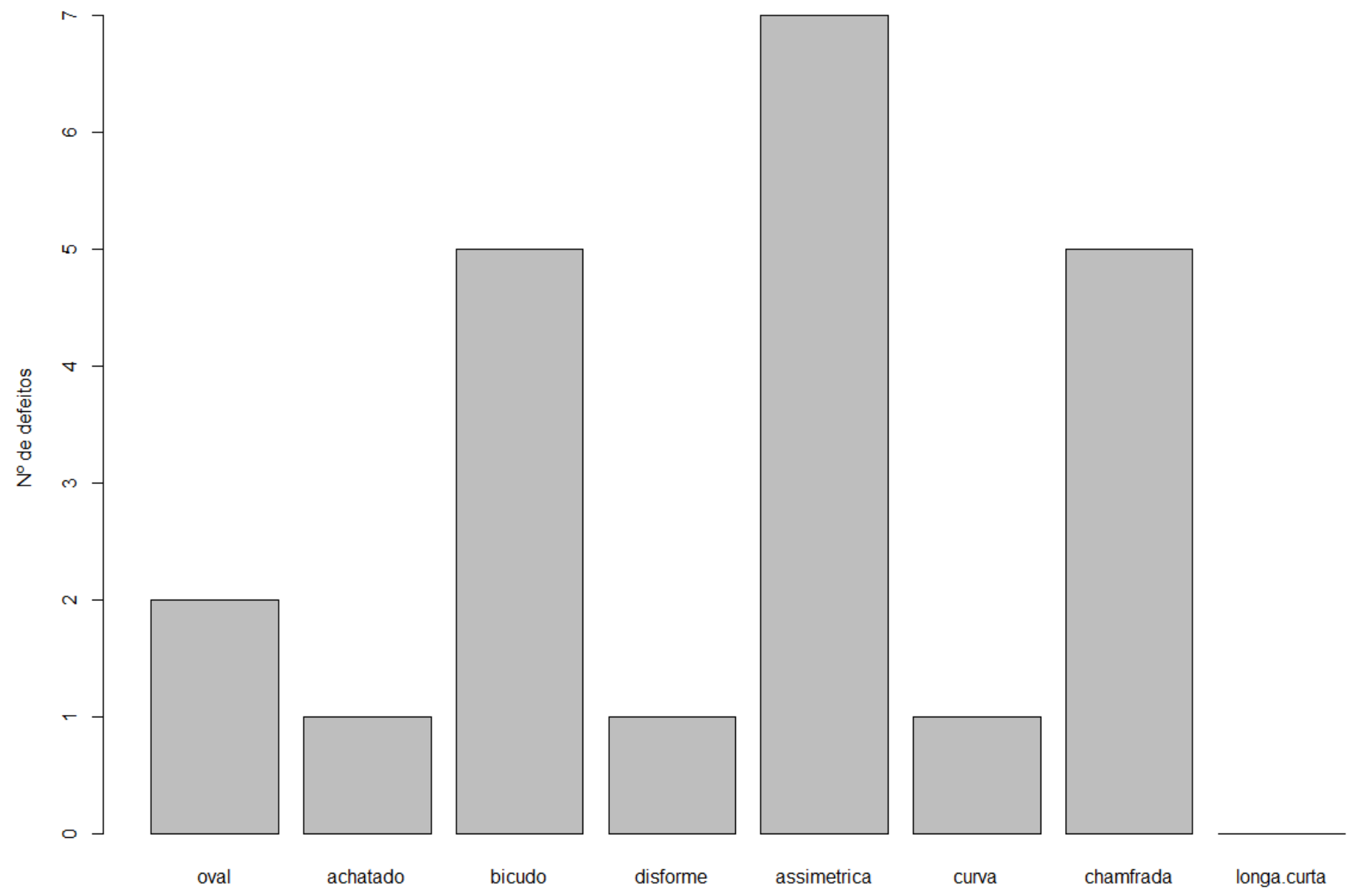
Quintis da População	Renda
Richest 20%	82.70%
Second 20%	11.75%
Third 20%	2.30%
Fourth 20%	1.85%
Poorest 20%	1.40%



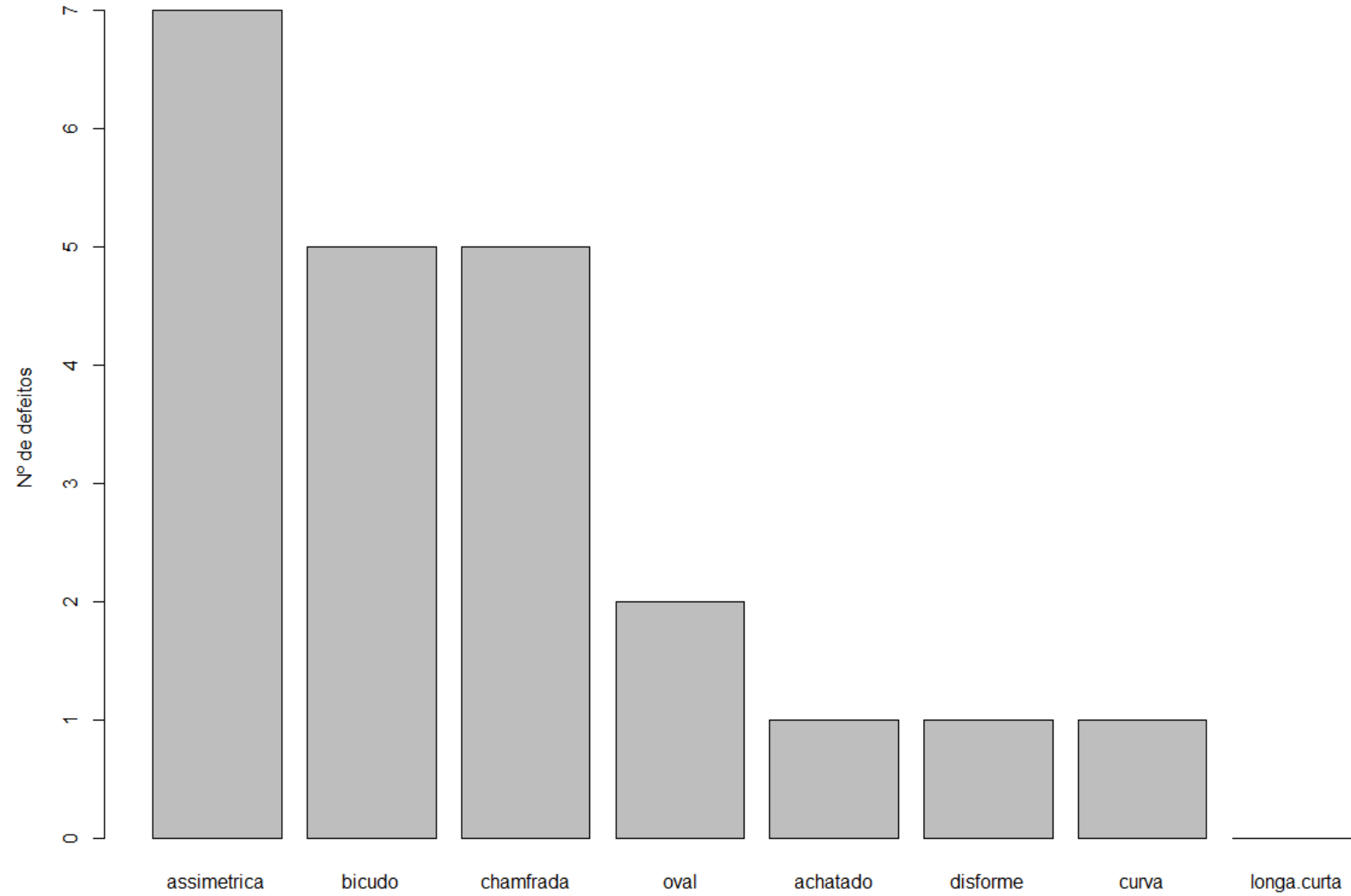
Fonte:

https://en.wikipedia.org/wiki/Pareto_principle

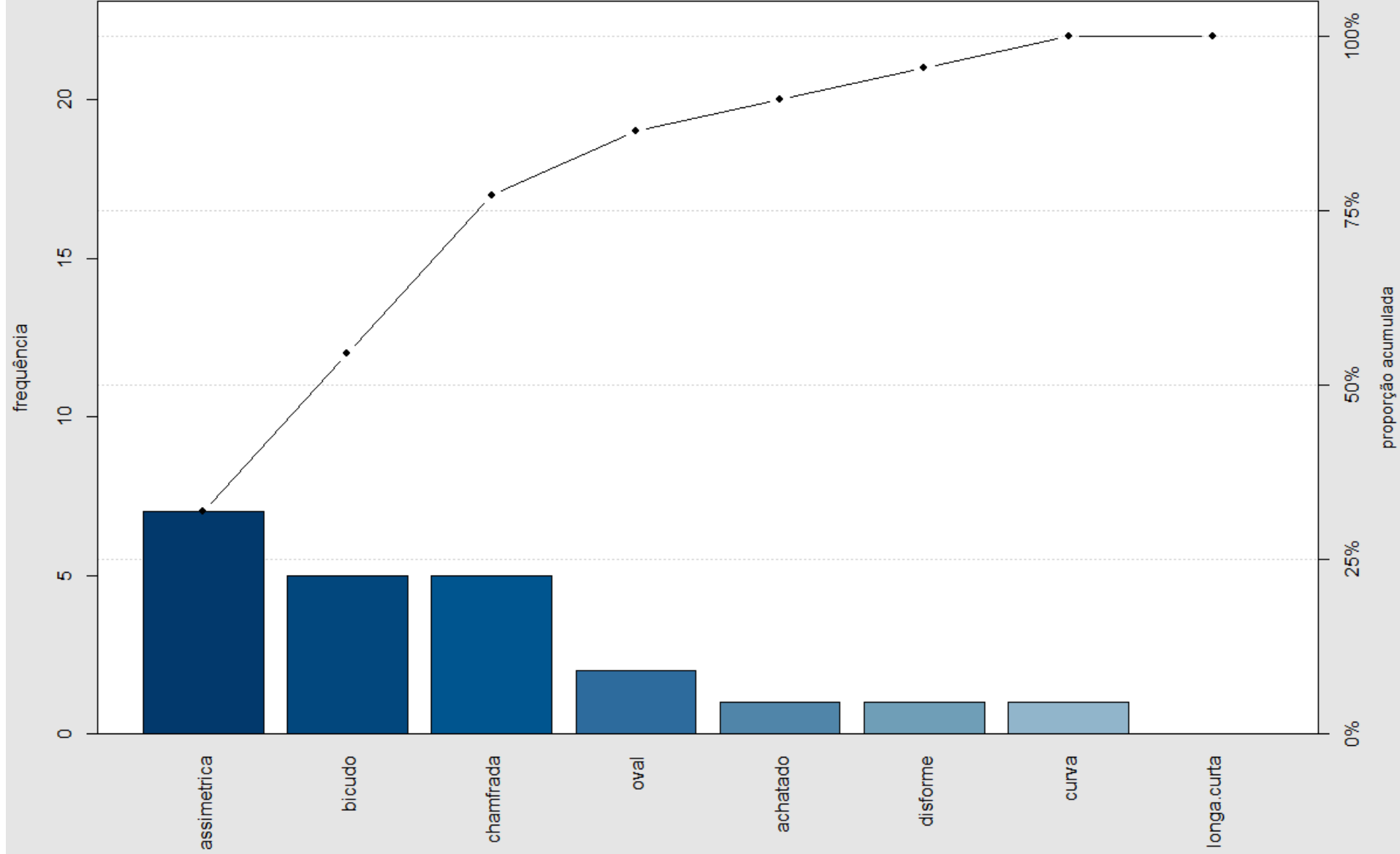
Lote Piloto



Lote Piloto



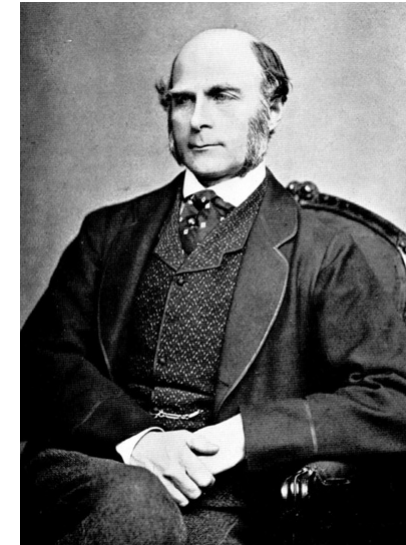
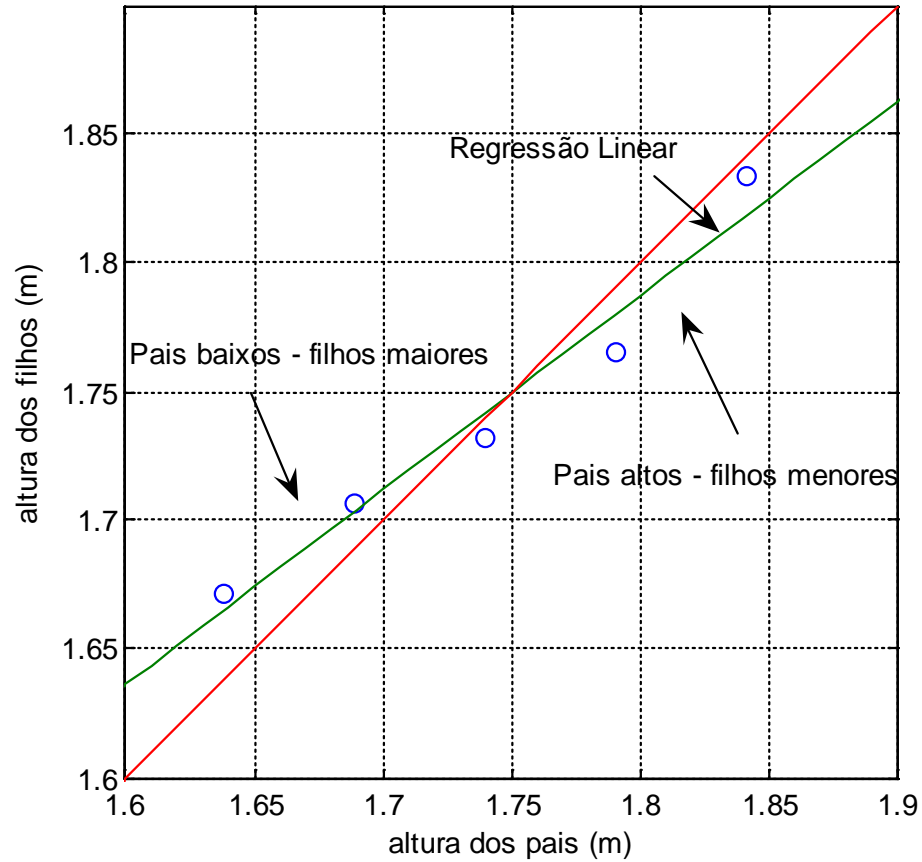
Lote Piloto



6 – Diagrama de Dispersão

- Avaliar se existe relação entre variáveis quantitativas
- Gráfico de pontos de valores de variáveis emparelhadas
- Avaliação visual da forma de relação
- Regressão Linear
- Cuidado com as escalas!

Regressão Linear



Sir Francis Galton (1822 – 1911)

“Regressão à media”

Pais	1,84	1,79	1,74	1,70	1,64
Filhos	1,83	1,77	1,73	1,71	1,67

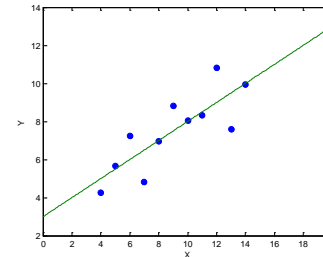
Coeficiente de Correlação Linear

- Parâmetro que mede a correlação linear

$$r_{xy} = \frac{COV(x, y)}{DP(x) \cdot DP(y)} = \frac{s_{xy}}{s_x \cdot s_y} = m \cdot \frac{s_x}{s_y}$$

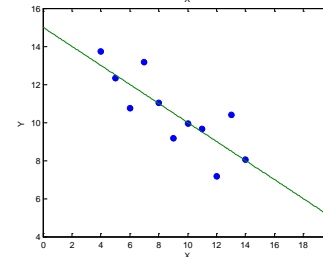
- *Correlação positiva*

$$r_{xy} \cong +1$$



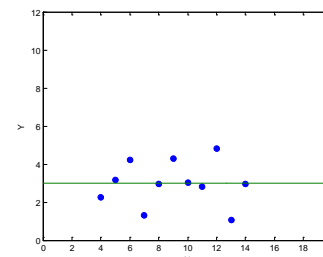
- *Correlação negativa*

$$r_{xy} \cong -1$$



- *Sem correlação*

$$r_{xy} \cong 0$$



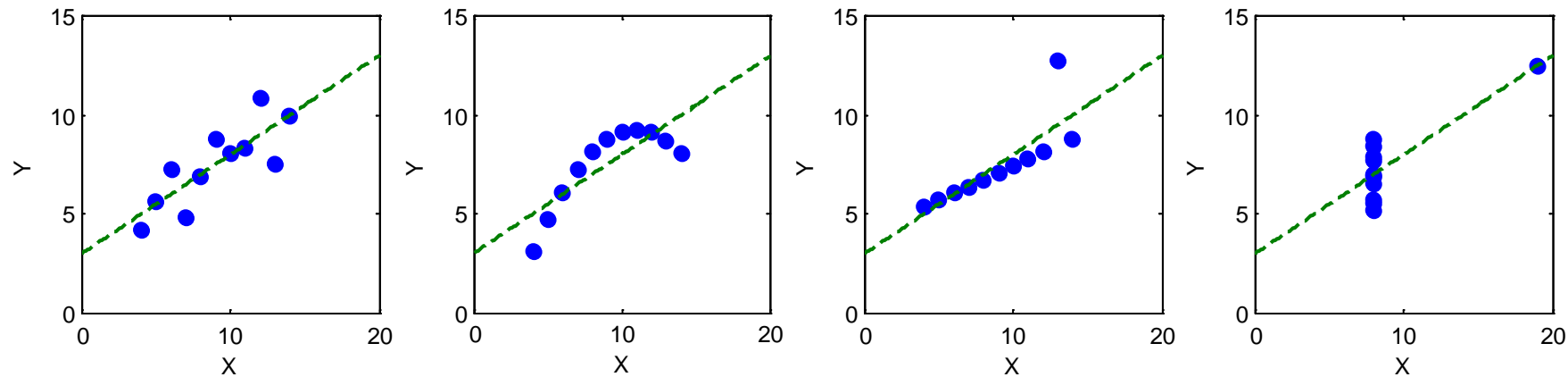
Exemplos de Regressão Linear

- Dados de Regressão de Ascombe

X	Y	X	Y	X	Y	X	Y
10	8,04	10	9,14	10	7,46	8	6,58
8	6,95	8	8,14	8	6,77	8	5,76
13	7,58	13	8,74	13	12,74	8	7,71
9	8,81	9	8,77	9	7,11	8	8,84
11	8,33	11	9,26	11	7,81	8	8,47
14	9,96	14	8,10	14	8,84	8	7,04
6	7,24	6	6,13	6	6,08	8	5,25
4	4,26	4	3,10	4	5,39	19	12,5
12	10,84	12	9,13	12	8,15	8	5,56
7	4,82	7	7,26	7	6,42	8	7,91
5	5,68	5	4,74	5	5,73	8	6,89

Exemplos de Regressão Linear

- Dados de Regressão de Ascombe

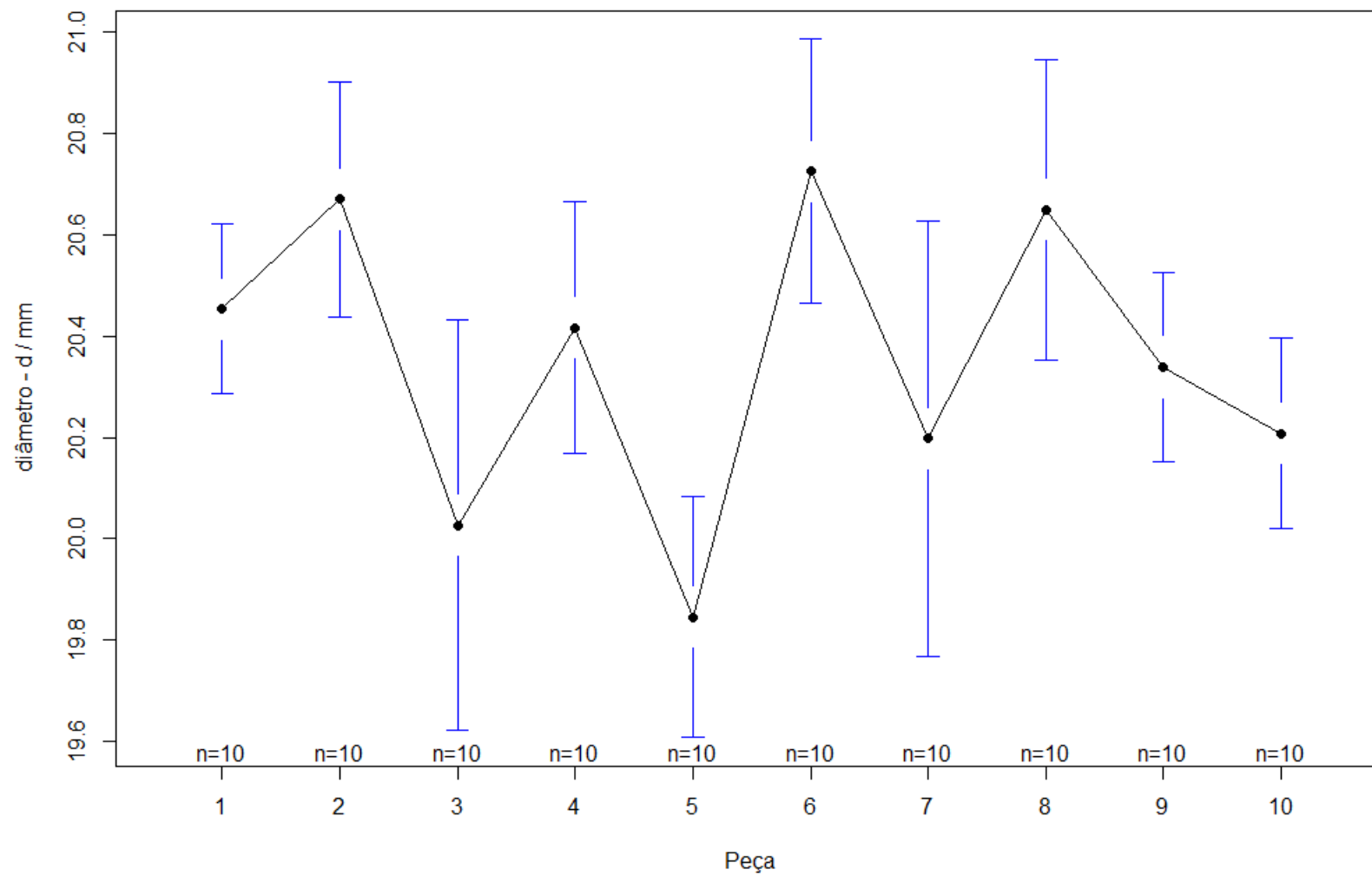


- Todos com os mesmos parâmetros:

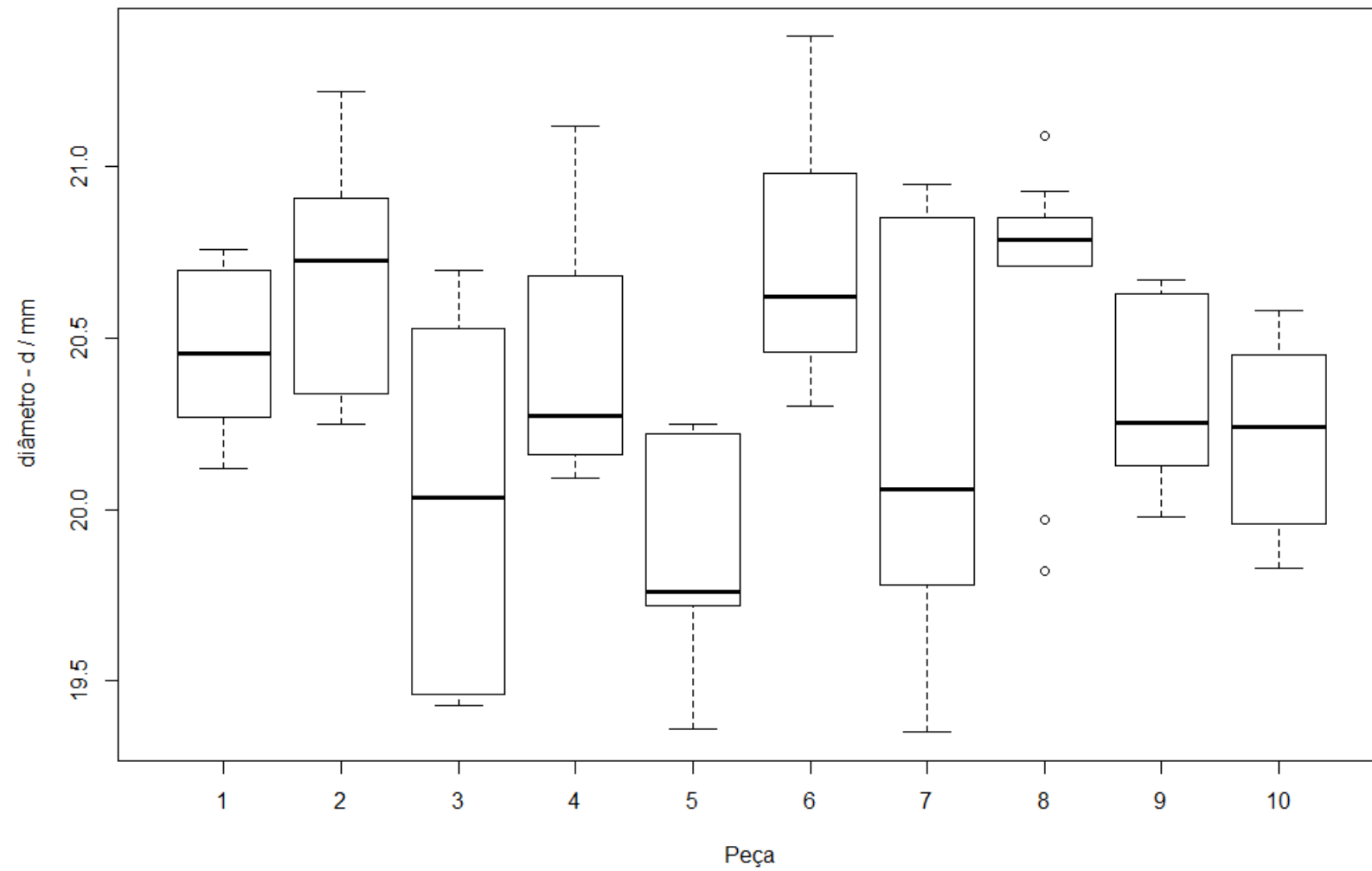
- $b = 3,0$
- $m = 0,5$
- $E[x] = 9,0$
- $E[y] = 7,5$

$$\hat{Y}_i = 3,0 + 0,5 X_i$$

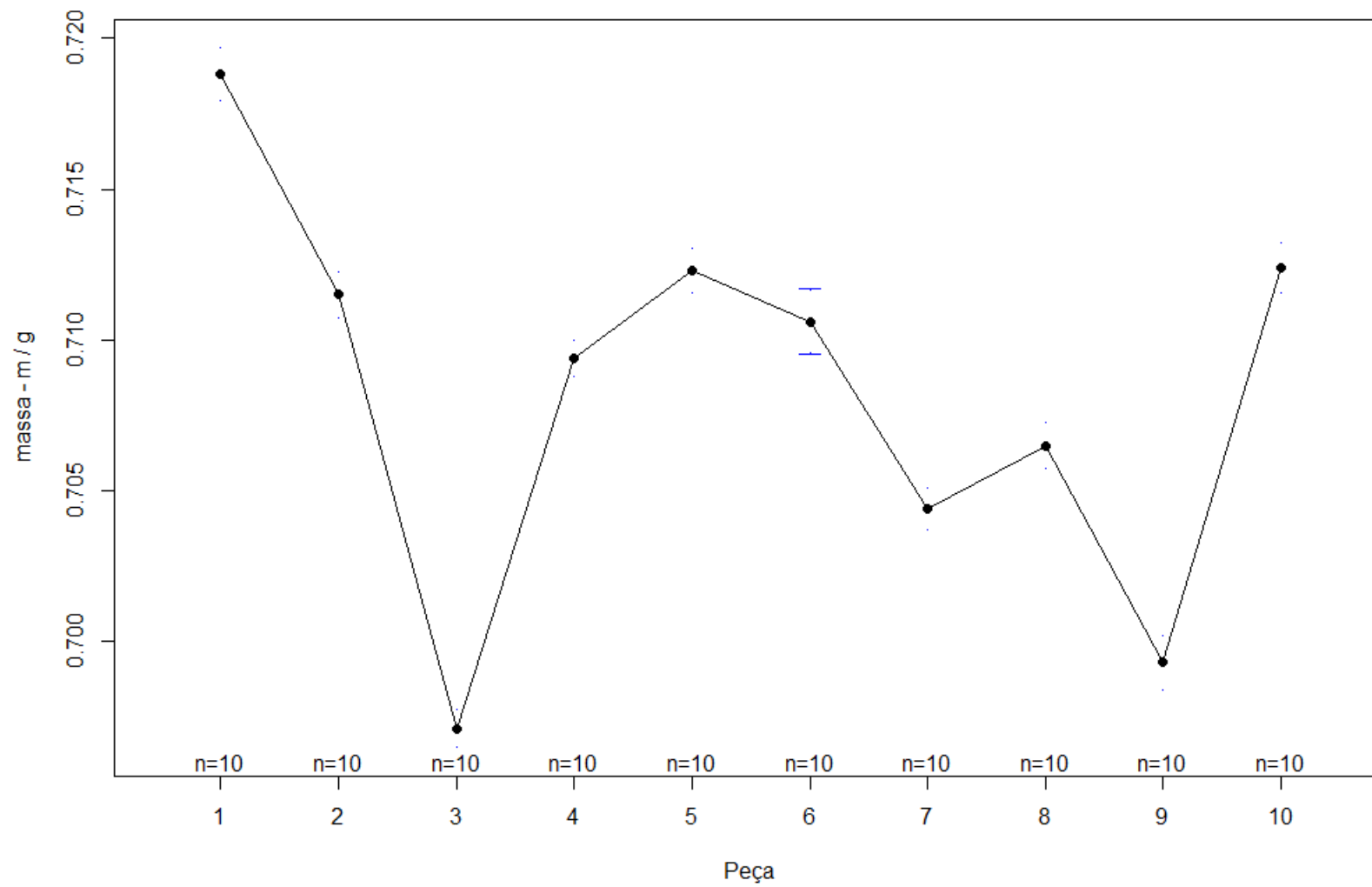
Lote Piloto



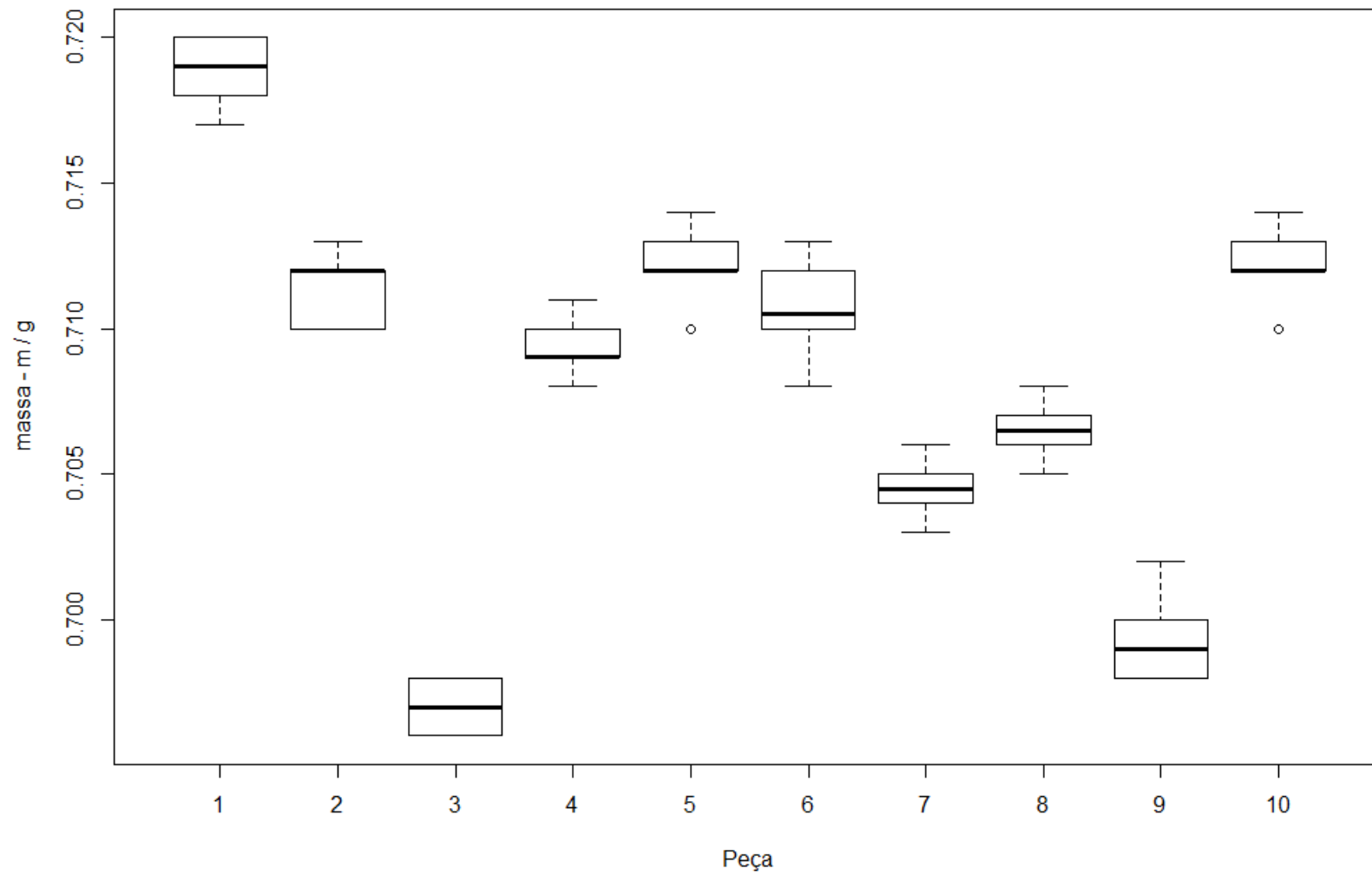
Lote Piloto



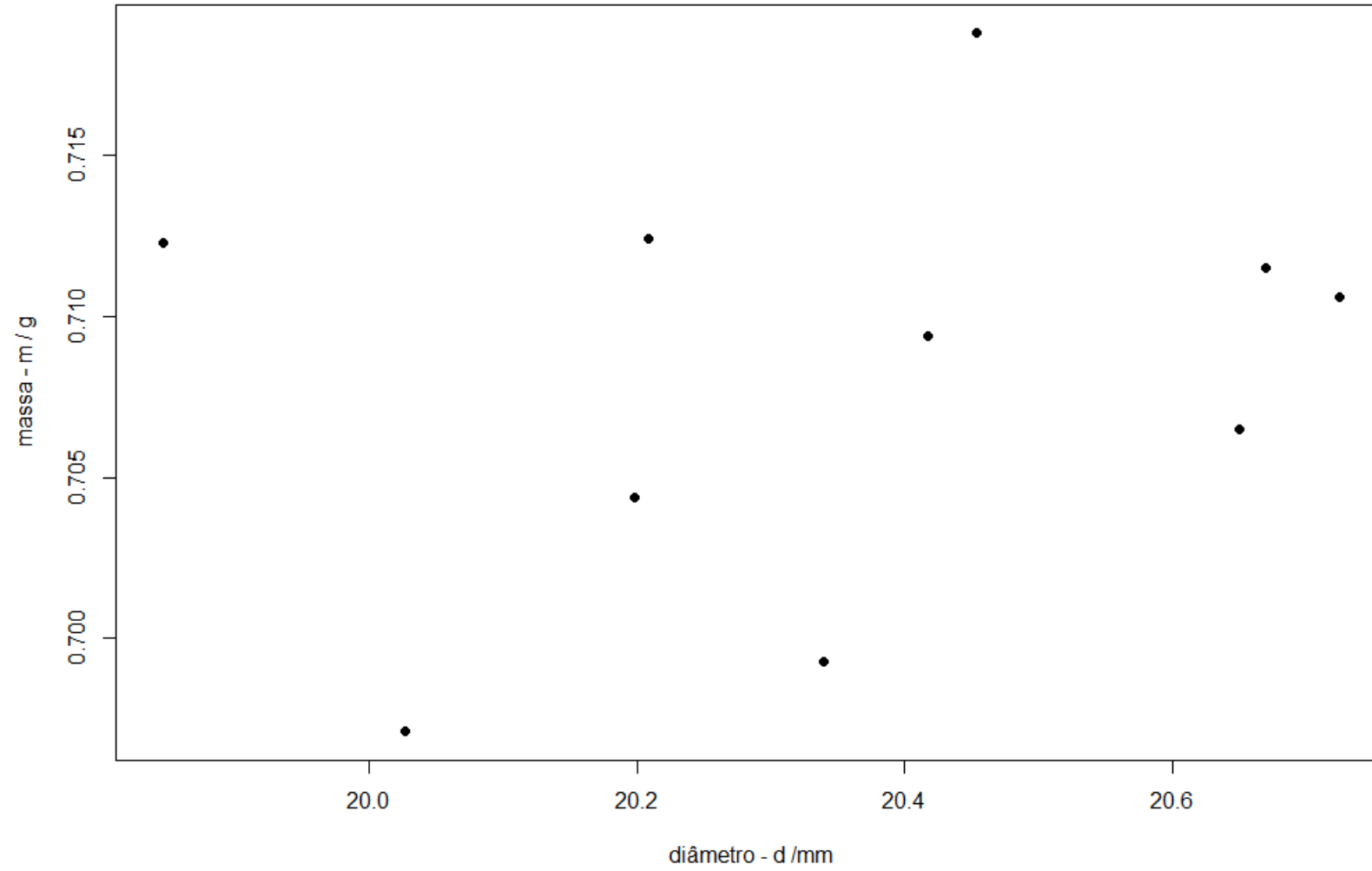
Lote Piloto



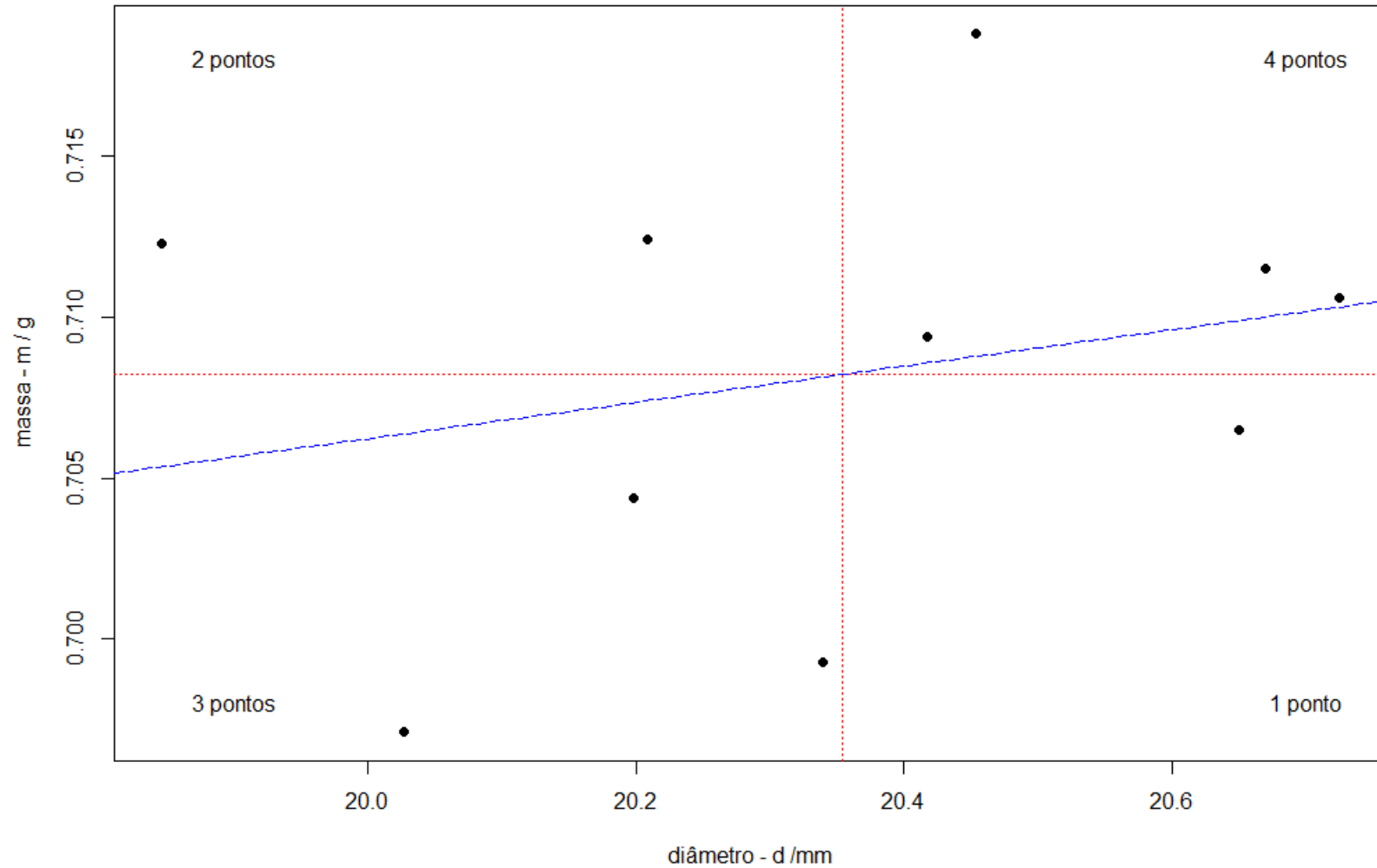
Lote Piloto



Lote Piloto



Lote Piloto



$$A = UL + LR$$

$$B = LL + UR$$

$$Q = \min(A, B)$$

$$N = A + B$$

Exemplo

$$A = 2 + 1 = 3$$

$$B = 3 + 4 = 7$$

$$Q = \min(3, 7) = 3$$

$$N = 3 + 7 = 10$$

Table 5.18 Trend test table.

<i>N</i>	Limit	<i>N</i>	Limit
1-8	0	51-53	18
9-11	1	54-55	19
12-14	2	56-57	20
15-16	3	58-60	21
17-19	4	61-62	22
20-22	5	63-64	23
23-24	6	65-66	24
25-27	7	67-69	25
28-29	8	70-71	26
30-32	9	72-73	27
33-34	10	74-76	28
35-36	11	77-78	29
37-39	12	79-80	30
40-41	13	81-82	31
42-43	14	83-85	32
44-46	15	86-87	33
47-48	16	88-89	34
49-50	17	90	35

Critério

$Q < Limit(N) \Rightarrow$ Variáveis Relacionadas

$Q \geq Limit(N) \Rightarrow$ Resultado Aleatório

Exemplo

$Q = 3 \geq Limit(10) = 1 \Rightarrow$ Resultado Aleatório

Correlação: $r = 0,25$

7 - Fluxograma

- **Flowchart**

ISO5807:1985

“Representação gráfica de definições, análise ou métodos de solução de problemas com símbolos que representam operações, dados, fluxo, equipamentos, etc.”

- **Fluxograma**

Guia D Simplificação

“É um desenho gráfico feito com símbolos padronizados, que mostra a sequência lógica das etapas de realização de um processo.”

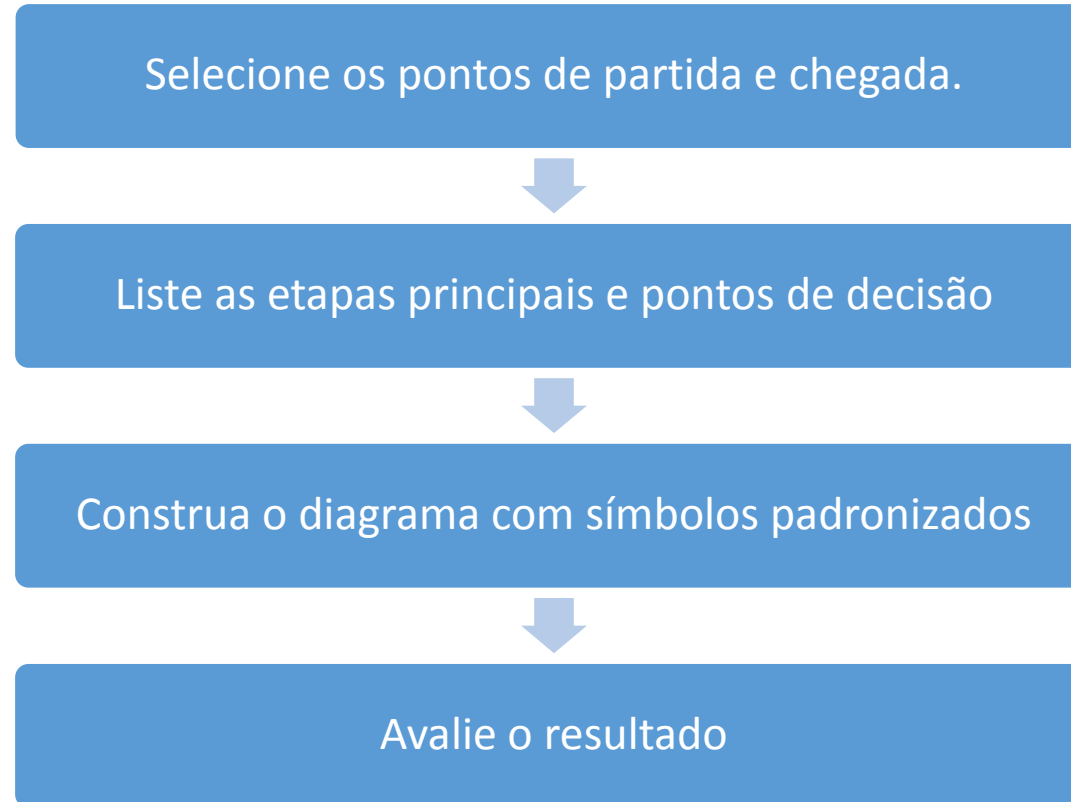
Vantagens:

- Visão integrada do processo
- Visualização de detalhes críticos do processo
- Identificação do fluxo do processo de trabalho, bem como das interações entre os subprocessos
- Identificação dos potenciais pontos de controle
- Identificação das oportunidades de melhoria

Fonte:

Ministério do Planejamento, Orçamento e Gestão, Secretaria de Gestão **Guia D Simplificação**. Brasília, 2005.





Etapas na elaboração de um Fluxograma



Fonte:

Burke, Sarah E.; Silvestrini, Rachel T. **The Certified Quality Engineer Handbook**. 4.ed, ASQ Quality Press, USA, 2017.

Símbolos Básicos

	Símbolo de Início e Fim	Símbolo utilizado para indicar o início e o fim do fluxograma.
	Linha de fluxo	Indica a direção do fluxo das etapas do processo.
	Símbolo de etapa de processo	Símbolo para representar uma etapa específica do processo. Deve conter um nome de identificação da etapa.
	Símbolo de decisão	Símbolo para ponto de decisão. Por exemplo para passa/não passa, sim/não.

ISO 5807:1985

Information processing -- Documentation symbols and conventions for data, program and system flowcharts, program network charts and system resources charts



ISO 5807:1985 [Preview](#)

Information processing -- Documentation symbols and conventions for data, program and system flowcharts, program network charts and system resources charts



This standard was last reviewed and confirmed in 2005. Therefore this version remains current.

Defines symbols to be used in information processing documentation and gives guidance on conventions for their use in data flowcharts, program flowcharts, system flowcharts, program network charts, system resources charts. Applicable in conjunction with ISO 2382/1.

General information ³

Current status : Published

Publication date : 1985-02

Edition : 1

Number of pages : 25

Technical Committee : ISO/IEC JTC 1/SC 7 Software and systems engineering

ICS : 35.080 Software | 01.080.50 Graphical symbols for use on information technology and telecommunications technical drawings and in relevant technical product documentation

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Fonte:

<https://www.iso.org/standard/11955.html>

Consulta em 01.04.2018

Exemplo

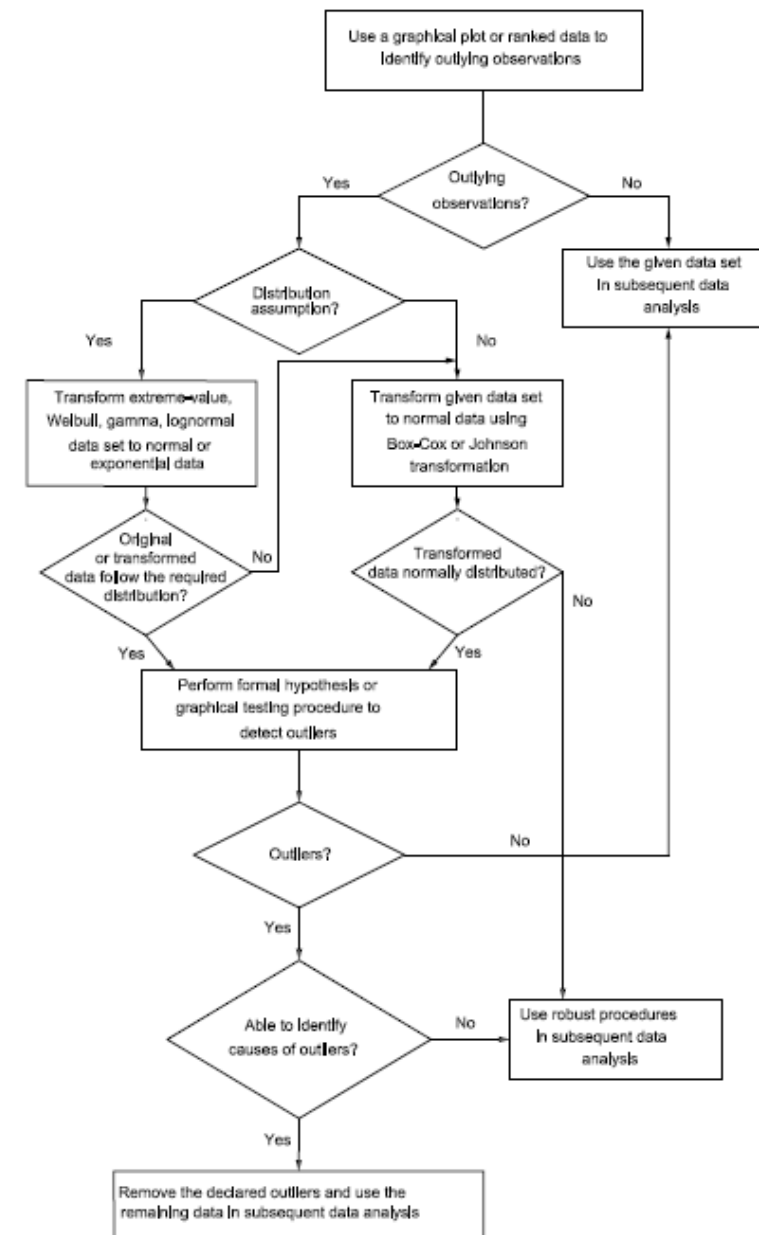
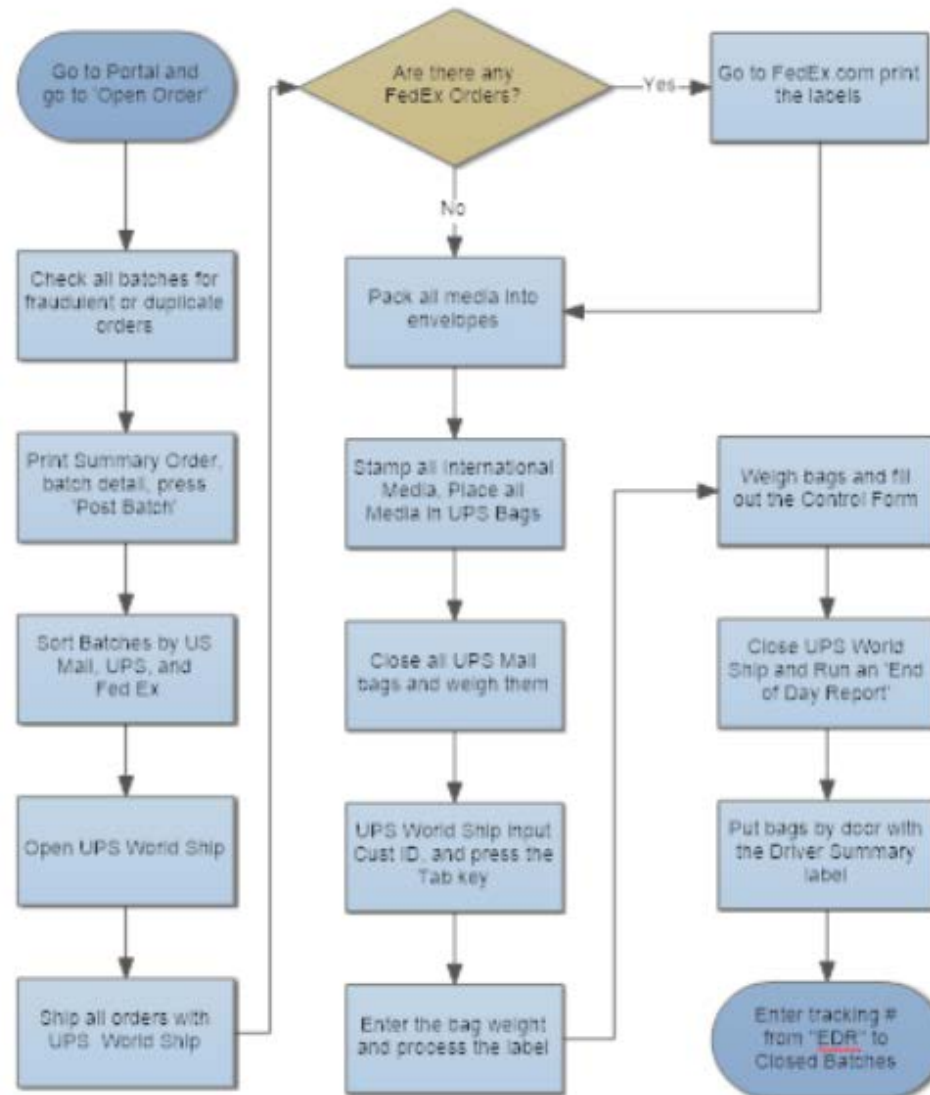


Figure F.1 — Flow chart for the detection and treatment of outliers

Fonte:
ISO 16269-4:2010

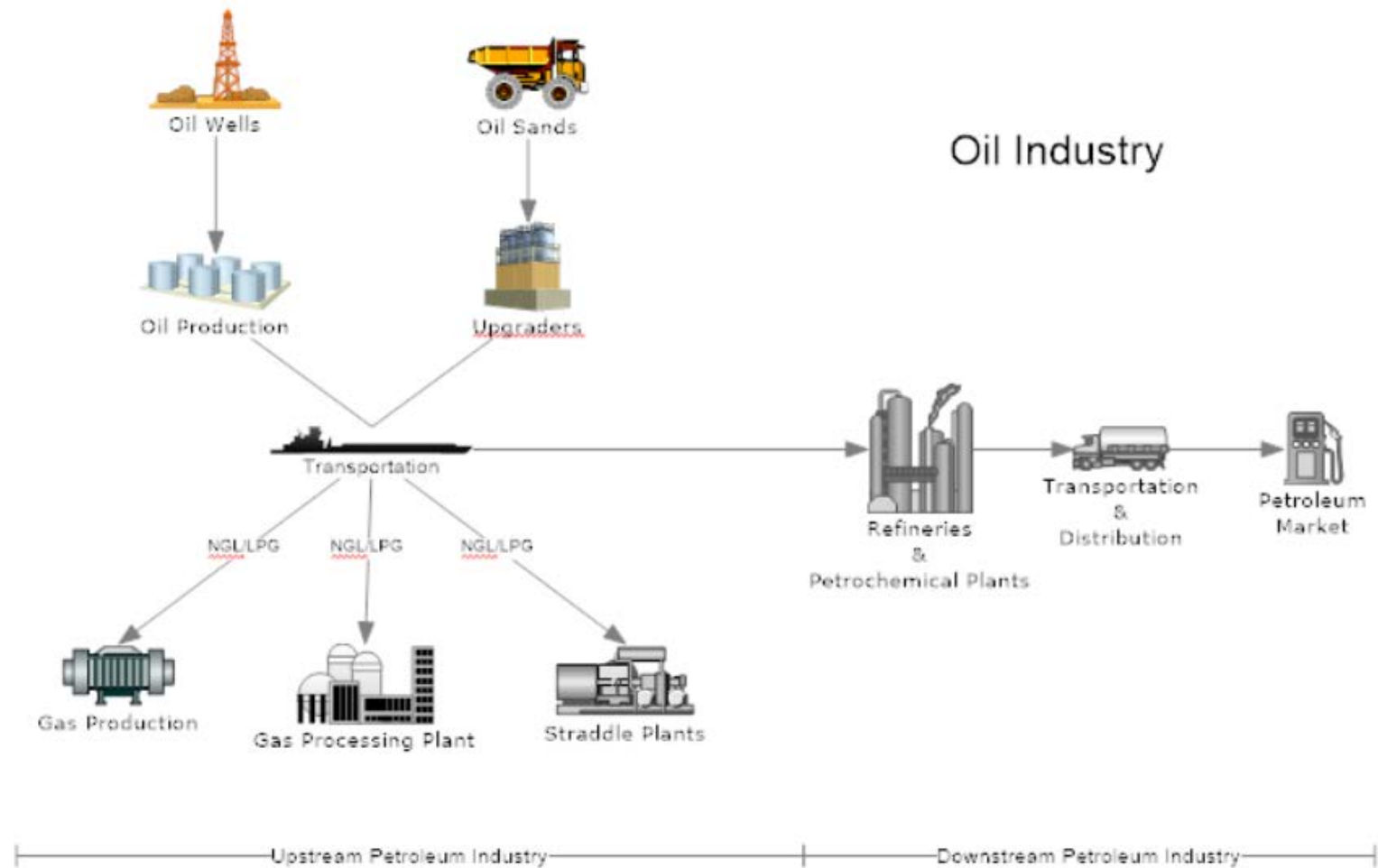
Exemplo

Shipping Process



Fonte:
Exemplo de Flowchart produzido pelo
SmartDraw <https://www.smartdraw.com/>

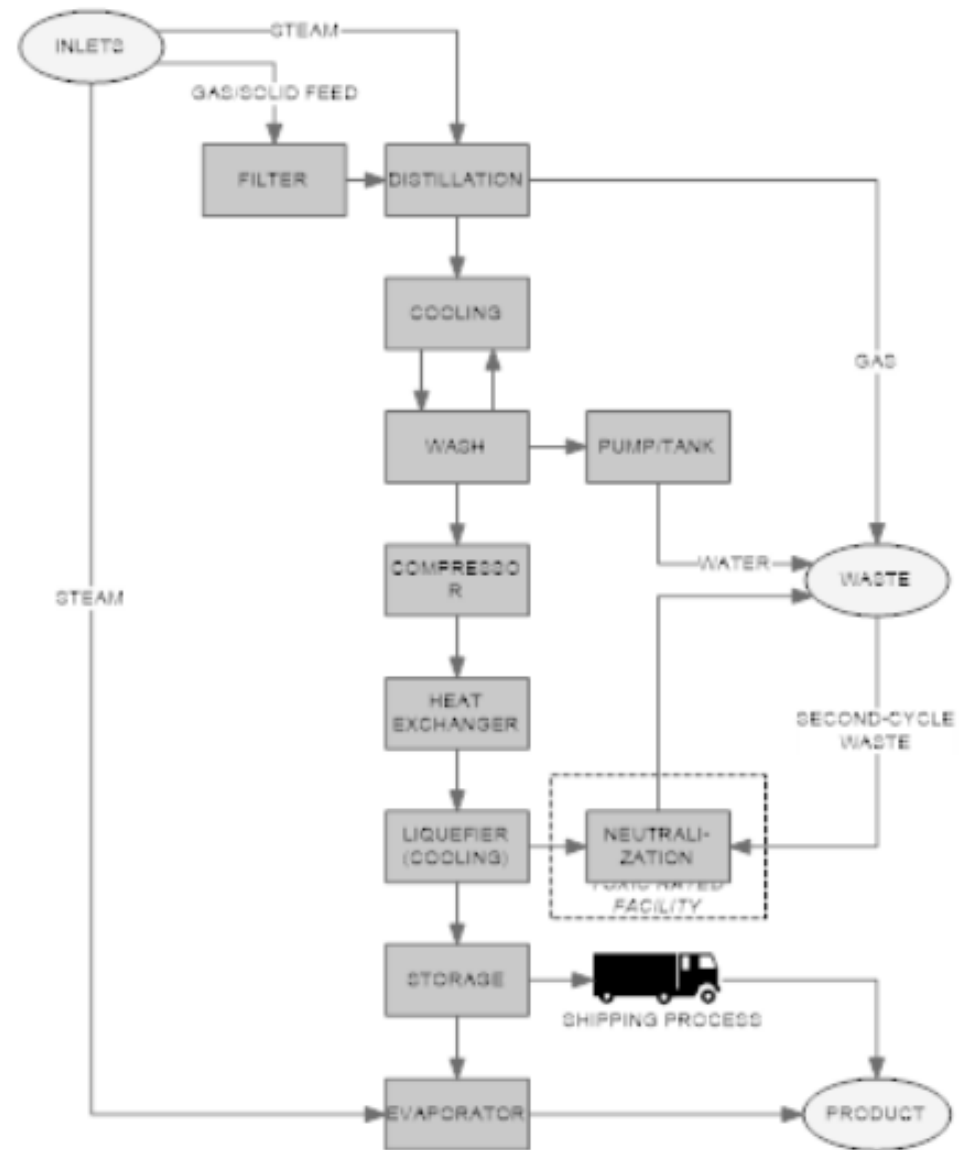
Exemplo



Fonte:

Exemplo de Flowchart produzido pelo SmartDraw <https://www.smartdraw.com/>

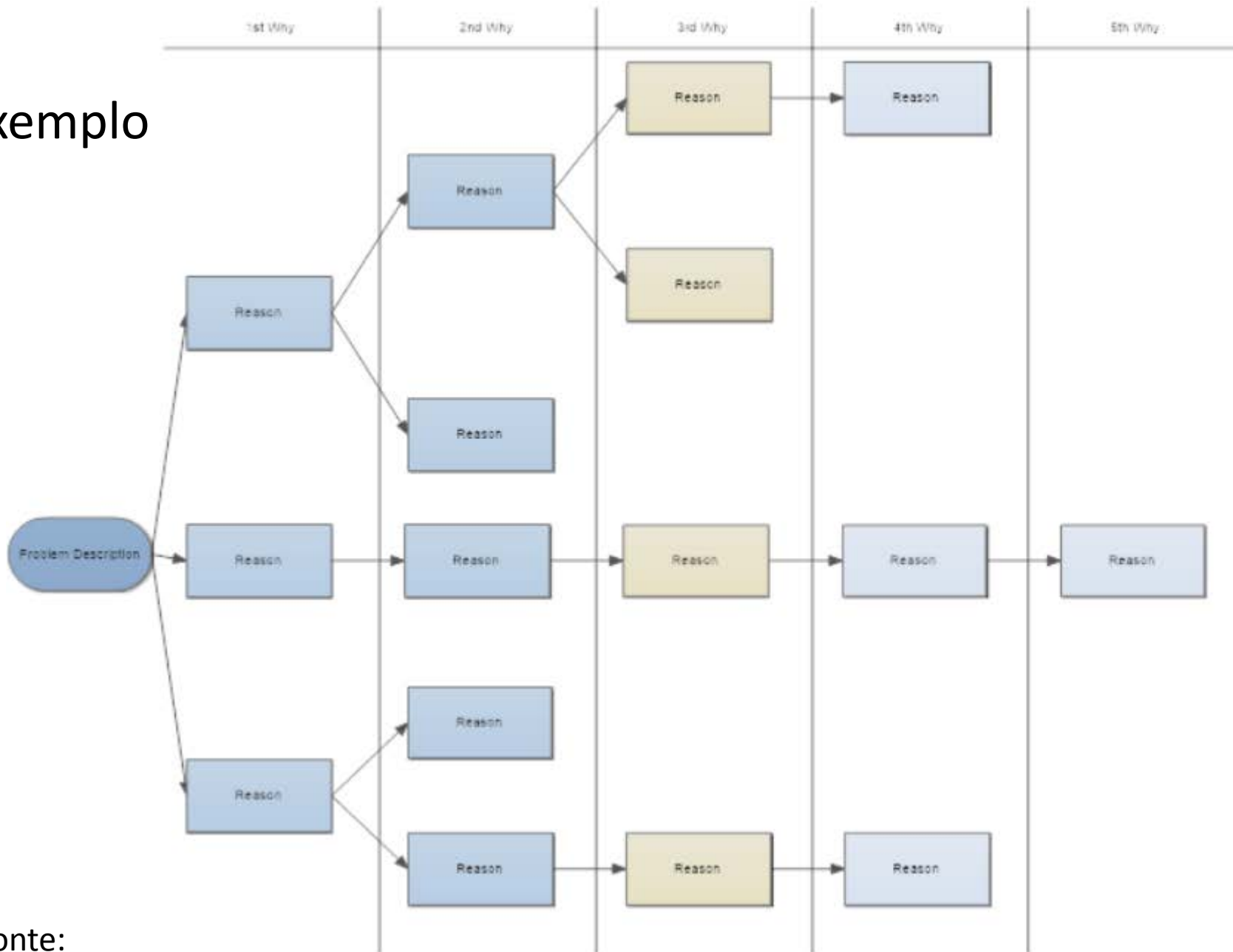
Exemplo



Fonte:
Exemplo de Flowchart produzido pelo
SmartDraw
<https://www.smartdraw.com/>

BLOCK DIAGRAM CHEMICAL FACILITY	DRAWN BY	CHECKED	DATE	SCALE	SHEET NO.
---	----------	---------	------	-------	-----------

Exemplo

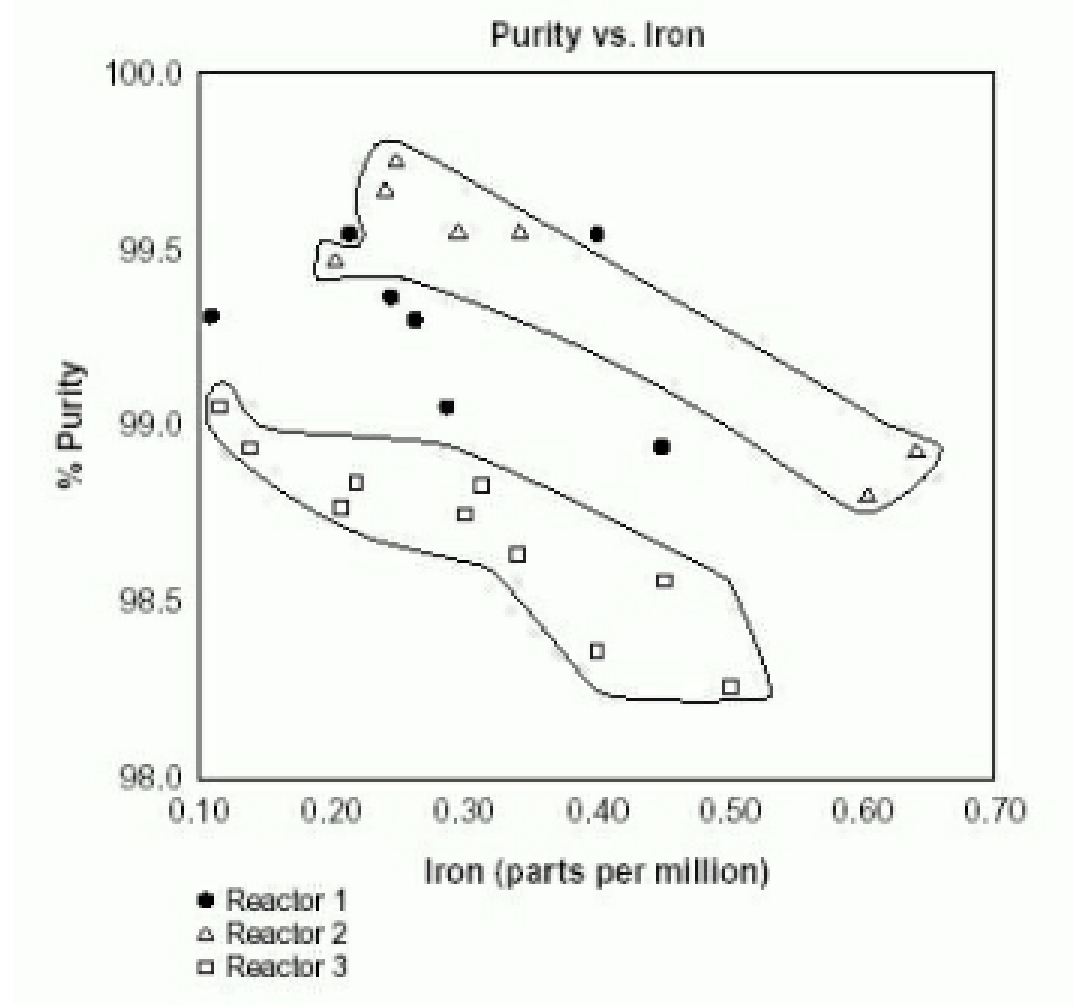


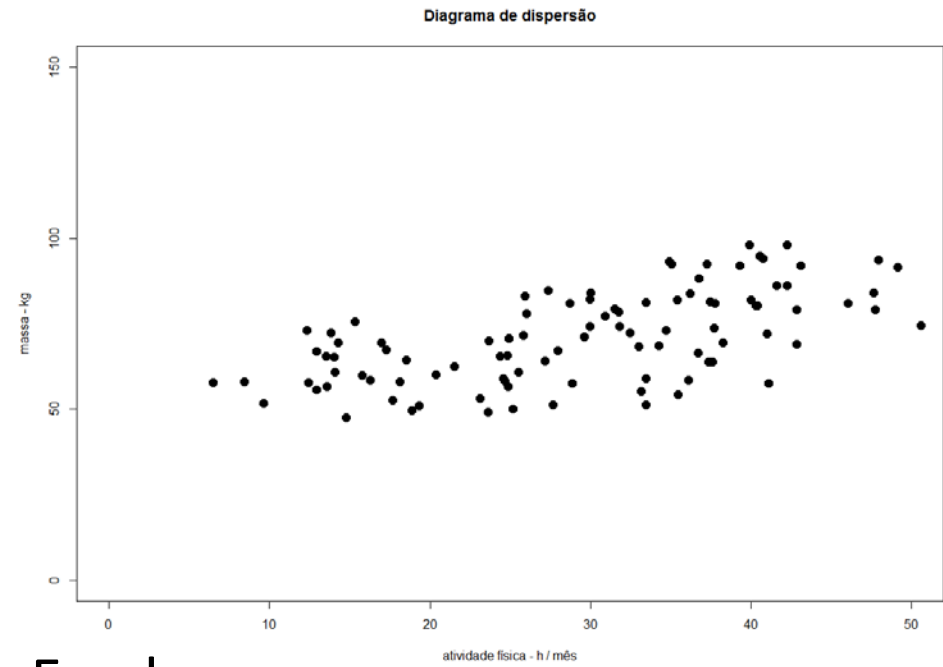
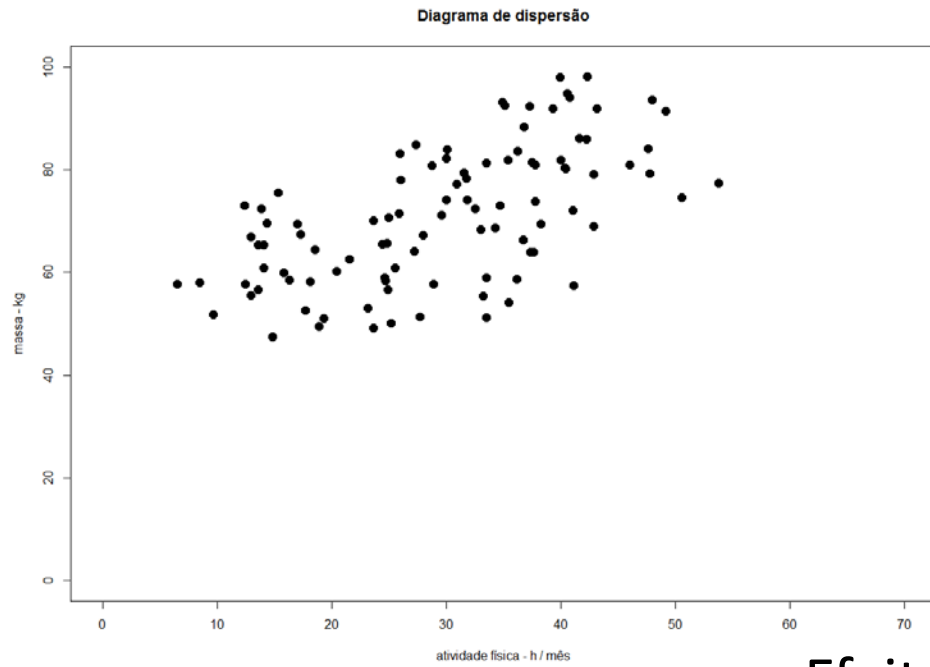
Fonte:

Exemplo de Diagrama de 5Ws produzido pelo SmartDraw <https://www.smartdraw.com/>

7' - Estratificação

- Identifique possíveis estratos na população
- Faça a amostragem estratificada
- Considere a influência dos possíveis estratos no comportamento da variável de interesse
- Pode haver contradição entre análise estratificada e análise agregada





Efeito das Escalas

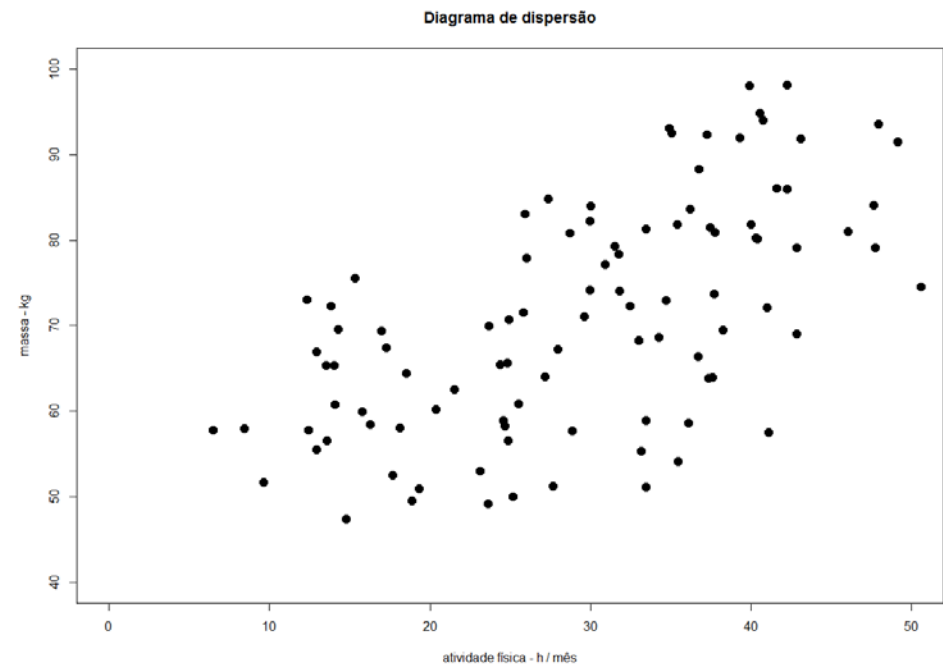
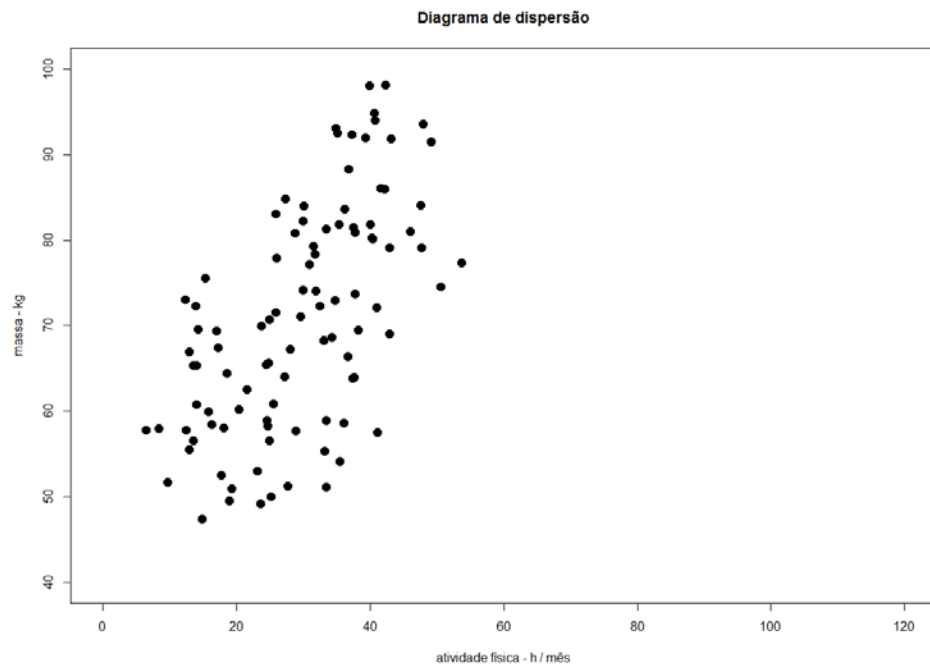


Diagrama de dispersão

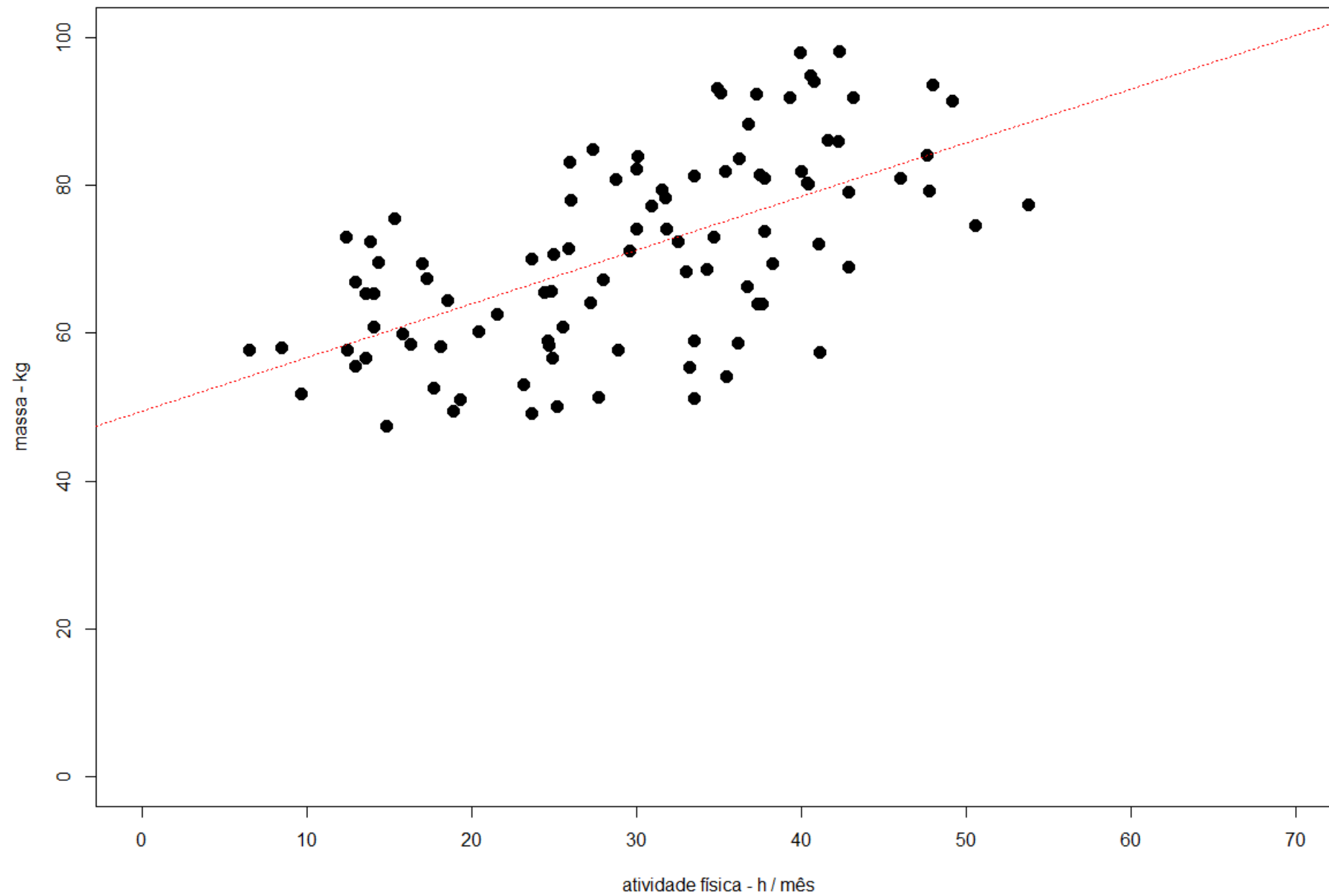


Diagrama de dispersão Estratificado

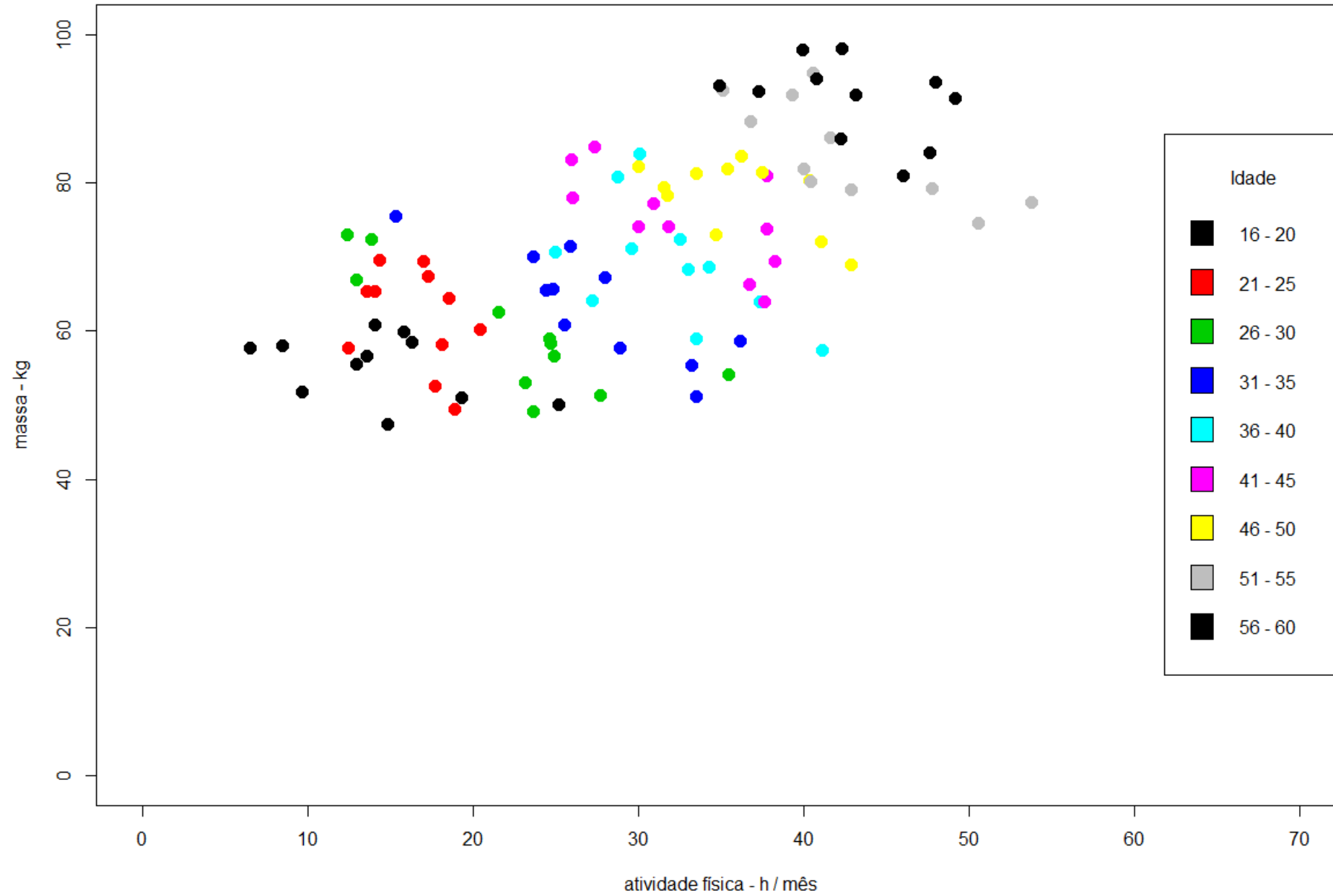
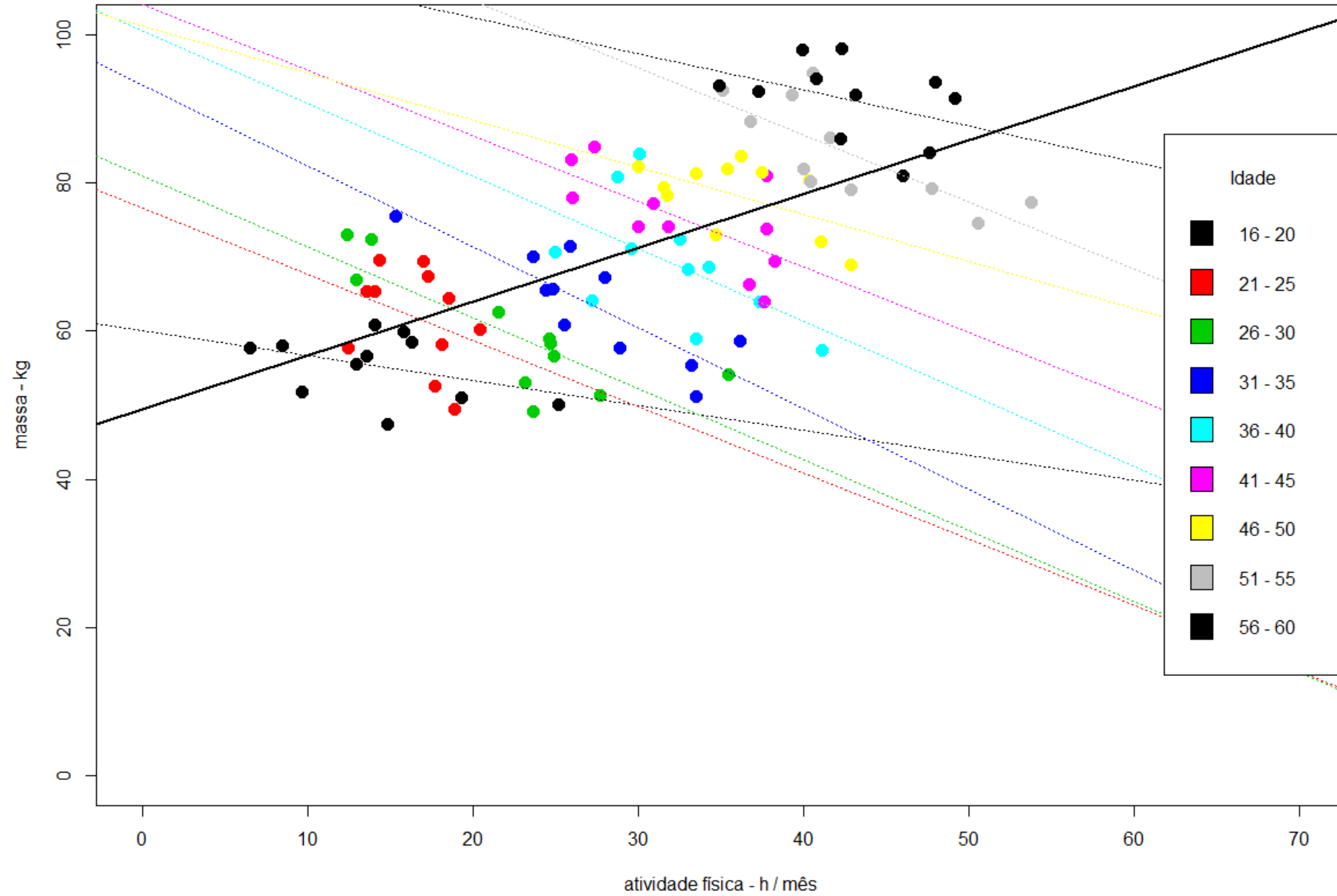
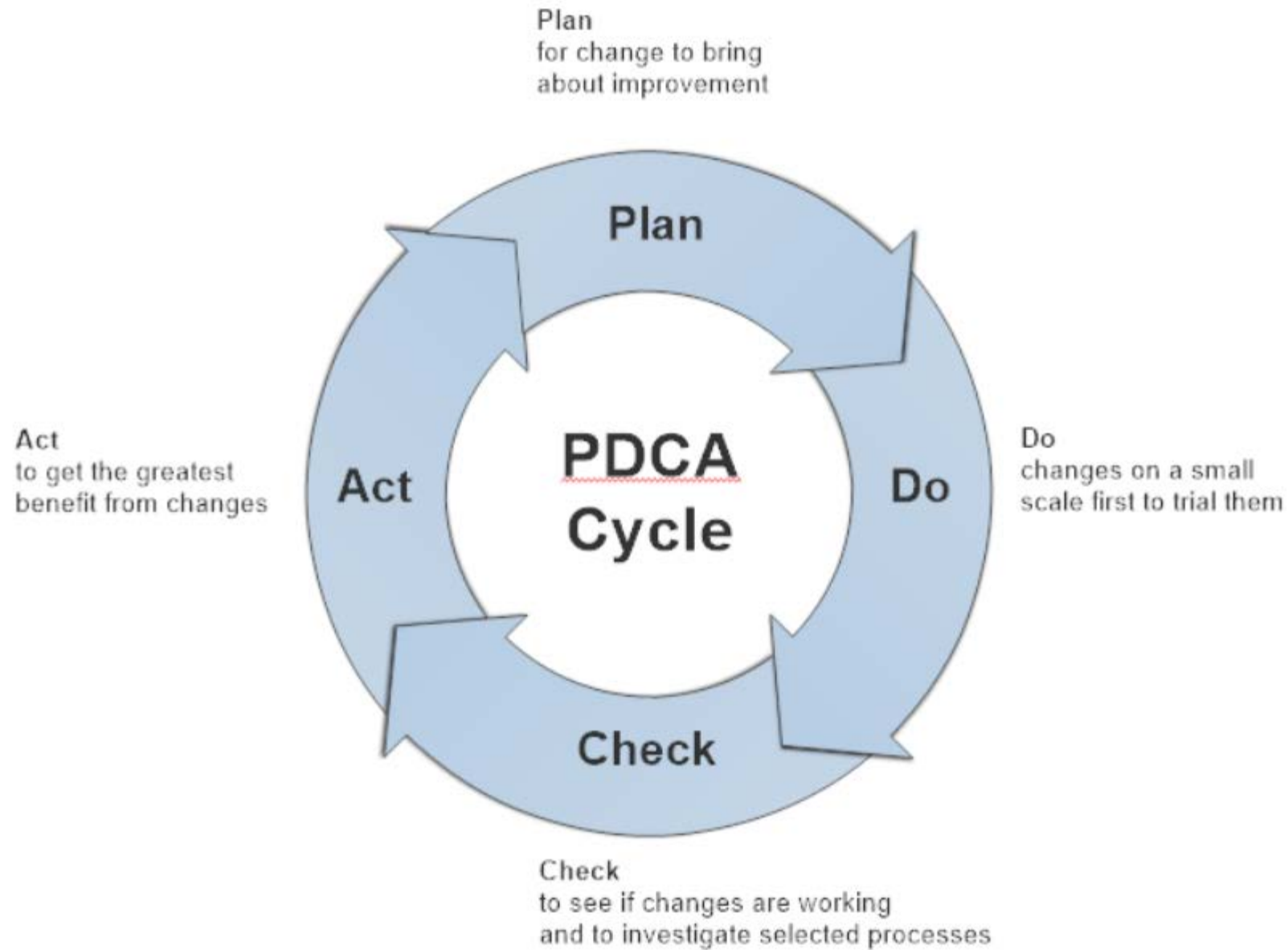


Diagrama de dispersão Estratificado

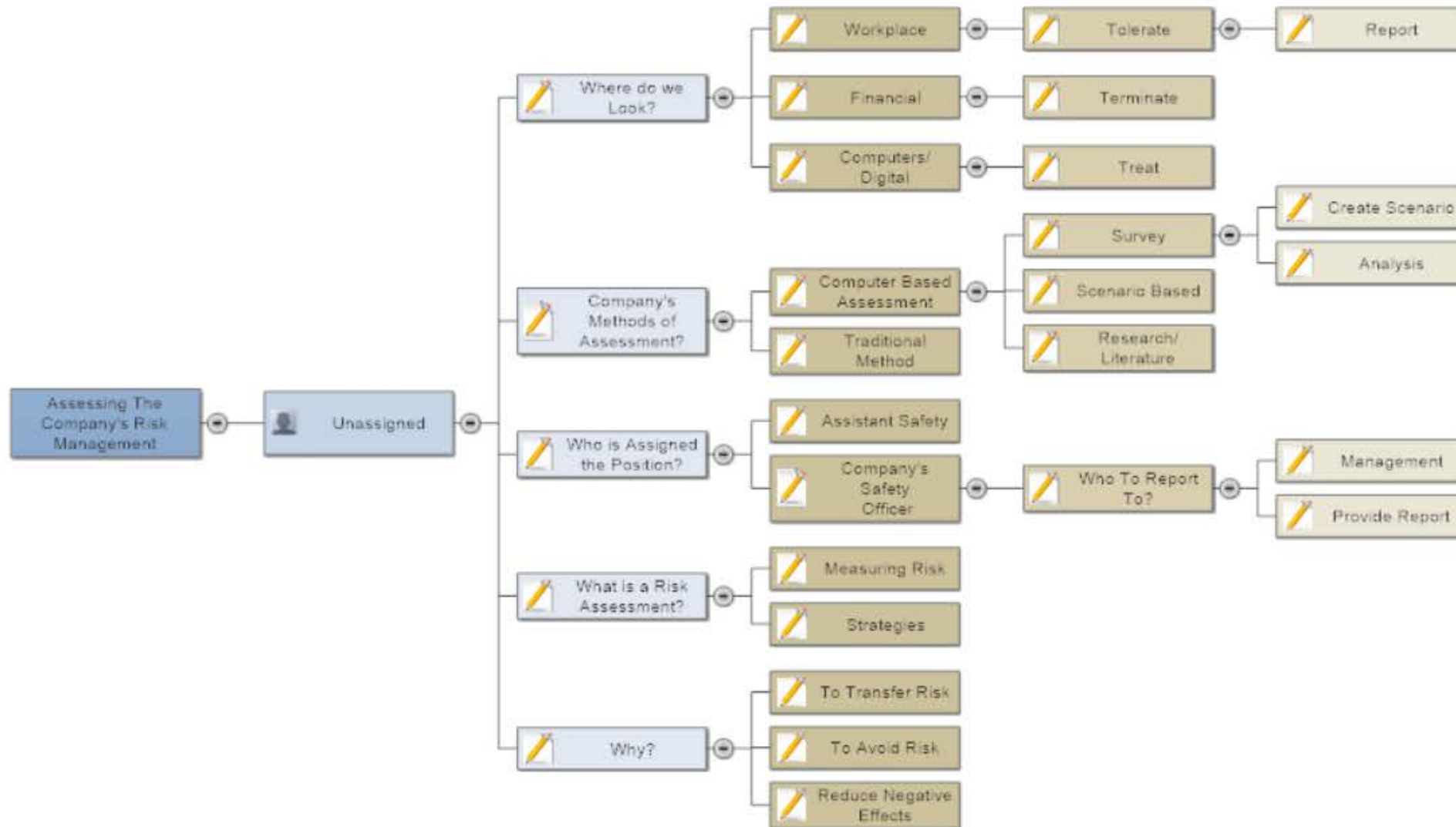


Outros Diagramas

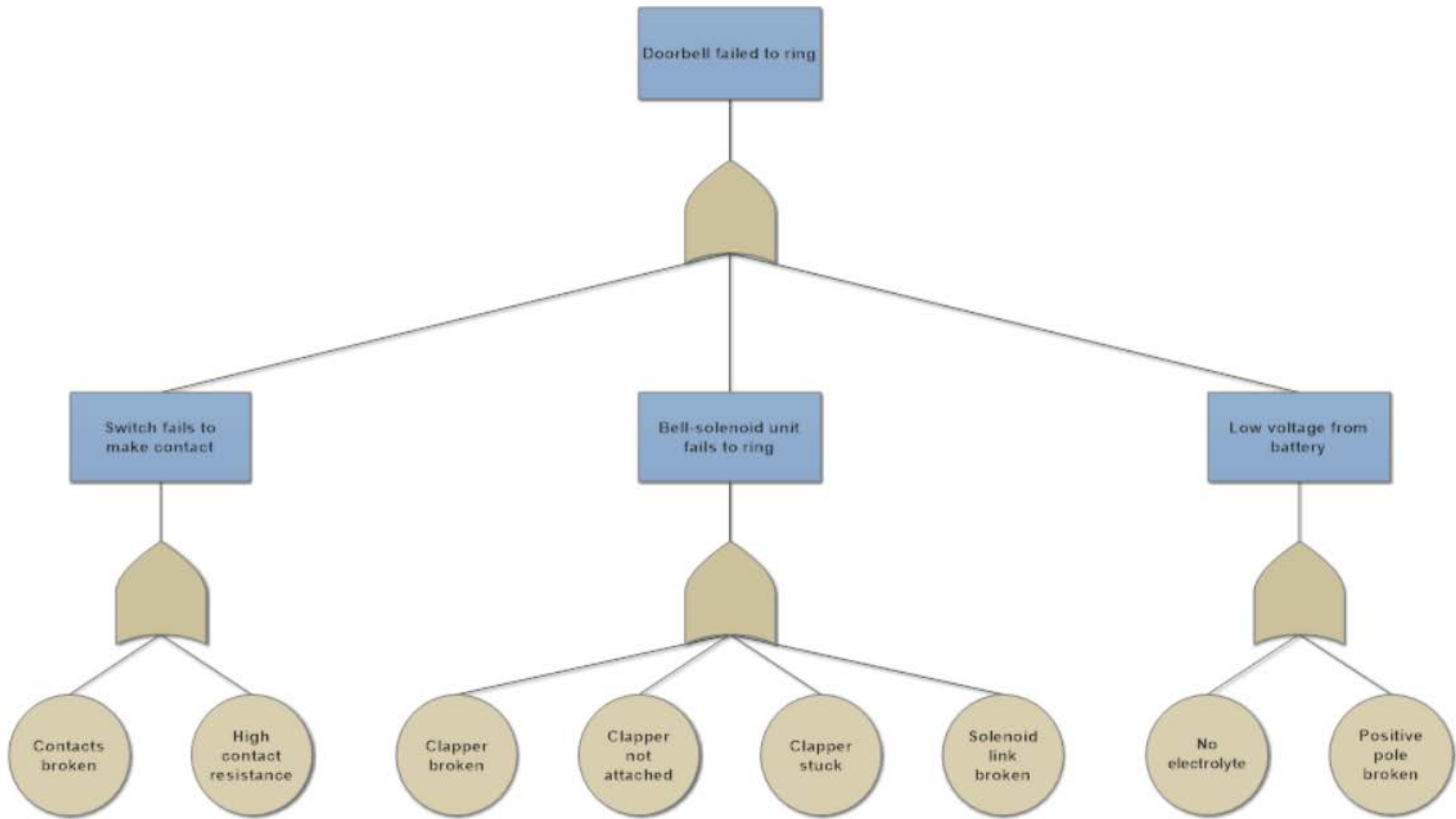


Fonte:

Exemplo de Diagrama PDCA produzido pelo SmartDraw <https://www.smartdraw.com/>



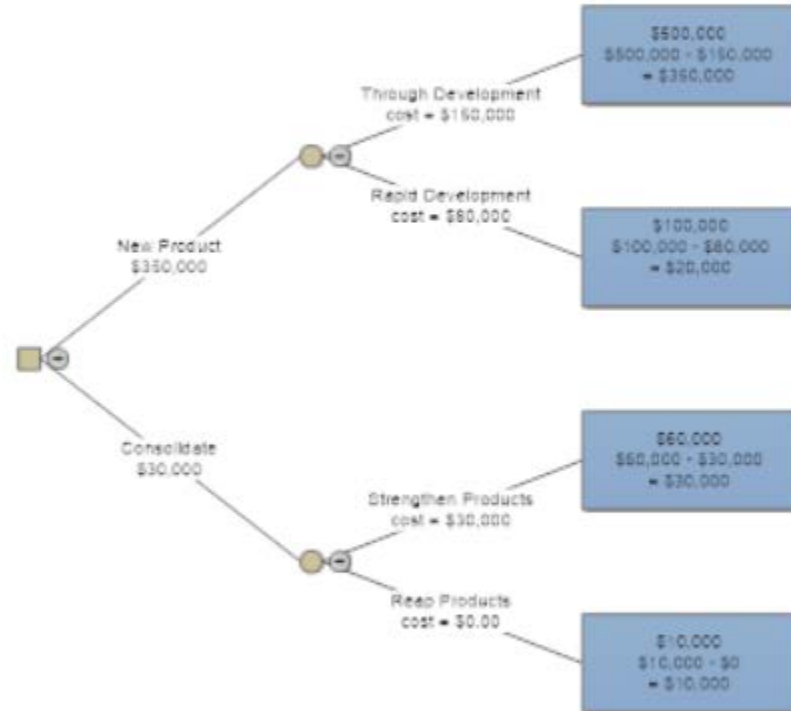
Fonte:
 Exemplo de Diagrama Mental/ Árvore de Possibilidades produzido pelo SmartDraw <https://www.smartdraw.com/>



Fonte:

Exemplo de Árvore de Falhas produzido pelo SmartDraw <https://www.smartdraw.com/>

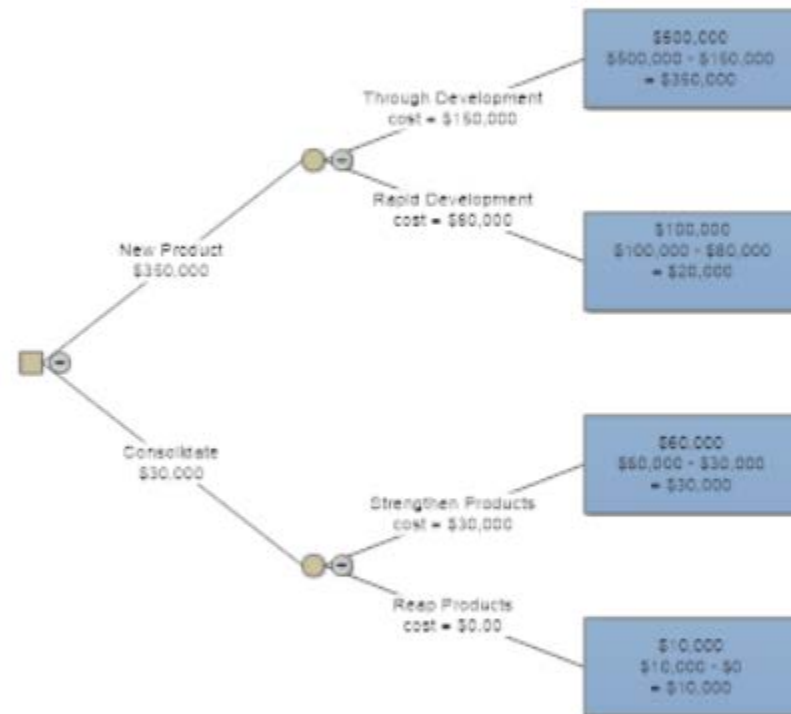
Develop a New Product *or* Consolidate?



Fonte:

Exemplo de Árvore de Decisão produzido pelo SmartDraw <https://www.smartdraw.com/>

Develop a New Product *or* Consolidate?

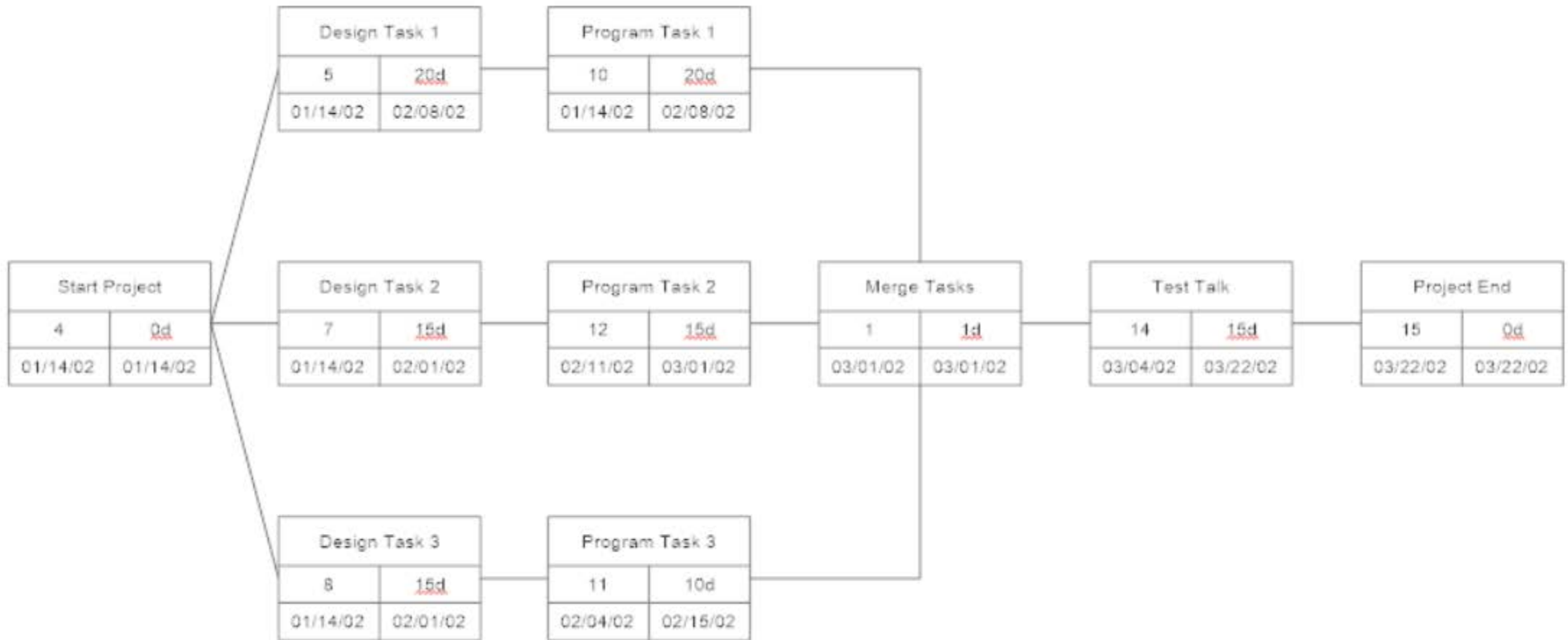


Fonte:
Exemplo de Árvore de Decisão
produzido pelo SmartDraw
<https://www.smartdraw.com/>

#	Task	Assigned To	Start	End	Dur	2017												2018	
						Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
	Design Project		1/1/17	9/2/18	289														
1	Planning/Organizing		1/1/17	4/3/17	45														
2	Research/Brainstorming		1/1/17	9/5/17	91														
3	Initial and Final Designs		2/4/17	29/6/17	63														
4	User Surveys/QA		2/7/17	30/9/17	65														
5	First Design Release to Public		2/10/17	29/11/17	42														
6	Second Design Release to Public		30/11/17	29/12/17	21														
7	Project Completion		29/12/17	9/2/18	30														

Fonte:

Exemplo de Diagrama de Gantt produzido pelo SmartDraw <https://www.smartdraw.com/>



Fonte:

Exemplo de Diagrama de PERT produzido pelo SmartDraw <https://www.smartdraw.com/>

RED TAG #

We have not used in last week/month "and/or" We will not use in next week/month

Date Tag Attached **Date Action Was Taken**

Item Classification

Purchase Component Machine / Equipment
 Raw Material Machine Parts
 Work In Progress Supplies
 Finished Product Other

Name of item

Part Number / Order Number

Quantity / Value

Number of Items X **Value Per Item** = **Total Value**

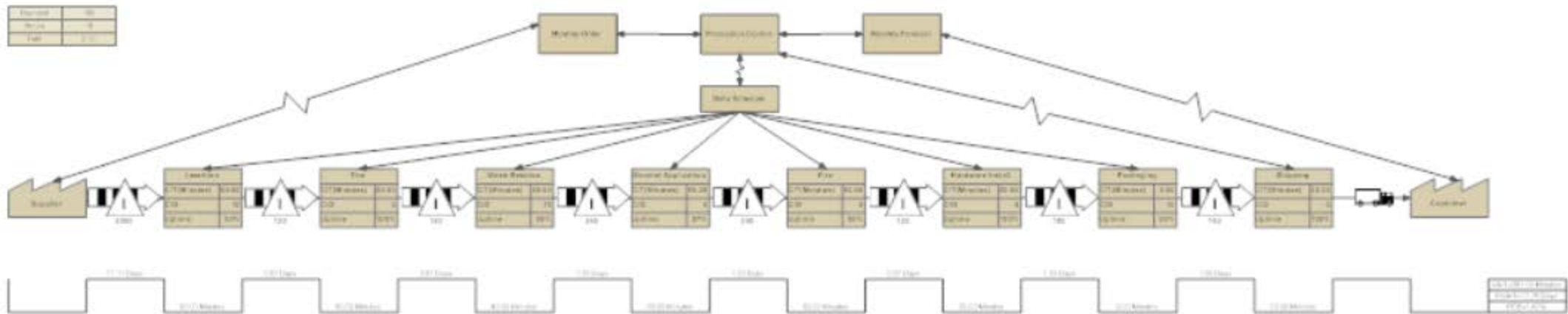
Reasons Tagged

Unnecessary Not Urgent
 Defective Other _____

Action to be Taken

Scrap Return to _____
 Dispose Other _____
 Move to Storage

Fonte:
 Exemplo de Targeta Vermelho – Lean
 produzido pelo SmartDraw
<https://www.smartdraw.com/>



Fonte:

Exemplo de Mapa de Fluxo de Valor produzido pelo SmartDraw <https://www.smartdraw.com/>

Softwares

- R
 - Pacote qcc <https://cran.r-project.org/web/packages/qcc>
 - Pacote SixSigma <https://cran.r-project.org/web/packages/SixSigma>
 - Pacote FaultTree <https://r-forge.r-project.org>
 - Pacote DiagrammeR <http://rich-annone.github.io/DiagrammeR/index.html>
- SmartDraw <https://www.smartdraw.com/>
- Livre Office <https://pt-br.libreoffice.org>
- MS Excel, PowerPoint e Power BI <https://powerbi.microsoft.com/pt-br/>
- Google Docs, Sheets e Slides <https://gsuite.google.com>