

R/exams



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

Achim Zeileis

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

Motivation

Goals:

- Enable individualized organization of learning, feedback, and assessment.
- Foster continuing active participation.
- Encourage learning from peers and supporting each other.

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Challenges:

- Deal with large(-ish) student groups.
- Discourage cheating without learning.

Motivation

Strategy:

- High-frequency low-stakes formative assessment in supportive environment.
- Strict summative assessment in controlled environment.
- One pool of exercises as the basis for all assessments.

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Technology: R/exams software & learning management systems.

- *Individualization*: Randomized dynamic exercise pools.
- *Feedback*: Support for complete correct solutions.
- *Automatic evaluation*: Rendering into different (closed) assessment formats.

Example: Formative assessments

Some possibilities:

- *Quick quiz*: Recap of knowledge from previous session or preparation.
- *Asynchronous test*: Several days, encourage group work, support in forum.
- *Synchronous test*: In learning groups in live sessions (possibly completion of individual tests afterwards).
- *Open-ended tasks*: Upload of solutions online, discussion in live sessions.

Example: First-year mathematics

Structure: Mandatory.

- 2-hour lecture (VO), 500+ participants.
- 2-hour tutorial (PS), up to 40 participants per tutorial.

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- 2-hour tutorial (PS), up to 40 participants per tutorial.

Weekly schedule:

- *Learning:* Textbook (soon online), screencasts, slides.
- *Flipped classroom:* Overview, questions & answers in lecture session.
- *Formative assessment:* Numeric online test, several days, support in forum.
- *Feedback:* Discussion of more complex exercises in tutorial session.
- *Formative assessment:* Another online test in tutorial learning groups.

Example: First-year mathematics

Structure: Mandatory.

- 2-hour lecture (VO), 500+ participants.
- 2-hour tutorial (PS), up to 40 participants per tutorial.

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- *Formative assessment:* Numeric online test, several days, support in forum.
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Summative assessment: Written single-choice exams (mid-term & end-term).

Example: Data analytics

Structure: Elective.

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Example: Data analytics

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Weekly schedule:

- *Learning:* Lecture session, online textbook/slides.
- *Formative assessment:* Quiz & numeric test, several days, support in forum.
- *Formative assessment:* Open-ended practical task, several days, file upload.
- *Feedback:* Discussion of practical tasks in tutorial session.

Summative assessment: Online exams with open-ended theory questions and individualized practical tasks (mid-term & end-term).

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 (either closed/short or open-ended).
- Combinations of the above (cloze).

R package *exams*

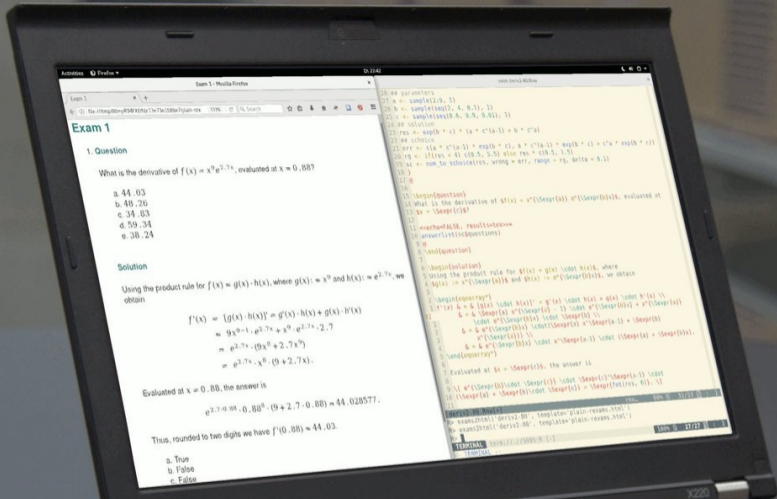
Output:

- 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 *Canvas*, *OpenOlat*, *ILIAS*.
- *Blackboard* (partially based on QTI 1.2)
- *learnr*, *Particify*, *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	Markdown, \LaTeX	Text formatting, mathematical notation
Reproducible research	knitr, rmarkdown, Sweave	Dynamically tie everything together
Document conversion	pandoc, TtH/TtM	Conversion to HTML and beyond
Image manipulation	ImageMagick, magick, png	Embedding graphics
Web technologies	base64enc, RCurl, ...	Embedding supplementary files
Learning management	Moodle, OpenOlat, Canvas, Particify, ...	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 the following cities are the capital of the corresponding country?



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 the following cities are the capital of the corresponding country?

Dynamic exercises: .Rmd

Example: Which of the following cities are the capital of the corresponding country?

Question

=====

Which of the following cities are the capital of the corresponding country?

Answerlist

- * Lagos (Nigeria)
- * São Paulo (Brazil)
- * Toronto (Canada)
- * Auckland (New Zealand)
- * Istanbul (Turkey)
- * Zürich (Switzerland)
- * Tokyo (Japan)
- * New Delhi (India)
- * Astana (Kazakhstan)
- * Warsaw (Poland)
- * Riyadh (Saudi Arabia)

Dynamic exercises: .Rmd

Example: Which of the following cities are the capital of the corresponding country?

Solution

=====

Answerlist

- * False. The capital of Nigeria is Abuja.
- * False. The capital of Brazil is Brasilia.
- * False. The capital of Canada is Ottawa.
- * False. The capital of New Zealand is Wellington.
- * False. The capital of Turkey is Ankara.
- * False. The de facto capital of Switzerland is Bern.
- * True. Tokyo is the capital of Japan.
- * True. New Delhi is the capital of India.
- * True. Astana is the capital of Kazakhstan.
- * True. Warsaw is the capital of Poland.
- * True. Riyadh is the capital of Saudi Arabia.

Dynamic exercises: .Rmd

Example: Which of the following cities are the capital of the corresponding country?

```
Meta-information
=====
exname: Capitals
extype: mchoice
exsolution: 00000011111
exshuffle: 5
```

Dynamic exercises: `.Rmd` vs `.Rnw`

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

Dynamic exercises: .Rmd vs .Rnw

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```
```{r data generation, 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: .Rmd vs .Rnw

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

```
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```

Question

=====

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

Dynamic exercises: .Rmd vs .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)  
@
```

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

Dynamic exercises: .Rmd vs .Rnw

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

Solution

=====

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

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

\$\$

`\begin{aligned}`

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

...

`\end{aligned}`

\$\$

...

Dynamic exercises: .Rmd vs .Rnw

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...

`\end{aligned}`

\$\$

...

Meta-information

=====

extype: num

exsolution: ``r fmt(res)``

exname: derivative exp

extol: 0.01

Dynamic exercises: .Rmd vs .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
 $g(x) := x^{\Sexpr{a}}$  and  $h(x) := e^{\Sexpr{b}x}$ , we obtain
\begin{eqnarray*}
f'(x) &= & [g(x) \cdot h(x)]' = g'(x) \cdot h(x) + g(x) \cdot h'(x) \\
&\dots & \\
\end{eqnarray*}
\end{solution}
```

```
\extype{num}
\exsolution{\Sexpr{fmt(res)}}
\exname{derivative exp}
\extol{0.01}
```

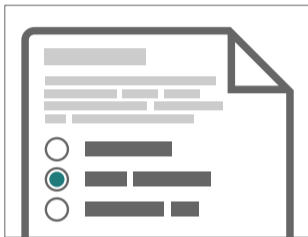
Dynamic exercises: Single choice



`extype: schoice`

`exsolution: 010`

Dynamic exercises: Single choice



extype: schoice

exsolution: 010

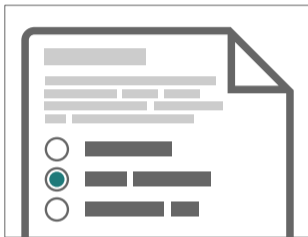
Question

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

- (a) Basel
- (b) Bern
- (c) Zurich
- (d) Geneva
- (e) Lausanne

Knowledge quiz: Shuffled distractors.

Dynamic exercises: Single choice



extype: schoice

exsolution: 010

Question

What is the derivative of $f(x) = x^9 e^{3.9x}$, evaluated at $x = 0.82$?

- (a) 61.05
- (b) 49.15
- (c) 72.53
- (d) 45.04
- (e) 61.47

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

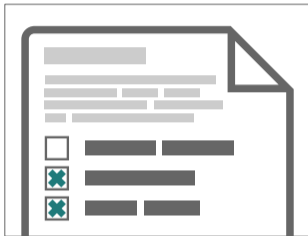
Dynamic exercises: Multiple choice



`extype: mchoice`

`exsolution: 011`

Dynamic exercises: Multiple choice



extype: mchoice

exsolution: 011

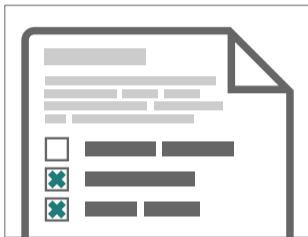
Question

Which of the following cities are the capital of the corresponding country?

- (a) New Delhi (India)
- (b) Tokyo (Japan)
- (c) Lagos (Nigeria)
- (d) Auckland (New Zealand)
- (e) Astana (Kazakhstan)

Knowledge quiz: Shuffled true/false statements.

Dynamic exercises: Multiple choice



extype: mchoice
exsolution: 011

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.*)

The figure shows two parallel boxplots, A and B, on a vertical axis ranging from -30 to 10. Boxplot A has a median at approximately -12, a box from -22 to -4, and whiskers from -34 to 8. Boxplot B has a median at approximately -12, a box from -15 to -10, and whiskers from -20 to -5. Both distributions appear to be roughly symmetric and contain no outliers.

(a) The location of both distributions is about the same.
(b) Both distributions contain no outliers.

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:

$$\text{orange} + \text{banana} + \text{banana} = 113$$

$$\text{orange} + \text{banana} + \text{orange} = 121$$

$$\text{banana} + \text{banana} + \text{pineapple} = 451$$

Compute:

$$\text{banana} + \text{orange} + \text{pineapple} = ?$$

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 extracting the fitted log-likelihood from a fitted (generalized) linear model object?

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

`extype: string`

`exsolution: ANSWER`

Dynamic exercises: String



`extype: string`

`exsolution: ANSWER`

Question

Consider the following regression results:

Call:

```
lm(formula = log(y) ~ log(x), data = d)
```

Residuals:

| Min | 1Q | Median | 3Q | Max |
|--------|--------|--------|-------|-------|
| -5.490 | -1.056 | 0.102 | 1.593 | 5.187 |

Coefficients:

| | Estimate | Std. Error | t value | Pr(> t) |
|-------------|----------|------------|---------|----------|
| (Intercept) | -0.039 | 0.304 | -0.13 | 0.90 |
| log(x) | 0.217 | 0.308 | 0.70 | 0.48 |

Residual standard error: 2.24 on 53 degrees of freedom

Multiple R-squared: 0.00927, Adjusted R-squared

F-statistic: 0.496 on 1 and 53 DF, p-value: 0.484

Describe how the response y depends on the regressor x .

Open-ended question: Answer in an essay editor and/or by file upload (via `exstringtype`).

Dynamic exercises: Cloze



extype: cloze

exclozetype: mchoice|num

exsolution: 10|123.45

Dynamic exercises: Cloze



extype: cloze

exclozetype: mchoice|num

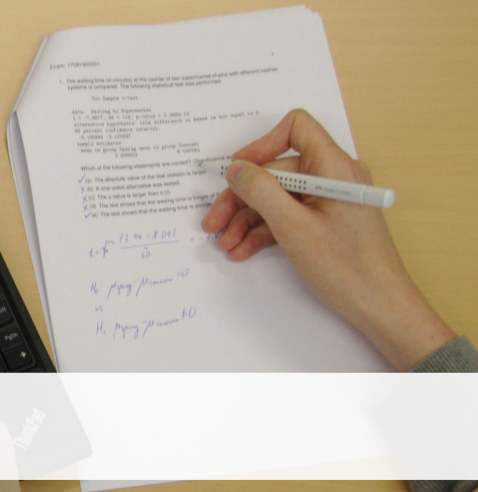
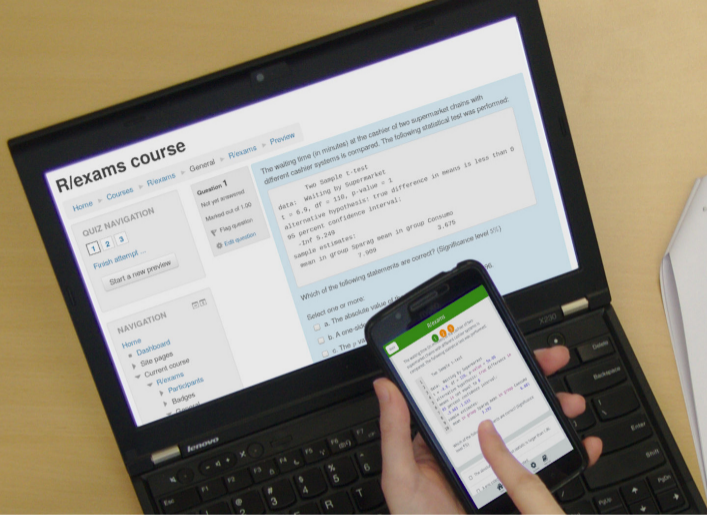
exsolution: 10|123.45

Question

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

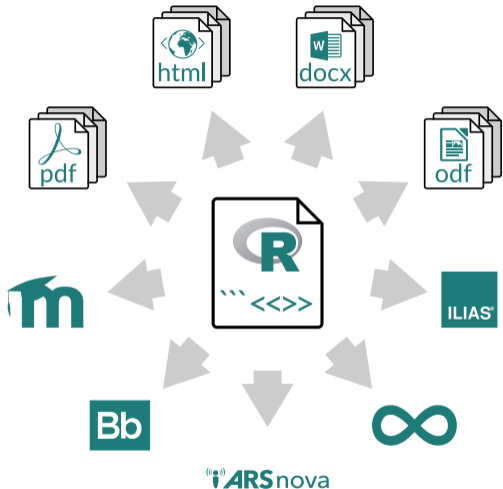
- (a) x and y are not significantly correlated / y increases significantly with x / y decreases significantly with x
- (b) Estimated slope with respect to x :

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(  
+   "capitals.Rmd",  
+   "deriv2.Rmd",  
+   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

Online test:

```
R> exams2openolat(myexam, n = 10, dir = odir)
```

Live quiz:

```
R> exams2particify(myexam, n = 1, dir = odir)
```

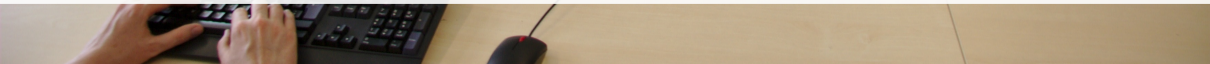
Written exam:

```
R> exams2nops(myexam, n = 3, dir = odir,  
+   language = "de", date = "2023-03-29",  
+   institution = "Universität Innsbruck", logo = "uibk-logo-bw.png")
```

Other: `exams2pdf()`, `exams2html()`, `exams2moodle()`, `exams2canvas()`, ...



E-Learning



E-Learning



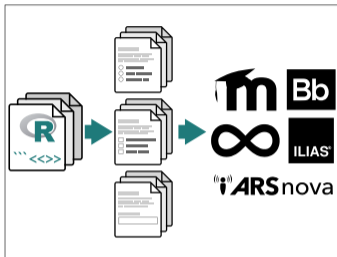
1. Goal

- 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., OpenOlat, Moodle, ...

Scenarios:

- Short quizzes conducted in-class.
- Online tests conducted over several days.
- E-exams conducted in-class or remotely.

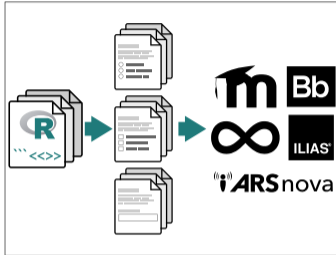
E-Learning



2. Create

- Draw random replications from exercise templates, e.g., via `exams2openolat()`, ...
- Automatically embed these into exchange file format (typically via HTML/XML).

E-Learning



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- Draw random replications from exercise templates, e.g., via `exams2openolat()`, ...
- 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%

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Preview question: R01 Q6 : lm

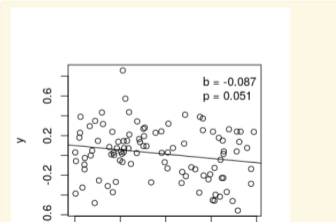
Question 1
Correct
Mark 2.00 out of 2.00

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



$b = -0.087$
 $p = 0.051$

E-Learning: Online test

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OpenOLAT - infinite learn x +

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

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eRun-2018

Finish test

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.

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OpenOLAT - infinite learn x +

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

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eRun-2018

Finish test

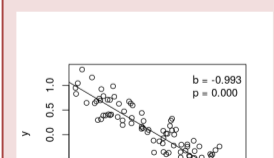
Show description

Question 2 points Completed

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

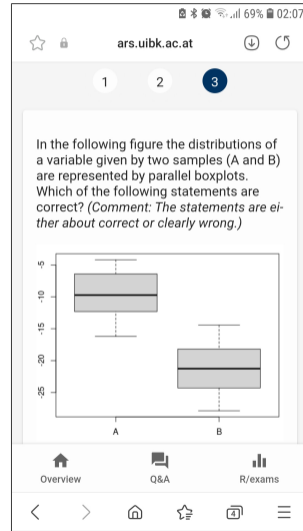
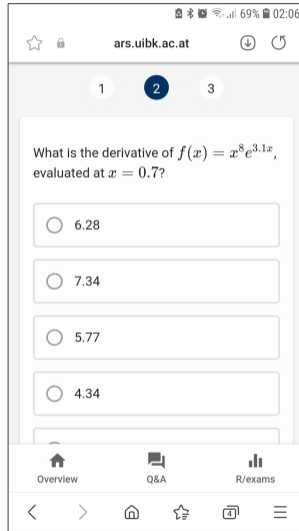
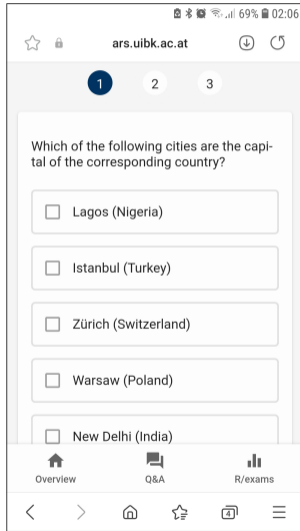
- a.1. x and y are not significantly correlated
- a.2. y increases significantly with x
- a.3. y decreases significantly with x

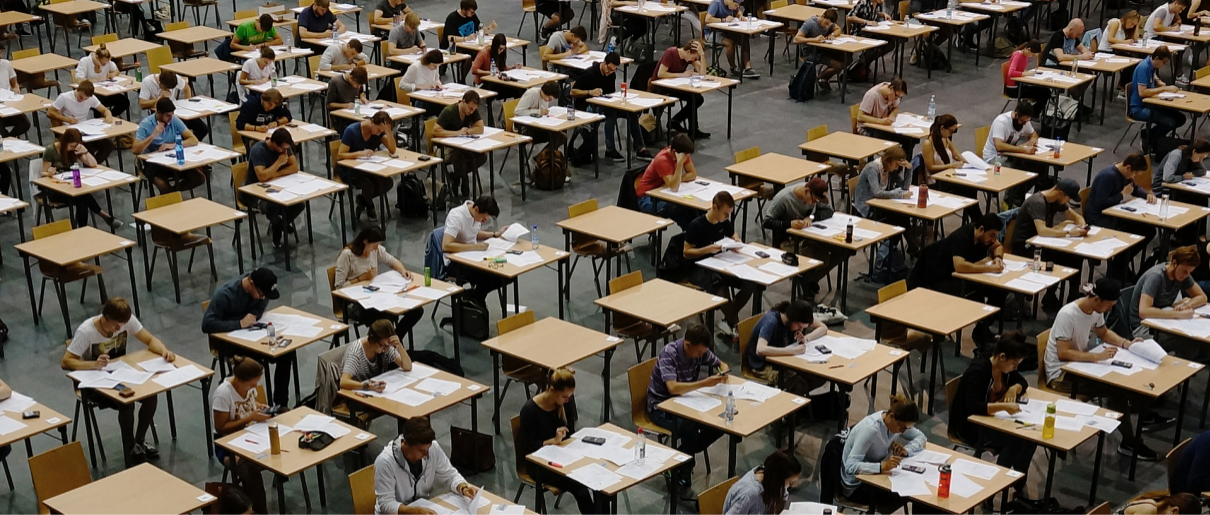
b. Estimated slope with respect to x :



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





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

+ **Universität Innsbruck** + 

Exam 2023-03-29

Persönliche Daten

Nachname: _____

Vorname: _____

Unterschrift: _____ www

Matrikelnummer

| | | | | | | | | | | |
|---|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| 0 | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 1 | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <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"/> | <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"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 4 | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 5 | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 6 | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 7 | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 8 | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 9 | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

In diesem Feld dürfen **keine** Veränderungen der Daten vorgenommen werden! **Scrambling** 0, 0

Belegart: Klausur-ID:

Bitte sorgsam ankreuzen: Nicht angekreuzt: oder

Dieser Beleg wird maschinell gelesen. Bitte nicht falten, nicht knicken und nicht beschmutzen. Verwenden Sie zum Markieren einen **blauen oder schwarzen Kugelschreiber**.
Nur **deutlich erkennbare und positionsgenaue Markierungen** werden ausgewertet!

Antworten 1 - 3

| | | | | | |
|---|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| 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"/> |

a b c d e

a b c d e

+ +

Exam: 23032900001 1

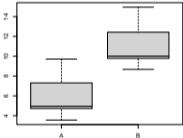
1. Which of the following cities are the capital of the corresponding country?

- (a) New Delhi (India)
- (b) Tokyo (Japan)
- (c) Lagos (Nigeria)
- (d) Auckland (New Zealand)
- (e) Astana (Kazakhstan)

2. What is the derivative of $f(x) = x^4 e^{3x}$, evaluated at $x = 0.89$?

- (a) 19.60
- (b) 27.40
- (c) 30.45
- (d) 31.09
- (e) 34.42

3. 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.

Written exams



1. Create

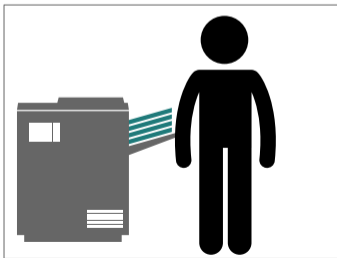
- As illustrated above.
- Using `exams2nops()`, create (individual) PDF files for each examinee.

Written exams



1. Create

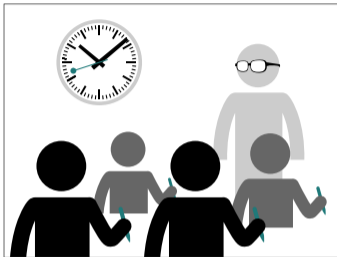
- As illustrated above.
- Using `exams2nops()`, create (individual) PDF files for each examinee.



2. Print

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

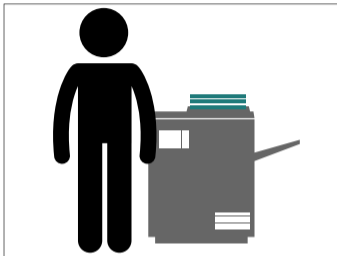
Written exams



3. Exam

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

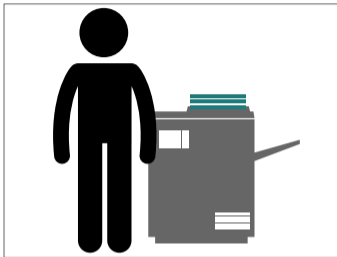
Written exams



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: JANE

Regist

1,5,0

0

1

2

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: Ambi Dexter

Matri

9,9,1

0

1

2

Getting Started



Getting started

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.).
- Connect to experienced users.
- Use exercise types creatively.
- Don't be afraid to try stuff, especially in formative assessments.
- Thorough quality control for dynamic exercises before summative assessments.

Getting started

Installation:

- ① R, Rtools on Windows, RStudio recommended for beginners.
- ② R package *exams* (including dependencies).
- ③ \LaTeX for producing PDF output.
- ④ Pandoc (e.g., provided along with RStudio).
- ⑤ Possibly further tools needed for scanning NOPS exams.

More details: <https://www.R-exams.org/tutorials/installation/>

Getting started

First steps: Create exams skeleton.

```
R> exams_skeleton()
```

Output:

- demo-*.R scripts.
- exercises/ folder with all .Rmd/.Rnw exercises.
- templates/ folder with various customizable templates.
- nops/ folder (empty) for exams2nops() output.

More details: https://www.R-exams.org/tutorials/first_steps/

Getting started

Quality control: Stress testing.

- Generate a large number of random versions of an exercise.
- Check for errors, warnings, long computation times, ...
- Especially for numeric exercises: Check solution distribution, outliers, dependency on randomized parameters.
- Especially for multiple-choice exercises: Check shuffling of correct answers.

More details: <https://www.R-exams.org/tutorials/stresstest/>

Resources

Contributors:

Zeileis, Grün, Leisch, Umlauf, Smits, Birbaumer, Ernst, Keller, Krimm, Sato, Stauffer, Wickelmaier.

Links:

| | |
|---------------|---|
| Web | https://www.R-exams.org/ |
| CRAN | https://CRAN.R-project.org/package=exams |
| StackOverflow | https://stackoverflow.com/questions/tagged/r-exams |
| Forum | https://R-Forge.R-project.org/forum/?group_id=1337 |
| Mastodon | @zeileis@fosstodon.org |
| Twitter | @AchimZeileis |