

# Learning Statistics based on the Compendium and Reproducible Computing

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# Outline

- 1 Motivation
  - The Problem of Irreproducible Research
  - Previous Work
- 2 A new Solution
  - The Concept
  - Creating the Compendium
  - Reading the Compendium
- 3 Applications
- 4 Conclusions and Future Work

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# Irreproducible Research. Literature.

## Claerbout's Principle

An article about computational science in a scientific publication is not the scholarship itself, it is merely **advertising** of the scholarship. The actual scholarship is the complete software development environment and that complete set of instructions that generated the figures.

- de Leeuw (2001); Green (2003); Koenker & Zeileis (2007); Peng, Dominici & Zeger (2006); Schwab, Karrenbach & Claerbout (2000); ...

# Irreproducible Research.

Jan de Leeuw's comments.

- First, there is no reason to single out figures.
- Second, there is no reason to limit the Claerbout's Principle to published articles.
- And third, and perhaps most importantly, it is not clearly defined what a "software environment" is. ... This violates the Freeware Principle...

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# Reproducible Research.

The “Sweave” solution.

- Donoho & Huo (2004), Gentleman (2005), Leisch (2003), ...
- R code is embedded in  $\LaTeX$

"S"weave R code in  $\LaTeX$

This is  $\LaTeX$  text...

and here we include Figure  $\backslash\text{ref}\{F1\}$  which is generated by the R engine

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<<F1, fig=TRUE>>=  
plot(data.x,data.y)  
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The “Sweave” solution is not practical...

- students are required to DIE  
(Download, Install, and Execute)
- assumes working knowledge of  $\text{\LaTeX}$  and R
- Reused computations cannot be easily distributed/disseminated
- The use of Sweave-based documents (“Compendia”) cannot be measured  
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# The Compendium: a new definition.

Complete separation of content and computing.

## Original Definition

An electronic *collection* of Text, Data and Software that allows the reader to reproduce the research that is presented in the document.

## New Definition

A document with (open-access) *references* to (remotely) archived computations (including Data, Meta-data, and Software) that allow us to reproduce, and reuse the underlying analysis.

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# Compendium Platform.

## How to create a Compendium?

- 1 create computations in R modules
  - 1 use (<http://www.wessa.net>)
  - 2 create new R modules (RC package TBR 2009)
- 2 “blog” (or archive) computations (<http://www.freestatistics.org>)
- 3 insert hyperlink in document
  - 1 in  $\text{\LaTeX}$  (example in paper)
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# Compendium Platform.

Inserting computational links in  $\text{\LaTeX}$ .

## Example in $\text{\LaTeX}$

```
\begin{lstlisting}[caption=Including the Histogram in  
\text{\LaTeX}\{Histogram\}  
\begin{figure*}  
\centerline{\mbox{\includegraphics[width=4.00in]{histogram.ps}} }  
\caption{Histogram of Gold prices (in Brussels) }  
\centerline{\htmladdnormallink{www....}{http://www....}}  
\label{histogram}  
\end{figure*}  
\end{lstlisting}
```

# Compendium Platform.

Conceptual overview.

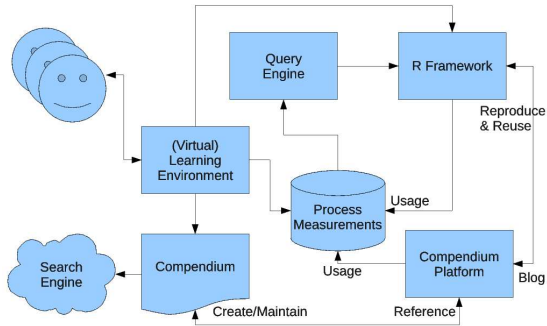


Figure: Reproducible Computing in Education



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# Reproducible Computing made easy.

## How to read a Compendium?

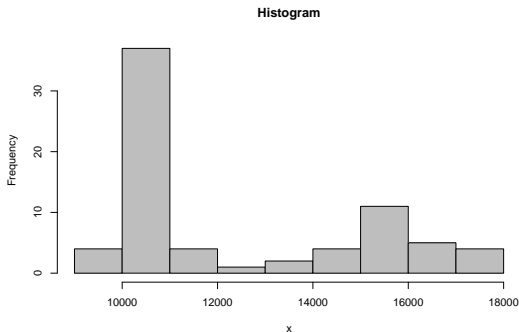


Figure:

<http://www.freeststatistics.org/blog/date/2008/Jun/20/t1213979586y9h8zd8mwz5x7br.htm>

# Reproducible & Reusable Computing.

## Example of Reproducible Computing (chain of events).

Family? (F = Feedback message, R = changed R code, M = changed R Module, P = changed Parameters, D = changed Data)

```
- \[Exercise 1.13\] [Exercise 1.13 (Wo...)] [2008-10-01 13:28:34] [Wessa Patrick] [Current]
- RMPD \[Univariate Data Series\] [time series] [2008-10-08 11:25:42] [Admin The]
- RMPD \[Univariate Data Series\] [dit is mijn eerst...] [2008-10-08 12:40:10] [Admin The]
- R \[Exercise 1.13\] [Ex 1.13] [2008-10-08 15:21:19] [Buelens David]
- R \[Exercise 1.13\] [Ex 1.13] [2008-10-08 15:21:19] [Buelens David]
- P \[Exercise 1.13\] [1.13] [2008-10-08 15:26:49] [Buelens David]
- R P \[Exercise 1.13\] [1.13 Norm] [2008-10-08 18:13:59] [Van den Heuvel Koen]
- R P \[Exercise 1.13\] [1.13 Norm-2] [2008-10-08 18:16:42] [Van den Heuvel Koen]
- R P \[Exercise 1.13\] [1.13 Norm-3] [2008-10-08 18:20:07] [Van den Heuvel Koen]
- R P \[Exercise 1.13\] [1.13 Gr-kl 60-20 ...] [2008-10-08 18:22:56] [Van den Heuvel Koen]
- R P \[Exercise 1.13\] [1.13 Gr-kl 90-30 ...] [2008-10-08 18:26:07] [Van den Heuvel Koen]
- R P \[Exercise 1.13\] [1.13 Gr-kl 105-35...] [2008-10-08 18:29:40] [Van den Heuvel Koen]
- \[Exercise 1.13\] [1.13 Gr-kl 105-35...] [2008-10-08 18:42:41] [Van den Heuvel Koen]
- P \[Exercise 1.13\] [1.13 80% male] [2008-10-08 19:17:52] [Van den Heuvel Koen]
- R P \[Exercise 1.13\] [1.13 <60%] [2008-10-08 19:27:49] [Van den Heuvel Koen]
- P \[Exercise 1.13\] [Aanpassing parame...] [2008-10-08 20:00:58] []
- P \[Exercise 1.13\] [1. Probability of...] [2008-10-09 10:55:33] [Mues Tommy]
- P \[Exercise 1.13\] [1. Probability of...] [2008-10-09 10:55:33] [van Keken Bas]
- P \[Exercise 1.13\] [2. The probabilit...] [2008-10-09 10:23:43] [Mues Tommy]
- P \[Exercise 1.13\] [2. The probabilit...] [2008-10-09 10:23:43] [van Keken Bas]
- \[Exercise 1.13\] [1.13 parameter ti...] [2008-10-09 11:00:12] []
- R \[Exercise 1.13\] [3. The greater nu...] [2008-10-09 10:27:48] [Mues Tommy]
```

# Statistics Education.

## Using the Compendium Platform in Statistics Education.

- Constructivist e-Learning Environments that support non-rote learning

How Reproducible Research Leads to Non-Rote Learning Within a Socially Constructivist E-Learning Environment, Proceedings of the 7th European Conference on e-Learning, 2008

- Worked-out examples & cases

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- Reproducible Errors instead of “Meaningful” Error Messages
- Master/PhD. thesis (making progress based on previous research)
- Fraud detection/prevention

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### Using the Compendium Platform in Educational Research.

- Measurements of actual learning activities:
  - Computing
  - Computing-based Communication
  - Parent-Child relationships
  - Impact of Reproducible Computing on Test Scores
- Comparison of actual versus reported data
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- The proposed solution satisfies Jan de Leeuw's criteria and:
  - is generic and easy to use
  - effectively supports various learning styles
  - allows us to build new applications
  - measures actual learning activities which can be used for educational research
- Best of all... it is free of charge for research and education.  
(some limitations might apply)
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