



A One-for-All Exams Generator: Written Exams, Online Tests, and Live Quizzes with R

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Motivation and challenges

Motivation:

- Introductory statistics and mathematics courses for business and economics students at WU Wien and Universität Innsbruck.
- Courses are attended by more than 1,000 students per semester.
- Currently: Several lecturers teach lectures (~500 participants) and tutorials (~150 participants) 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

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Challenges:

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

R package *exams*

Tools chosen:

- R for random data generation and computations.
- \LaTeX for mathematical notation.
- \LaTeX or Markdown for text formatting
- *Sweave* or *knitr/rmarkdown* for tying everything together.

HTML conversion: Required for some output formats.

- Via *tth* or *pandoc*.
- Default: MathML for mathematical notation.
- Default: Base64 encoding for images and other supplements.

R package *exams*

Exercises:

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

Answer types:

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

R package *exams*

Output:

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

R package exams: PDF output

R University

Statistics Exam 2016-11-25

Exam ID 00001

Name: _____

Student ID: _____

Signature: _____

1. (a) (b) (c) (d) (e)

2.

3.

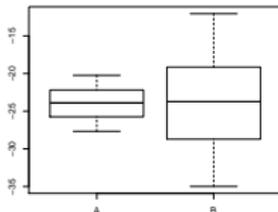
4. (a) (b) (c) (d) (e)

5. (a) (b) (c) (d) (e)

Statistics Exam: 00001

2

1. 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.)



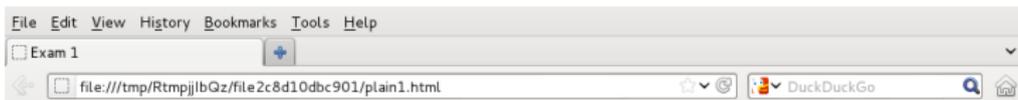
- (a) The location of both distributions is about the same.
(b) Both distributions contain no outliers.
(c) The spread in sample A is clearly bigger than in B.
(d) The skewness of both samples is similar.
(e) Distribution A is about symmetric.
2. A machine fills milk into 500ml packages. It is suspected that the machine is not working correctly and that the amount of milk filled differs from the setpoint $\mu_0 = 500$. A sample of 226 packages filled by the machine are collected. The sample mean \bar{y} is equal to 499.7 and the sample variance s_{y-1}^2 is equal to 576.1.
Test the hypothesis that the amount filled corresponds on average to the setpoint. What is the absolute value of the t test statistic?
3. For 49 firms the number of employees X and the amount of expenses for continuing education Y (in EUR) were recorded. The statistical summary of the data set is given by:

	Variable X	Variable Y
Mean	58	232
Variance	124	1606

The correlation between X and Y is equal to 0.65.
Estimate the expected amount of money spent for continuing education by a firm with 60 employees using least squares regression.

4. The following figure shows a scatterplot. Which of the following statements are correct?

R package *exams*: HTML output



Exam 1

1. Question

In 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.*)

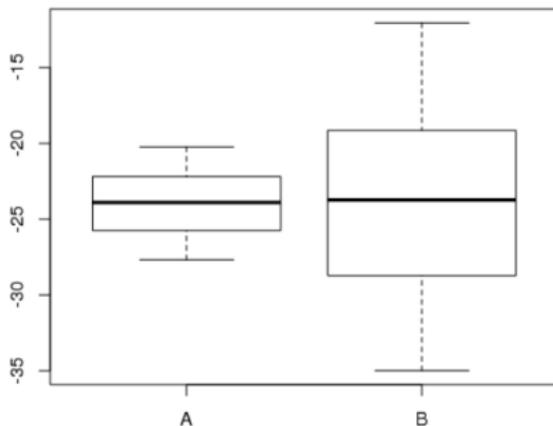


Figure 1: Parallel boxplots.

- The location of both distributions is about the same.
- Both distributions contain no outliers.
- The spread in sample A is clearly bigger than in B.
- The skewness of both samples is similar.
- Distribution A is about symmetric.

R package exams: Moodle XML

File Edit View History Bookmarks Tools Help

JSS Quiz

138.232.202.120/mod/quiz/attempt.php?attempt=2 DuckDuckGo

You are logged in as **Nikolaus Umlauf** (Logout)

R exams course

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Quiz navigation

1 2 3 4 5

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Home

- My home
- Site pages
- My profile
- Current course
 - Rexams**
 - Participants
 - Reports
 - General
 - 20 November - 26 November
 - JSS Quiz**
 - Info
 - Results
 - 27 November - 3 December
 - 4 December - 10 December
 - 11 December - 17 December
 - 18 December - 24 December
 - 25 December - 31 December

Question 1

Not yet answered

Marked out of 1.00

Flag question

Edit question

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

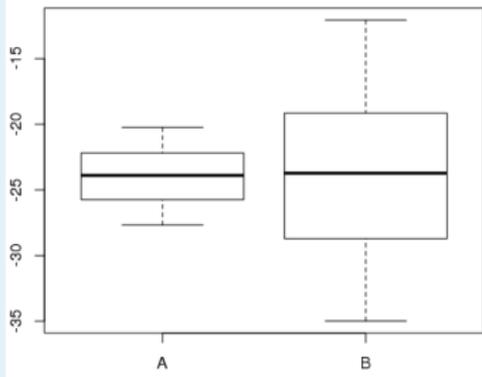


Figure 1: Parallel boxplots.

Select one or more:

- 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 A is about symmetric.

R package exams: QTI

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OLAT - OLAT: Course templat... +

138.232.202.96:8080/OLAT-LMS-7.6.0.0/auth/1%3A6%3A1000020776%3A1%: DuckDuckGo

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qt12 Finish test

Actual score: 0 / 5

qt12

1. Exercise Still 1 attempt(s)

1.1. Question 0/0

2. Exercise 0/0

2.1. Question 0/0

3. Exercise 0/0

3.1. Question 0/0

4. Exercise 0/0

4.1. Question 0/0

5. Exercise 0/0

5.1. Question 0/0

Question

In 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.)

Figure 1: Parallel boxplots.

- 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 A is about symmetric.

Save answer

R package exams: ARSnova

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ARSnova: Student - L... x

https://arsnova.uibk.ac.at/mobile/#

Back R/exams/1

1 2 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.)

Statistic	Sample A	Sample B
Minimum	-34	-26
Q1	-28	-24
Median	-22	-22
Q3	-16	-20
Maximum	-11	-17

The location of both distributions is about the same.

Start Questions Feedback System Menu

Exercises

Exercise templates: Either .Rnw files composed of

- R code chunks for random data generation within `<<>=` and `@`.
- Question and solution descriptions contained in `\begin/\end` pairs for `{question}/\{solution}`.
- Metainformation about `ex`type (numeric, multiple choice, ...), correct `ex`solution, a short `ex`name, etc.
`\ex`type{mchoice}, `\ex`solution{01001}, ...
- Question and basic metainformation is mandatory – everything else optional. Insertion of data elements with `\Sexpr{...}`.

Alternatively: .Rmd files with

- Code chunks: ````{r} ... ````.
- Question/Solution sections with `=====
=====
=====
=====` markup.
- `ex`type: `mchoice`, `ex`solution: `01001, ...`
- Insertions: ``r ...``.

Exams: Combination of exercises

Idea: An exam is simply a list of exercise templates. For example, using statistics exercise templates contained in *exams*.

```
R> myexam <- list(  
+   "boxplots.Rnw",  
+   c("confint.Rnw", "ttest.Rnw", "tstat.Rnw"),  
+   c("anova.Rnw", "regression.Rnw"),  
+   "scatterplot.Rnw",  
+   "relfreq.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, ...).

Interfaces: `exams2pdf()`, `exams2html()`, `exams2moodle()`,
`exams2qti12()`, `exams2nops()`, `exams2arsnova()`, ...

Exams: Combination of exercises

Usage:

- A single exam popped up in a PDF viewer:

```
R> exams2pdf(myexam, template = "exam")
```

- Multiple PDF/NOPS exams written to an output directory:

```
R> odir <- tempfile()
```

```
R> exams2nops(myexam[-(2:3)], n = 3, dir = odir)
```

- Multiple replications in a single Moodle XML file in output directory:

```
R> exams2moodle(myexam, n = 3, dir = odir)
```

Discussion

Package *exams*:

- Framework for automatic generation of simple (mathematical or statistical) exams and associated self-study materials.
- Based on independent exercises in `.Rnw/.Rmd` format which can be compiled into exams (or other collections of exercises).
- Version 1 (Grün and Zeileis 2009) only supported PDF output, version 2 (Zeileis *et al.* 2014) added a toolbox for various output formats, recent versions add support for Markdown and *pandoc*.
- Contributing to the pool of exercises only requires knowledge of *Sweave/knitr* and minimal markup for meta-information.
- For a first session employ `exams_skeleton()` which copies demo scripts, exercises, and templates into a working directory.
- Hosted on R-Forge, providing a support forum:
<https://R-Forge.R-project.org/projects/exams/>

Discussion

Under development:

- *Nikolaus Umlauf*: Graphical exams manager based on *shiny* that can be used on a local machine or on a server.
- *Niels Smits*: *Blackboard* interface based on QTI 1.2.
- *Mirko Birbaumer, Achim Zeileis*: *Ilias* interface based on QTI 1.2.
- *Achim Zeileis*: Evaluation reports for lecturers/examiners based on IRT models.

References

Zeileis A, Grün B, Leisch F, Umlauf N, Smits N (2016). *exams: Automatic Generation of Exams in R*. R package version 2.2-0.

URL <https://CRAN.R-project.org/package=exams>

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