



R/exams



R/exams: A One-for-All Exams Generator

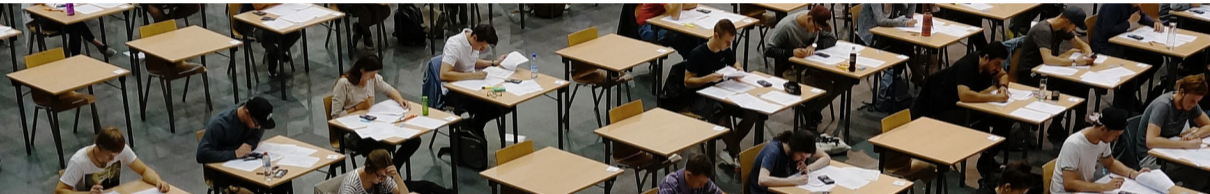
Written Exams, Online Tests, and Live Quizzes with R

Achim Zeileis

<http://www.R-exams.org/>



R/exams



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R/exams

Solution

Using the product rule for $f(x) = g(x) \cdot h(x)$, where $g(x) := x^9$ and $h(x) := e^{2.7x}$, we obtain

$$\begin{aligned} f'(x) &= [g(x) \cdot h(x)]' = g'(x) \cdot h(x) + g(x) \cdot h'(x) \\ &= 9x^{9-1} \cdot e^{2.7x} + x^9 \cdot e^{2.7x} \cdot 2.7 \\ &= e^{2.7x} \cdot (9x^8 + 2.7x^9) \\ &= e^{2.7x} \cdot x^8 \cdot (9 + 2.7x). \end{aligned}$$

Evaluated at $x = 0.88$, the answer is

```
7 \begin{solution}
8 Using the product rule for  $f(x) = g(x) \cdot h(x)$ , where
9  $g(x) := x^{\{Sexpr(a)\}}$  and  $h(x) := e^{\{Sexpr(b)x\}}$ , we obtain
10
11 \begin{equation*}
12 f'(x) = [g(x) \cdot h(x)]' = g'(x) \cdot h(x) + g(x) \cdot h'(x) \\
13 = \{Sexpr(a)\} x^{\{Sexpr(a)-1\}} \cdot e^{\{Sexpr(b)x\}} + x^{\{Sexpr(a)\}} \\
14 \cdot e^{\{Sexpr(b)x\}} \cdot \{Sexpr(b)\} \\
15 = e^{\{Sexpr(b)x\}} \cdot \{Sexpr(a)\} x^{\{Sexpr(a)-1\}} + \{Sexpr(b)\} \\
16 \cdot x^{\{Sexpr(a)\}} \cdot e^{\{Sexpr(b)x\}} \\
17 \end{equation*}
18 Evaluated at  $x = \{Sexpr(c)\}$ , the answer is
19  $\{ e^{\{Sexpr(b)\} \cdot \{Sexpr(c)\}} \cdot \{Sexpr(c)\}^{\{Sexpr(a)-1\}} \cdot \{Sexpr(a)\} + \{Sexpr(b)\} \cdot \{Sexpr(c)\}^{\{Sexpr(a)\}} \cdot e^{\{Sexpr(b)\} \cdot \{Sexpr(c)\}} \}$ 
```

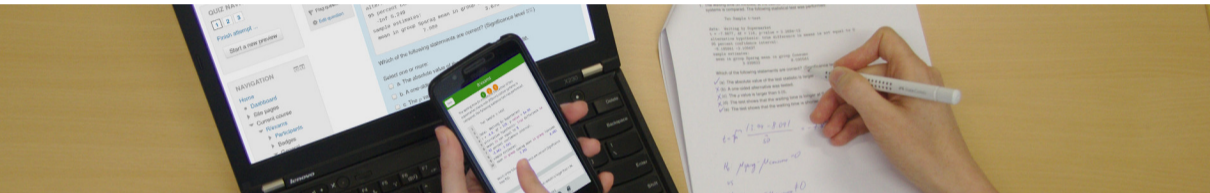
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Motivation and challenges

Motivation:

- Many of us teach large lecture courses, also as support for other fields.
- For example, statistics, probability, or mathematics in curricula such as business and economics, social sciences, psychology, etc.
- At WU Wien and Universität Innsbruck: Some courses are attended by more than 1,000 students per semester.
- Several lecturers teach lectures and tutorials in parallel.

Strategy:

- Individualized organization of learning, feedback, and assessment.
- The same pool of exercises at the core of all parts of the course.

Motivation and challenges

	Learning	Feedback	Assessment
Synchronous	Lecture Live stream	Live quiz (+ Tutorial)	Written exam
Asynchronous	Textbook Screencast	Self test (+ Forum)	Online test

Motivation and challenges

	Learning	Feedback	Assessment
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Learning:

- *Standard*: Textbook along with presentation slides.
- *Streaming*: Videos streamed simultaneously or (pre-)recorded.

Motivation and challenges

	Learning	Feedback	Assessment
Synchronous	Lecture Live stream	Live quiz (+ Tutorial)	Written exam
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Feedback & assessment:

- *Scalability*: Randomized dynamic exercises required.
- *Feedback*: Support for complete correct solutions.
- *Flexibility*: Automatic rendering into different assessment formats.

R package *exams*

Exercises:

- Each exercise is a single file (either `.Rmd` or `.Rnw`).
- Contains question and (optionally) the corresponding solution.
- Dynamic templates if R code is used for randomization.

Answer types:

- Single choice and multiple choice.
- Numeric values.
- Text strings (typically short).
- Combinations of the above (cloze).

R package *exams*

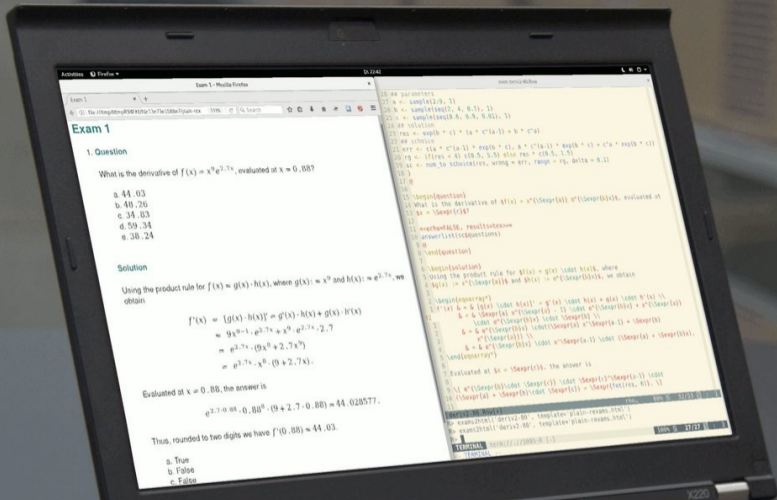
Output:

- PDF – fully customizable vs. standardized with automatic scanning/evaluation.
- HTML – fully customizable vs. embedded into exchange formats below.
- *Moodle XML*.
- QTI XML standard (version 1.2 or 2.1), e.g., for *OLAT/OpenOLAT*.
- *ARSnova, TCExam, LOPS, ...*

Infrastructure: Standing on the shoulders of lots of open-source software...

R package exams

Type	Software	Purpose
Statistical computing	R	Random data generation, computations
Writing/reporting	\LaTeX , <i>Markdown</i>	Text formatting, mathematical notation
Reproducible research	<i>knitr</i> , <i>rmarkdown</i> , <i>Sweave</i>	Dynamically tie everything together
Document conversion	<i>TtH/TtM</i> , <i>pandoc</i>	Conversion to HTML and beyond
Image manipulation	<i>ImageMagick</i> , <i>magick</i> , <i>png</i>	Embedding graphics
Web technologies	<i>base64enc</i> , <i>RCurl</i> , ...	Embedding supplementary files
Learning management	<i>Moodle</i> , <i>OpenOLAT</i> , <i>ARSnova</i> , ...	E-learning infrastructure



Dynamic Exercises

Dynamic exercises

Text file:

- 1 Random data generation (optional).
- 2 Question.
- 3 Solution (optional).
- 4 Metainformation.

Examples:



Multiple-choice knowledge quiz with shuffled answer alternatives.

Which of these institutions already hosted a useR! or eRum conference?



Dynamic numeric arithmetic exercise.

What is the derivative of $f(x) = x^a e^{b \cdot x}$, evaluated at $x = c$?

Dynamic exercises: .Rmd

Example: Which of these institutions already hosted a useR! or eRum conference?

Dynamic exercises: .Rmd

Example: Which of these institutions already hosted a useR! or eRum conference?

Question

=====

Which of these institutions already hosted a useR! or eRum conference?

Answerlist

- * Uniwersytet Ekonomiczny w Poznaniu
- * Agrocampus Ovest
- * Technische Universität Dortmund
- * Universität Wien
- * ETH Zürich
- * Københavns Universitet

Dynamic exercises: .Rmd

Example: Which of these institutions already hosted a useR! or eRum conference?

Solution

=====

The list of useR!/DSC and eRum hosts can be found at
<<https://www.R-project.org/conferences.html>> and <<https://erum.io/>>, respectively.

Answerlist

- * True. eRum 2016 was hosted in Poznan.
- * True. useR! 2009 was hosted at Agrocampus Ouest, Rennes.
- * True. useR! 2008 was hosted at TU Dortmund.
- * False. Universität Wien did not host an R conference yet (only TU Wien and WU Wien).
- * False. ETH Zürich did not host an R conference yet.
- * False. Københavns Universitet hosted DSC but not useR! or eRum.

Dynamic exercises: .Rmd

Example: Which of these institutions already hosted a useR! or eRum conference?

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Meta-information

=====

exname: R conferences

extype: mchoice

exsolution: 111000

exshuffle: 5

Dynamic exercises: .Rnw

Example: What is the derivative of $f(x) = x^a e^{b \cdot x}$, evaluated at $x = c$?

Dynamic exercises: .Rnw

Example: What is the derivative of $f(x) = x^a e^{b \cdot x}$, evaluated at $x = c$?

```
<<echo=FALSE, results=hide>>=
## parameters
a <- sample(2:9, 1)
b <- sample(seq(2, 4, 0.1), 1)
c <- sample(seq(0.5, 0.8, 0.01), 1)
## solution
res <- exp(b * c) * (a * c^(a-1) + b * c^a)
@
```

Dynamic exercises: .Rnw

Example: What is the derivative of $f(x) = x^a e^{b \cdot x}$, evaluated at $x = c$?

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<<echo=FALSE, results=hide>>=
## parameters
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c <- sample(seq(0.5, 0.8, 0.01), 1)
## solution
res <- exp(b * c) * (a * c^(a-1) + b * c^a)
@
```

```
\begin{question}
What is the derivative of  $f(x) = x^{\Sexpr{a}} e^{\Sexpr{b}x}$ ,
evaluated at  $x = \Sexpr{c}$ ?
\end{question}
```

Dynamic exercises: .Rnw

Example: What is the derivative of $f(x) = x^a e^{b \cdot x}$, evaluated at $x = c$?

```
\begin{solution}
```

Using the product rule for $f(x) = g(x) \cdot h(x)$, where

$g(x) := x^{\text{\Sexpr{a}}}$ and $h(x) := e^{\text{\Sexpr{b}x}}$, we obtain

```
\begin{eqnarray*}
```

```
f'(x) & = & [g(x) \cdot h(x)]' = g'(x) \cdot h(x) + g(x) \cdot h'(x) \ \ \
```

```
& = & \text{\Sexpr{a}} x^{\text{\Sexpr{a}} - 1} \cdot e^{\text{\Sexpr{b}x}} +
```

```
      \dots
```

```
\end{eqnarray*}
```

Evaluated at $x = \text{\Sexpr{c}}$, the answer is

```
\[ e^{\text{\Sexpr{b}} \cdot \text{\Sexpr{c}}} \cdot \text{\Sexpr{c}}^{\text{\Sexpr{a}} - 1} \cdot
```

```
(\text{\Sexpr{a}} + \text{\Sexpr{b}} \cdot \text{\Sexpr{c}}) = \text{\Sexpr{fmt}(res, 6)}. \]
```

Thus, rounded to two digits we have $f'(\text{\Sexpr{c}}) = \text{\Sexpr{fmt}(res)}$.

```
\end{solution}
```

Dynamic exercises: .Rnw

Example: What is the derivative of $f(x) = x^a e^{b \cdot x}$, evaluated at $x = c$?

```
\begin{solution}
```

Using the product rule for $f(x) = g(x) \cdot h(x)$, where

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f'(x) & = & [g(x) \cdot h(x)]' = g'(x) \cdot h(x) + g(x) \cdot h'(x) \ \ \
```

```
& = & \text{\Sexpr{a}} x^{\text{\Sexpr{a}} - 1} \cdot e^{\text{\Sexpr{b}x}} +
```

```
... 
```

```
\end{eqnarray*}
```

Evaluated at $x = \text{\Sexpr{c}}$, the answer is

```
\[ e^{\text{\Sexpr{b}} \cdot \text{\Sexpr{c}}} \cdot \text{\Sexpr{c}}^{\text{\Sexpr{a}} - 1} \cdot
```

```
(\text{\Sexpr{a}} + \text{\Sexpr{b}} \cdot \text{\Sexpr{c}}) = \text{\Sexpr{fmt}(res, 6)}. \]
```

Thus, rounded to two digits we have $f'(\text{\Sexpr{c}}) = \text{\Sexpr{fmt}(res)}$.

```
\end{solution}
```

```
\extype{num}
```

```
\exsolution{\text{\Sexpr{fmt}(res)}}
```

```
\exname{derivative exp}
```

```
\extol{0.01}
```

Dynamic exercises: Single choice



`extype: schoice`

`exsolution: 010`

Dynamic exercises: Single choice



extype: schoice

exsolution: 010

Question

What is the seat of the federal authorities in Switzerland (i.e., the de facto capital)?

- (a) Bern
- (b) Lausanne
- (c) Zurich
- (d) St. Gallen
- (e) Basel

Knowledge quiz: Shuffled distractors.

Dynamic exercises: Single choice



extype: schoice

exsolution: 010

Question

What is the derivative of $f(x) = x^3 e^{3.3x}$, evaluated at $x = 0.85$?

- (a) 45.97
- (b) 35.82
- (c) 56.45
- (d) 69.32
- (e) 39.31

Numeric exercises: Distractors are random numbers and/or typical arithmetic mistakes.

Dynamic exercises: Multiple choice



`extype: mchoice`

`exsolution: 011`

Dynamic exercises: Multiple choice



extype: mchoice

exsolution: 011

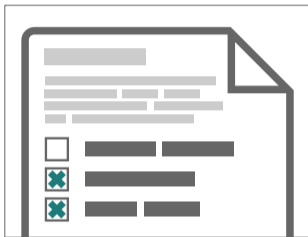
Question

Which of these institutions already hosted a useR! or eRum conference?

- (a) Agrocampus Ouest
- (b) Universität Wien
- (c) ETH Zürich
- (d) Technische Universität Dortmund
- (e) Uniwersytet Ekonomiczny w Poznaniu

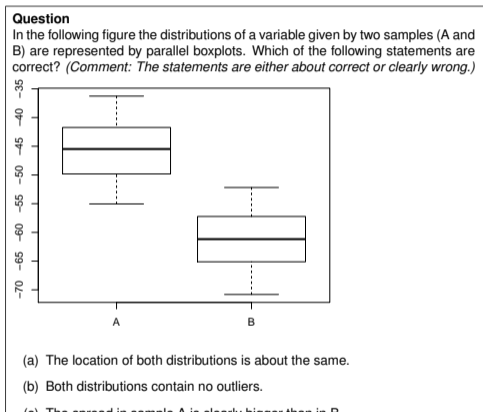
Knowledge quiz: Shuffled true/false statements.

Dynamic exercises: Multiple choice



extype: mchoice

exsolution: 011



Interpretations: Statements that are approximately correct or clearly wrong.

Dynamic exercises: Numeric



`extype: num`










`exsolution: 123.45`

Dynamic exercises: Numeric






```
extype: num  
exsolution: 123.45
```

Question
Given the following information:

	+		+		=	585
	+		+		=	144
	+		+		=	177

Compute:

	+		+		=	?
---	---	--	---	---	---	---

Numeric exercises: Solving arithmetic problems.

Dynamic exercises: String



```
extype: string  
exsolution: ANSWER
```

Dynamic exercises: String



Question

What is the name of the R function for Poisson regression?

Knowledge quiz: Sample a word/phrase from a given vocabulary or list of question/answer pairs.

```
exctype: string
```

```
exsolution: ANSWER
```


Dynamic exercises: Cloze



extype: cloze

exclozetype: schoice|num

exsolution: 10|123.45

Dynamic exercises: Cloze



extype: cloze

exclozetype: schoice|num

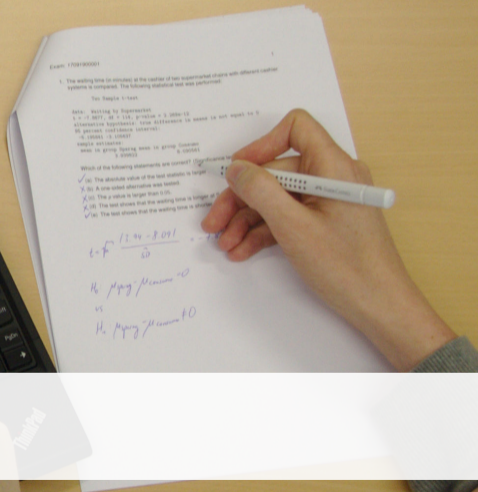
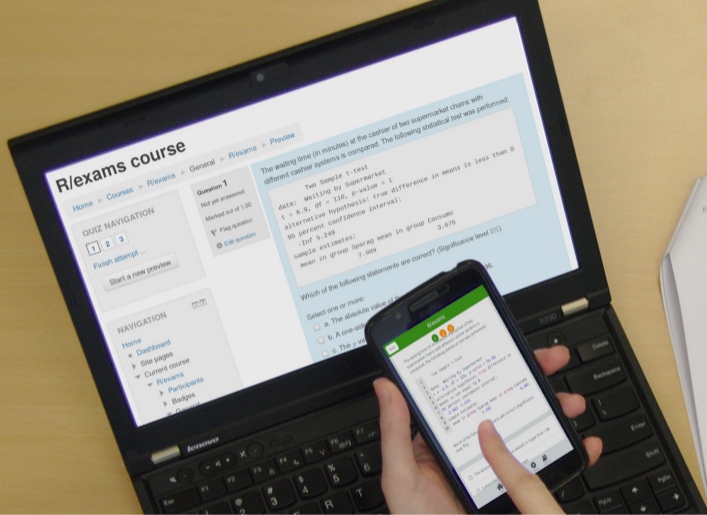
exsolution: 10|123.45

Question

Using the data provided in `regression.csv` estimate a linear regression of y on x and answer the following questions.

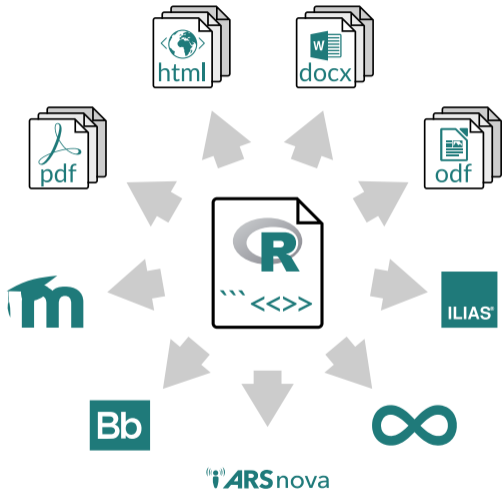
- (a) x and y are not significantly correlated / y increases significantly with x / y decreases significantly with x
- (b) Estimated slope with respect to x :

Exercises with sub tasks: Several questions based on same problem setting.



One-for-All

One-for-all



- The *same* exercise can be exported into different formats.
- Multiple standalone documents vs. combined exercise pool.
- Multiple-choice and single-choice supported in all output formats.

One-for-All

Idea: An exam is simply a list of exercise templates.

```
R> myexam <- list(  
+   "deriv2.Rnw",  
+   "fruit2.Rnw",  
+   c("ttest.Rnw", "boxplots.Rnw")  
+ )
```

Draw random exams:

- First randomly select one exercise from each list element.
- Generate random numbers/input for each selected exercise.
- Combine all exercises in output file(s) (PDF, HTML, ...).

One-for-All

Written exam:

```
R> exams2nops(myexam, n = 3, dir = odir,  
+   language = "hu", institution = "eRum 2018")
```

Online test:

```
R> exams2moodle(myexam, n = 10, dir = odir)
```

Live quiz:

```
R> exams2arsnova(myexam, n = 1, dir = odir)
```

Other: `exams2pdf()`, `exams2html()`, `exams2qti12()`, `exams2qti21()`, ...



Written Exams



Written Exams

Flexible: Roll your own.

- Combination with user-specified template in `exams2pdf()` and `exams2pandoc()`.
- Customizable but typically has to be evaluated “by hand”.

Standardized: “NOPS” format.

- `exams2nops()` intended for single- and multiple-choice questions.
- Can be scanned and evaluated automatically within R.
- Limited support for open-ended questions that have to be marked by a person.

Written exams

+ eRum 2018
Exam 2018-05-11



Személyes adatok		Regisztrációs szám	
Vezetéknév:		0	0
Keresztnév:		1	1
Állás:		2	2
		3	3
		4	4
		5	5
		6	6
		7	7
		8	8
		9	9

Variáció	
Típus	Dokumentum ID
005	18051100001

A választás jelölje egyértelmű Jelöltesen célja: vagy

A vizsgalap szkennelése automatikusan történik, ezért kérjük, hogy ne hajtsa össze és a kiállításához használjon **lék vagy fekete tollat.**

Kizárólag az egyértelműen és pontosan megjelölt válaszok kerülnek feldolgozásra!

Válaszok: 1 - 3

	a	b	c	d	e
1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

+

+

Exam: 18051100001

1

1. What is the derivative of $f(x) = x^2 e^{3x}$, evaluated at $x = 0.53$?

- (a) 49.35
- (b) 87.17
- (c) 71.00
- (d) 72.46
- (e) 55.20

2. Given the following information:

$$\begin{aligned} \text{Banana} + \text{Apple} + \text{Banana} &= 262 \\ \text{Banana} + \text{Apple} + \text{Banana} &= 137 \\ \text{Banana} + \text{Apple} + \text{Banana} &= 106 \end{aligned}$$

Compute:

$$\text{Banana} + \text{Apple} + \text{Banana} = ?$$

- (a) 106
- (b) 313
- (c) 161
- (d) 232
- (e) 454

3. The waiting time (in minutes) at the cashier of two supermarket chains with different cashier systems is compared. The following statistical test was performed:

Two Sample t-test

```
data: Waiting by Supermarket
t = -3.3, df = 50, p-value = 1
alternative hypothesis: true difference in means is greater than 0
95 percent confidence interval:
-3.237      1inf
sample estimates:
mean in group Sparag mean in group Consumo
 4.245          6.192
```

Which of the following statements are correct? (Significance level 5%)

- (a) The absolute value of the test statistic is larger than 1.96.
- (b) A one-sided alternative was tested.
- (c) The p value is larger than 0.05.
- (d) The test shows that the waiting time is longer at Sparag than at Consumo.
- (e) The test shows that the waiting time is shorter at Sparag than at Consumo.

Written exams



1. Create

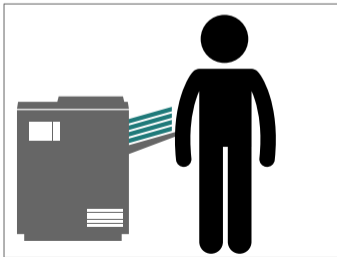
- As illustrated above.
- Using `exams2nops()`, create (individual) PDF files for each examinee.

Written exams



1. Create

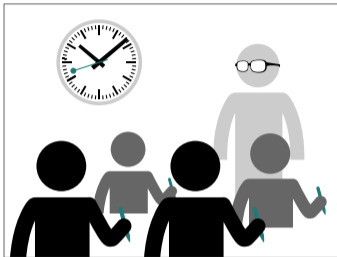
- As illustrated above.
- Using `exams2nops()`, create (individual) PDF files for each examinee.



2. Print

- Print the PDF exams, e.g., on a standard printer.
- ...or for large exams at a print shop.

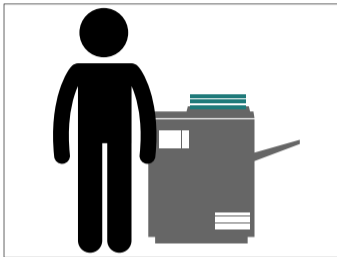
Written exams



3. Exam

- Conduct the exam as usual.
- Collect the completed exams sheets.

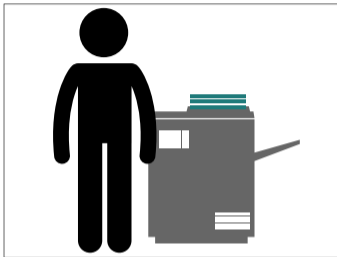
Written exams



4. Scan

- Scan exam sheets, e.g., on a photocopier.
- Using `nops_scan()`, process the scanned exam sheets to machine-readable content.

Written exams



4. Scan

- Scan exam sheets, e.g., on a photocopier.
- Using `nops_scan()`, process the scanned exam sheets to machine-readable content.



5. Evaluate

- Using `nops_eval()`, evaluate the exam to obtain marks, points, etc. and individual HTML reports for each examinee.
- Required files: Correct answers (1.), scans (4.), and a participant list in CSV format.

Written exams

A vizsga eredménye

Név: Jane Doe
Regisztrációs szám: 1501090
Érdemjegy: 5
Pontok: 3.16666666666667

Értékelés

Kérdés	Pontok	Adott válasz	Helyes válasz
1	1.0000000	_c_	_c_
2	0.5000000	abc_e	abc_
3	0.0000000	_____	ab_d_
4	1.0000000	_c_	_bc_
5	0.6666667	_d_	ab_d_
6	0.0000000	_bc_e	a_c_

Vizsgalap

+ **R University**
Exam 2015-07-29

Personal Data

Family Name:	DOE
Given Name:	JANE
Signature:	

Registr

	1,5,0
0	<input checked="" type="checkbox"/> <input type="checkbox"/> <input checked="" type="checkbox"/>
1	<input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
2	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>

A vizsga eredménye

Név: Ambi Dexter
Regisztrációs szám: 9901071
Érdemjegy: 5
Pontok: 1.5

Értékelés

Kérdés	Pontok	Adott válasz	Helyes válasz
1	0.0	a_c_	_d_
2	0.0	a_cde	ab_d_
3	0.0	_b_	_e_
4	0.0	_____	a_cd_
5	0.0	_____	_bc_
6	1.5	abc_	a_

Vizsgalap

+ **Universität Innsbruck**
Klausur 2015-07-29

Persönliche Daten

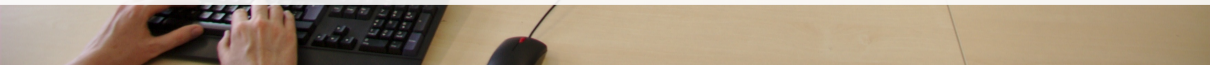
Nachname:	Dexter
Vorname:	Ambi
Unterschrift:	

Matri

	9,9,1
0	<input type="checkbox"/> <input type="checkbox"/> <input checked="" type="checkbox"/>
1	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
2	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>



E-Learning



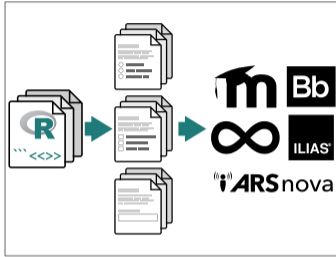
E-Learning



1. Goal

- Online tests with flexible exercise types.
- Possibly: Dynamic supplements and/or complete correct solution.
- Random variations of similar exercises to reduce the risk of cheating.
- Use university's learning management system, e.g., Moodle, ...

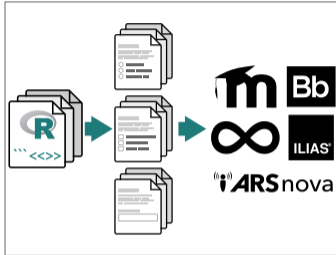
E-Learning



2. Create

- Draw random replications from exercise templates, e.g., via `exams2moodle()`, ...
- Automatically embed these into exchange file format (typically via HTML/XML).

E-Learning



2. Create

- Draw random replications from exercise templates, e.g., via `exams2moodle()`, ...
- Automatically embed these into exchange file format (typically via HTML/XML).



3. Import

- Import in learning management system.
- From there handling “as usual” in the system.

E-Learning: Online test

Preview question: R01 Q1 : deriv - Mozilla Firefox

File Edit View History Bookmarks Tools Help

Edit questions Preview question: R01 Q1

138.232.212.178/question/p/ 110%

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Preview question: R01 Q1 : deriv

Question 1
Incorrect
Mark 0.00 out of 1.00

What is the derivative of $f(x) = x^3 e^{3-3x}$, evaluated at $x = 0.75$?

Answer: ✗

Check

Using the product rule for $f(x) = g(x) \cdot h(x)$, where $g(x) = x^3$ and $h(x) = e^{3-3x}$, we obtain

$$\begin{aligned} f'(x) &= [g(x) \cdot h(x)]' = g'(x) \cdot h(x) + g(x) \cdot h'(x) \\ &= 3x^{3-1} \cdot e^{3-3x} + x^3 \cdot e^{3-3x} \cdot (-3) \\ &= e^{3-3x} \cdot (3x^2 + 3 \cdot 3x^3) \\ &= e^{3-3x} \cdot x^2 \cdot (3 + 3 \cdot 3x) \end{aligned}$$

Evaluated at $x = 0.75$, the answer is

$$e^{3-3 \cdot 0.75} \cdot 0.75^2 \cdot (3 + 3 \cdot 3 \cdot 0.75) = 36.591945.$$

Thus, rounded to two digits we have $f'(0.75) = 36.59$.

The correct answer is: 36.59

Start again Save Fill in correct responses Submit and finish Close preview

Preview question: R01 Q6 : lm - Mozilla Firefox

File Edit View History Bookmarks Tools Help

Edit questions Preview question: R01 Q6

138.232.212.178/question/p/ 110%

DuckDuckGo Search Images OpenStreetMap Maps EO wikipedia

Preview question: R01 Q6 : lm

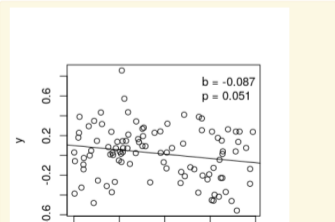
Question 1
Correct
Mark 2.00 out of 2.00

Using the data provided in [regression.csv](#) estimate a linear regression of y on x and answer the following questions.

a. ✓

b. Estimated slope with respect to x : ✓

Check



Scatter plot showing data points and a fitted regression line. The y-axis ranges from -0.6 to 0.6, and the x-axis ranges from -0.6 to 0.6. The regression line is labeled with $b = -0.087$ and $p = 0.051$.

E-Learning: Online test

OpenOLAT - infinite learning - Mozilla Firefox

File Edit View History Bookmarks Tools Help

OpenOLAT - infinite learn x +

https://lms-t.uibk.ac.at/auth/Repo

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eRun-2018

Show description

Question 1 point Not answered

The waiting time (in minutes) at the cashier of two supermarket chains with different cashier systems is compared. The following statistical test was performed:

```
Two Sample t-test
data: Waiting by Supermarket
t = -0.50168, df = 135, p-value = 0.3084
alternative hypothesis: true difference in means is less than 0
95 percent confidence interval:
 -Inf 0.5862572
sample estimates:
mean in group Sparag mean in group Consumo
 7.698248      7.862992
```

Which of the following statements are correct? (Significance level 5%)

- a. The absolute value of the test statistic is larger than 1.96.
- b. A one-sided alternative was tested.
- c. The p value is larger than 0.05 .
- d. The test shows that the waiting time is longer at Sparag than at Consumo.

OpenOLAT - infinite learning - Mozilla Firefox

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OpenOLAT - infinite learn x +

https://lms-t.uibk.ac.at/auth/Repositoryf

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eRun-2018

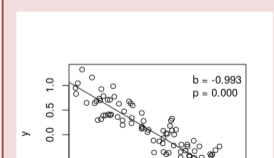
Show description

Question 2 points Completed

Using the data provided in `regression.csv` estimate a linear regression of y on x and answer the following questions.

- a.1. x and y are not significantly correlated
- a.2. y increases significantly with x
- a.3. y decreases significantly with x

b. Estimated slope with respect to x :



The scatter plot displays a series of data points with a downward-sloping regression line. The y-axis is labeled 'y' and ranges from 0.0 to 1.0. The x-axis is not explicitly labeled but represents the variable 'x'. The regression equation is $b = -0.993$ and the p-value is $p = 0.000$.

E-Learning: Live quiz

arsnova.uibk.ac.at 15:44

Back R/exams/1

1 2 3 4

Which of these institutions already hosted a user! or eRun conference?

- Universität Wien
- ETH Zürich
- Københavns Universitet

Start (2) Questions (4) Feedback System Manual

Back Forward Home Bookmarks Tabs

arsnova.uibk.ac.at 15:45

Back R/exams/2

1 2 3 4

What is the derivative of $f(x) = x^9 e^{2x}$, evaluated at $x = 0.7$?

- 2.43
- 3.70
- 2.10

Start (2) Questions (4) Feedback System Manual










Back Forward Home Bookmarks Tabs

arsnova.uibk.ac.at 15:45




Back R/exams/3

1 2 3 4

Given the following information:

	+		+		=	470
	+		+		=	502
	+		+		=	166

Compute:

	+		+		=	?
---	---	---	---	---	---	---

Start (2) Questions (4) Feedback System Manual

Back Forward Home Bookmarks Tabs

What Else?



What else?

Under development:

- *Many volunteers*: Internationalization for “NOPS” exams.
- *Nikolaus Umlauf*: Exercise “stress tester”.
- *Stefan Coors, Nikolaus Umlauf*: Graphical exams manager based on *shiny* that can be used on a local machine or on a server.
- *Achim Zeileis*: Reports for lecturers based on IRT models.
- *Niels Smits*: Better management of exercise categories.
- *Mirko Birbaumer, Andreas Melillo, Achim Zeileis*: *Ilias* interface based on QTI 1.2.

Internationalization

Please mark the boxes carefully: Not marked: or

This document is scanned automatically. Please keep clean and do not please use a **blue or black pen**.

Only clearly marked and positionally accurate crosses will be

Answers 1 - 15					Answers 16 - 21					
	a	b	c	d	e		a	b	c	d
1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	16	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	17	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Merci de cocher soigneusement: Non coché: ou

Cet examen sera corrigé par un système automatisé. Ne pas plier **bille bleu ou noir**.

Seul les marques lisibles et bien positionnées seront évaluées

Réponses 1 - 15					Réponses 16 - 21					
	a	b	c	d	e		a	b	c	d
1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	16	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	17	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

A választát jelölje egyértelmű x-el: Jelöletlen cella: vagy

A vizsgalap szkennelése automatikusan történik, ezért kérjük, hogy **kék vagy fekete tollal**.

Kizárólag az egyértelműen és pontosan megjelölt válaszok ke

Válaszok 1 - 15					Válaszok 16 - 21					
	a	b	c	d	e		a	b	c	d
1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	16	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	17	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

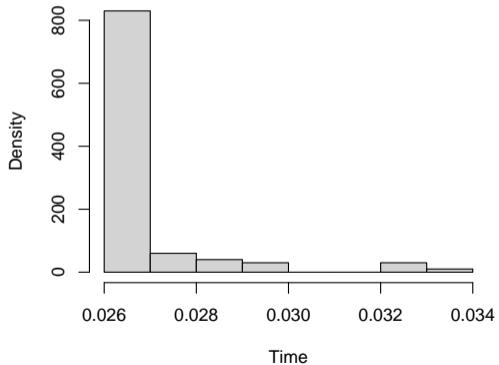
da Jensen, Messner
de Zeileis
en Zeileis
es Kogelnik
fi Nordhausen
fr Allignol
gsw Stauffer
hr Juraić
hu Daróczi, Tóth
it Zambella
nl Smits
pt Calvão, Dellinger,
Petutschnig (pt-PT/pt-BR)
ro Gatu
sk Fabsic
sr Kecojevic
tr Er

[More contributions
welcome ...](#)

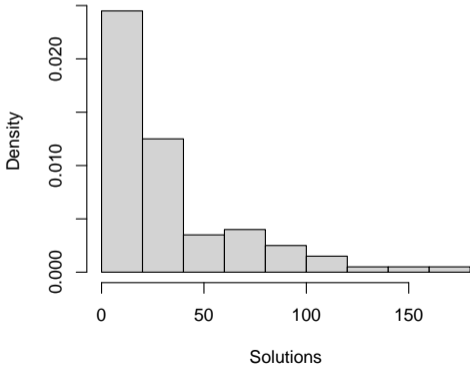
Stress tester

```
R> s <- stresstest_exercise("deriv2.Rnw")  
R> plot(s)
```

Runtimes 0.026–0.034

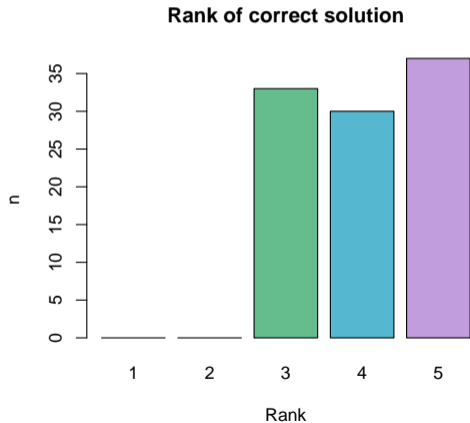
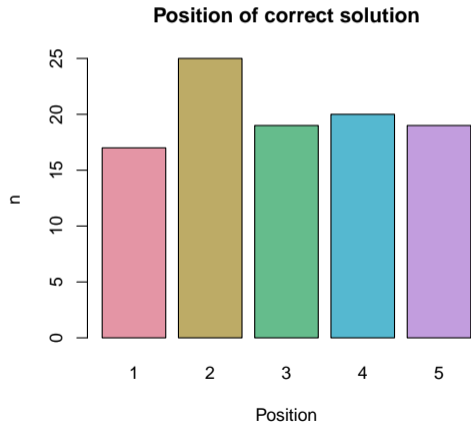


Histogram of numeric solutions



Stress tester

```
R> s <- stresstest_exercise("deriv2.Rnw")  
R> plot(s)
```



Graphical exams manager

The screenshot displays the 'Graphical exams manager' interface. At the top, there are navigation tabs: 'Create/Edit Exercises', 'Import/Export Exercises', 'Define Exams', and 'Generate Exams'. The main area is divided into a left sidebar and a central code editor.

Left Sidebar:

- Load a template. Markup?** (Dropdown menu with 'LaTeX' selected)
- Type?** (Dropdown menu with 'num' selected)
- Load template** (Button)
- Load exams package exercises.** (Dropdown menu with 'boxplots.Rnw' selected)
- Load exercise** (Button)
- Select exercise to be modified.** (Dropdown menu)
- Encoding?** (Dropdown menu with 'UTF-8' selected)

Central Code Editor:

The code editor shows R code for generating data and calculating statistics. The code is as follows:

```
1 <<echo=FALSE, results=hide>>
2 ## convenience functions
3 SK <- function(x) diff(diff(fivenum(x)[2:4]))/diff(fivenum(x)[c(2, 4)])
4 trob <- function(a, b)
5   (median(a) - median(b))/sqrt((var(a)/length(a) + var(b)/length(b)))
6
7 ## DATA GENERATION
8 ## dgp for one sample
9 dgp <- function(location = 0, scale = 1, skewed = FALSE, outlier = NULL,
10   n = 10, amount = 0.1)
11 {
12   ## basic intervals from which equal amounts of observations are drawn
13   qq <- if (skewed) c(0, 2, 2.2, 6, 10) else c(0, 3, 5, 7, 10)
14   sim <- function(x) {
15     rval <- NULL
16     for(i in 1:(length(x)-1)) rval <- c(rval, runif(n, min = x[i], max = x[i+1]))
17     rval <- jitter(rval, amount = amount)
18     rval <- rval/4
19     rval
20   }
21   ## draw under restrictions about IQR and SK
22   rval <- sim(qq)
23   if (skewed) {
24     while(IQR(rval) > 1.15 | IQR(rval) < 0.85 | abs(SK(rval)) < 0.7) rval <- sim(qq)
25   } else {
26     while(IQR(rval) > 1.15 | IQR(rval) < 0.85 | abs(SK(rval)) > 0.15) rval <- sim(qq)
27   }
28   rval
29 }
```

Below the code editor is a **Show preview** button.

Graphical exams manager

Create/Edit Exercises Import/Export Exercises Define Exams Generate Exams

Load a template. Markup?
LaTeX

Type?
num

Load template

Load exams package exercises.
boxplots.Rnw

Load exercise

Select exercise to be modified.

Encoding?
UTF-8

show help

Create Exercises Preview

Question

In the following figure the distributions of a variable given by two samples (A and B) are represented by parallel boxplots. Which of the following statements are correct? (Comment: The statements are either about correct or clearly wrong.)

a. The location of both distributions is about the same.
b. Both distributions contain no outliers.
c. The spread in sample A is clearly bigger than in B.
d. The skewness of both samples is similar.
e. Distribution B is left-skewed.

Solution

a. True. Both distributions have a similar location.
b. True. Both distributions have no observations which deviate more than 1.5 times the interquartile range from the box.
c. True. The interquartile range is clearly bigger in A.
d. True. Both distributions are symmetric.
e. False. Both distributions are symmetric.

Examining exams

Report: Exercise difficulty, student performance, unidimensionality, fairness.

Methods: Psychometrics, especially item response theory.

Example: End-term exam from first-year mathematics course for business and economics students at Universität Innsbruck.

- 729 students (out of 941 registered).
- 13 single-choice exercises on the basics of analysis, linear algebra, financial mathematics.
- Two groups with partially different pools of exercise templates.

```
R> library("psychotools")
```

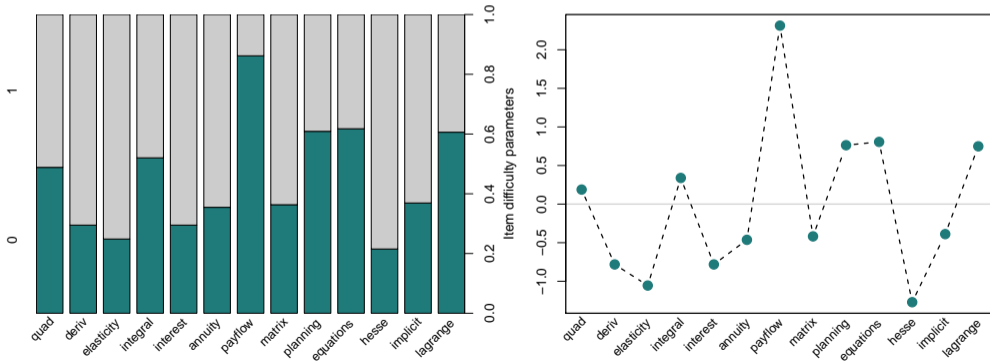
```
R> data("MathExam14W", package = "psychotools")
```

```
R> mex <- subset(MathExam14W, nsolved > 0 & nsolved < 13)
```

Examining exams

Item difficulty: Raw proportions vs. Rasch model.

```
R> plot(mex$solved, ...)  
R> mr <- raschmodel(mex$solved)  
R> plot(mr, ...)
```

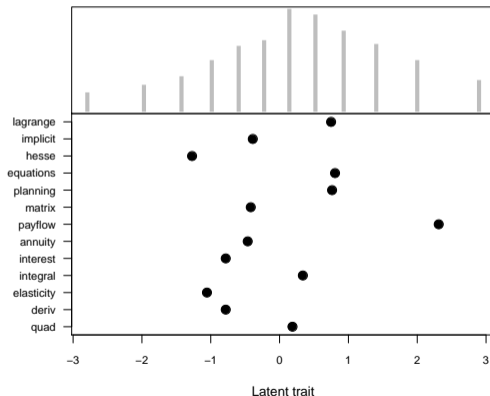
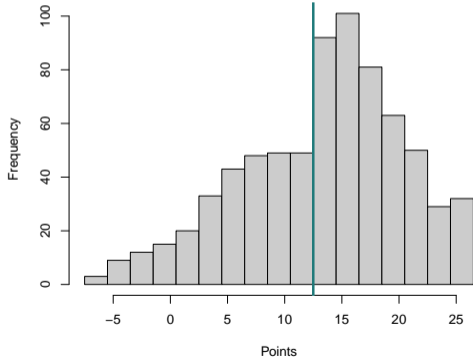


Examining exams

Student performance: Points and person-item map.

```
R> hist(MathExam14W$points, ...)
```

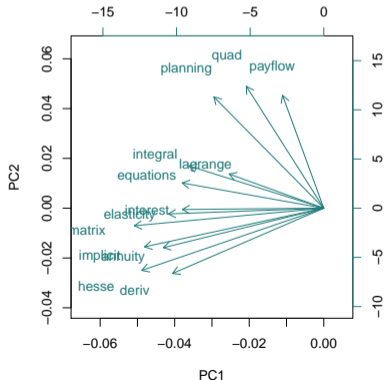
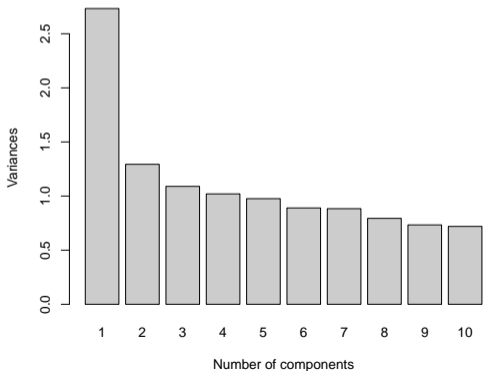
```
R> piplot(mr)
```



Examining exams

Unidimensionality: Principal component analysis.

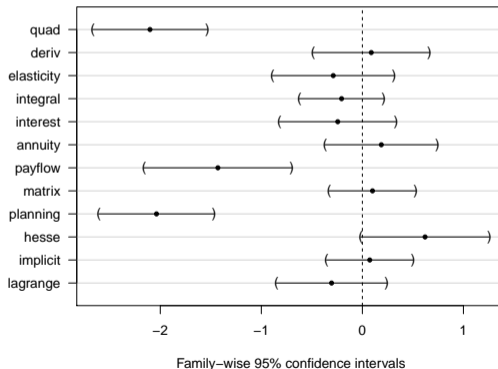
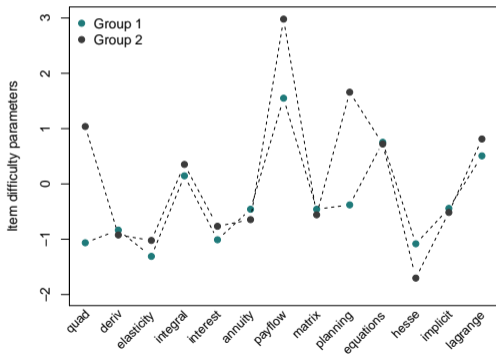
```
R> pr <- prcomp(mex$solved, scale = TRUE)
R> plot(pr, ...)
R> biplot(pr, ...)
```



Examining exams

Fairness: Differential item functioning.

```
R> ma <- anchortest(solved ~ group, data = mex, adjust = "single-step")  
R> plot(ma$final_tests, ...)
```



Recommendations

If you want to try  R/exams:

- Start with simple exercises before moving to more complex tasks.
- Focus on content of exercises.
- Don't worry about layout/formatting too much.
- Try to build a team (with lecturers, assistants, etc.).
- Use exercise types creatively.
- Don't be afraid to try stuff, especially in formative assessments.
- Thorough quality control for dynamic exercises before summative assessments.

Resources

Software: Zeileis A, Grün B, Leisch F, Umlauf N, Birbaumer M, Ernst D, Keller P, Smits N, Stauffer R (2018). *R/exams: Automatic Generation of Exams in R*. R package version 2.3-1.

Links:

Web	http://www.R-exams.org/
CRAN	https://CRAN.R-project.org/package=exams
Forum	http://R-Forge.R-project.org/forum/?group_id=1337
StackOverflow	https://stackoverflow.com/questions/tagged/exams

References:

- Zeileis A, Umlauf N, Leisch F (2014). “Flexible Generation of E-Learning Exams in R: Moodle Quizzes, OLAT Assessments, and Beyond.” *Journal of Statistical Software*, **58**(1), 1–36. doi:10.18637/jss.v058.i01
- Grün B, Zeileis A (2009). “Automatic Generation of Exams in R.” *Journal of Statistical Software*, **29**(10), 1–14. doi:10.18637/jss.v029.i10