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

Achim Zeileis

http://www.R-exams.org/
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## Overview

<table>
<thead>
<tr>
<th>Time</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>14:00</td>
<td>Introduction (overview, installation, …)</td>
</tr>
<tr>
<td>14:30</td>
<td>Dynamic exercises</td>
</tr>
<tr>
<td>15:00</td>
<td>One-for-all</td>
</tr>
<tr>
<td>15:30</td>
<td>— Break —</td>
</tr>
<tr>
<td>16:00</td>
<td>E-Learning (Moodle, Canvas, ARSnova, …)</td>
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<tr>
<td>16:30</td>
<td>Written exams (NOPS)</td>
</tr>
<tr>
<td>17:00</td>
<td>Outlook</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th></th>
<th>Learning</th>
<th>Feedback</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Synchronous</strong></td>
<td>Lecture</td>
<td>Live quiz</td>
<td>Written exam</td>
</tr>
<tr>
<td></td>
<td>Live stream</td>
<td>(+ Tutorial)</td>
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</tr>
<tr>
<td><strong>Asynchronous</strong></td>
<td>Textbook</td>
<td>Self test</td>
<td>Online test</td>
</tr>
<tr>
<td></td>
<td>Screencast</td>
<td>(+ Forum)</td>
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</table>
## Motivation and challenges

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</tr>
<tr>
<td></td>
<td>Screencast</td>
<td>(+ Forum)</td>
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</table>

### Learning:
- **Standard**: Textbook along with presentation slides.
- **Streaming**: Videos streamed simultaneously or (pre-)recorded.
## Motivation and challenges

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<tr>
<td>Screencast</td>
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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 Canvas or OLAT/OpenOLAT.
- Blackboard (partially based on QTI 1.2)
- ARSnova, TCExam, LOPS, …

Infrastructure: Standing on the shoulders of lots of open-source software…
R package *exams*

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

Required tools:

1. R (including Rtools on Windows and OS X)
   RStudio recommended for beginners
2. R package `exams` (including dependencies)
   `install.packages("exams", dependencies = TRUE)`
3. \LaTeX \ for producing PDF output
4. Pandoc (e.g., provided along with RStudio)

First steps

Starting point: Create exams skeleton.

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

R> exams_skeleton()

First steps

Single-choice question: knowledge quiz about the Swiss capital
(\url{http://www.R-exams.org/templates/swisscapital/}).
R> exams2html("swisscapital.Rmd")
R> exams2pdf("swisscapital.Rmd")

Numeric question with mathematical notation: product rule for derivatives
(\url{http://www.R-exams.org/templates/deriv/}).
R> exams2html("deriv.Rmd")
R> exams2html("deriv.Rmd", converter = "pandoc-mathjax")
R> exams2pdf("deriv.Rmd")

Extract the meta-information to check whether it is processed correctly.
R> exams_metainfo(exams2html(c("swisscapital.Rmd", "tstat.Rmd")))

exam1
  1. Swiss Capital: 2
  2. t statistic: 8.493 (8.483--8.503)
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! 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! conference?
Dynamic exercises: .Rmd

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

**Question**

Which of these institutions already hosted a useR! conference?

**Answerlist**

* National Institute of Standards and Technology
* Agrocampus Ouest
* Technische Universität Dortmund
* Universität Wien
* ETH Zürich
* Københavns Universitet
**Dynamic exercises: .Rmd**

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

**Solution**

The list of useR! (and DSC) hosts can be found at <https://www.R-project.org/conferences/>.

**Answerlist**

* True. useR! 2010 was hosted at NIST.
* 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!.
Example: Which of these institutions already hosted a useR! conference?

Solution
=========
The list of useR! (and DSC) hosts can be found at <https://www.R-project.org/conferences/>.

Answerlist
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* True. useR! 2010 was hosted at NIST.
* 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!.

Meta-information
=================
exname: useR! conferences
extype: mchoice
exsolution: 111000
exshuffle: 5
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 $x = c$?

```r
<<echo=FALSE, results=hide>>=
## parameters
a <- sample(2:9, 1)
b <- sample(2:4, 1)/10
c <- sample(6:9, 1)/10
## 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 $x = c$?

```r
<<echo=FALSE, results=hide>>=
## parameters
a <- sample(2:9, 1)
b <- sample(2:4, 1)/10
c <- sample(6:9, 1)/10
## solution
res <- exp(b * c) * (a * c^(a-1) + b * c^a)
@

\begin{question}
What is the derivative of $f(x) = x^{\text{\Sexpr{a}}} e^{\text{\Sexpr{b} \cdot x}}$, evaluated at $x = \text{\Sexpr{c}}$?
\end{question}
```
Dynamic exercises: \texttt{.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 we obtain
\[
\left[ f'(x) = e^{b \cdot x} \cdot (a \cdot x^{a-1} + b \cdot x^a) \right].
\]
Evaluated at $x = c$ and rounded to two digits the answer is $f'(c) \approx \text{\texttt{fmt}(res, 2)}$.
\end{solution}
**Dynamic exercises: .Rnw**

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

\[
\begin{align*}
\text{Using the product rule we obtain } & \quad f'(x) = e^{\textbf{\Sexpr{b} x}} \cdot \\
& \quad (\textbf{\Sexpr{a} x}^{-\textbf{\Sexpr{a-1}}} + \textbf{\Sexpr{b} x}^{-\textbf{\Sexpr{a}}}). \\
\text{Evaluated at } x = \textbf{\Sexpr{c}} & \quad \approx \textbf{\Sexpr{fmt(res, 2)}}.
\end{align*}
\]

\text{\texttt{extype{num}}} \text{\texttt{exsolution{\Sexpr{fmt(res, 2)}}}} \text{\texttt{exname{exp derivative}}} \text{\texttt{extol{0.01}}}

\(15\)
Dynamic exercises: Single choice

extype: schoice
exsolution: 010
Dynamic exercises: Single choice

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

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

*Knowledge quiz: Shuffled distractors.*
Dynamic exercises: Single choice

Question
What is the derivative of $f(x) = x^7 e^{3.2x}$, evaluated at $x = 0.85$?

(a) 40.08
(b) 55.65
(c) 44.94
(d) 45.32
(e) 31.56

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

exetype: mchoice
exsolution: 011
Dynamic exercises: Multiple choice

**Question**
Which of these institutions already hosted a useR! conference?

(a) Københavns Universitet
(b) ETH Zürich
(c) Agrocampus Ouest
(d) National Institute of Standards and Technology
(e) Universität Wien

**Knowledge quiz:** Shuffled true/false statements.
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.

Interpretations: Statements that are approximately correct or clearly wrong.
Dynamic exercises: Numeric

extype: num
exsolution: 123.45
Dynamic exercises: Numeric

Question
Given the following information:

\[
\begin{align*}
\text{banana} & + \text{orange} + \text{pineapple} = 486 \\
\text{orange} & + \text{pineapple} + \text{banana} = 194 \\
\text{pineapple} & + \text{orange} + \text{banana} = 339 \\
\end{align*}
\]

Compute:

\[
\text{banana} + \text{orange} + \text{pineapple} = ?
\]

Numeric exercises: Solving arithmetic problems.
Dynamic exercises: String

exetype: string
exsolution: ANSWER
Dynamic exercises: String

**Question**
What is the name of the R function for extracting the estimated coefficients from a fitted (generalized) linear model object?

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

```plaintext
extype: string
exsolution: ANSWER
```
Dynamic exercises: Cloze

extype: cloze
exclozetype: mchoice|num
exsolution: 10|123.45
Dynamic exercises: Cloze

**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.*
## Dynamic exercises: Static to numeric to single-choice

<table>
<thead>
<tr>
<th>#</th>
<th>Exercise templates</th>
<th>Dynamic?</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>expderiv1.Rmd</td>
<td>No</td>
<td>num</td>
<td>Fixed parameters and numeric solution.</td>
</tr>
<tr>
<td></td>
<td>expderiv1.Rnw</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>expderiv2.Rmd</td>
<td>No</td>
<td>schoice</td>
<td>As in #1 but with single-choice solution (five answer alternatives).</td>
</tr>
<tr>
<td></td>
<td>expderiv2.Rnw</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>expderiv3.Rmd</td>
<td>Yes</td>
<td>num</td>
<td>Randomly-drawn parameters with dynamic computation of correct solution, based on #1.</td>
</tr>
<tr>
<td></td>
<td>expderiv3.Rnw</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>expderiv4.Rmd</td>
<td>Yes</td>
<td>schoice</td>
<td>Randomly-drawn parameters (as in #3) with dynamically-generated single-choice solution (as in #2), computed by num_to_schoice().</td>
</tr>
<tr>
<td></td>
<td>expderiv4.Rnw</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>expderiv5.Rmd</td>
<td>Yes</td>
<td>schoice</td>
<td>As in #4 but with the last alternative: None of the above.</td>
</tr>
<tr>
<td></td>
<td>expderiv5.Rnw</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Stress tester

R> s <- stresstest_exercise("expderiv4.Rmd")
R> plot(s)
Stress tester

```r
R> s <- stress_test_exercise("expderiv4.Rmd")
R> plot(s)
```

Position of correct solution

```
<table>
<thead>
<tr>
<th>Position</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td>30</td>
</tr>
<tr>
<td>4</td>
<td>15</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
</tr>
</tbody>
</table>
```

Rank of correct solution

```
<table>
<thead>
<tr>
<th>Rank</th>
<th>n</th>
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<tbody>
<tr>
<td>1</td>
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<tr>
<td>2</td>
<td>30</td>
</tr>
<tr>
<td>3</td>
<td>30</td>
</tr>
<tr>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
</tr>
</tbody>
</table>
```
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
R> myexam <- list(
+   "conferences.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

Written exam:
R> exams2nops(myexam, n = 3, dir = odir,
+    language = "fr", institution = "useR! 2019")

Online test:
R> exams2moodle(myexam, n = 10, dir = odir)

Live quiz:
R> exams2arsnova(myexam, n = 1, dir = odir)

Other: exams2pdf(), exams2html(), exams2canvas(), exams2blackboard(), ...
E-Learning

Online quiz: https://eeecon.uibk.ac.at/~moodle/

Login: E-mail (lower-case)
Password: 8-digit code
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, …
2. Create

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

What is the derivative of \( f(x) = x^3 e^{3x} \), evaluated at \( x = 0.757 \)?

Answer: 51.83594

Check

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

\[
 f'(x) = \left[ g(x) \cdot h(x) \right]' = g'(x) \cdot h(x) + g(x) \cdot h'(x) \\
 = 3x^2 \cdot e^{3x} + x^3 \cdot 3e^{3x} \\
 = 3x^2 e^{3x} + 3x^3 e^{3x} \\
 = e^{3x} (3x^2 + 3x^3) \\
 = e^{3x} (3x^2 + 3x^3). 
\]

Evaluated at \( x = 0.757 \), the answer is

\[ e^{3.3 \cdot 0.757} \cdot 0.757 \cdot (3 + 3 \cdot 0.757) = 36.50945 . \]

Thus, rounded to two digits we have \( f'(0.757) = 36.59 \).

The correct answer is: 36.59

Preview question: R01 Q6: Im

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

b. Estimated slope with respect to \( x \): \(-0.08\)

Check
E-Learning: Online test

**Question**

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 = -0.90198, df = 53, p-value = 0.3684
- alternative hypothesis: true difference in means is less than 0
- 95 percent confidence interval:
  - Inf < 0.0862971
- sample estimates:
  - mean in group Sparag: 7.688248
  - mean in group Consumo: 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.

**Question**

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` = 0.08
E-Learning: Live quiz

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

- Universität Wien
- ETH Zürich
- Københavns Universitet

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

- 2.43
- 3.70
- 2.10

Given the following information:

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Compute:

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</table>
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.

1. Which of these institutions already hosted a useR! conference?
(a) ETH Zürich
(b) Agrocampus Ouest
(c) National Institute of Standards and Technology
(d) Københavns Universitet
(e) Universität Wien

2. What is the derivative of $f(x) = x^{6}e^{2.8x}$, evaluated at $x = 0.77$?
(a) 22.14
(b) 19.07
(c) 15.83
(d) 14.03
(e) 25.48

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 A is about symmetric.
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()` function, 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.
### A vizsga eredménye

<table>
<thead>
<tr>
<th>Név:</th>
<th>Jane Doe</th>
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<tr>
<td>Regisztrációs szám:</td>
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#### Értékelés

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### Vizsgalap

**R University**

**Exam 2015-07-29**

### A vizsga eredménye

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<tr>
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### Vizsgalap

**Universität Innsbruck**

**Klausur 2015-07-29**

#### Personal Data

- **Family Name:** Doe
- **Given Name:** Jane
- **Signature:**

#### Persönliche Daten

- **Nachname:** Dexter
- **Vorname:** Ambi
- **Unterschrift:**
Outlook
Outlook

Under development:

- *Many volunteers*: Internationalization for “NOPS” exams.
- *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 (started in c403).
Please mark the boxes carefully: ☒ Not marked: ☐ or ☐
This document is scanned automatically. Please keep clean and do not bend or fold. Only clearly marked and positionally accurate crosses will be processed!
For filling in the document please use a blue or black pen.

Exam 2019-07-06
Answers 1 - 15
a b c d e
1 ☐ ☐ ☐ ☐ ☐
2 ☐ ☐ ☐ ☐ ☐
Answers 16 - 21
a b c d
16 ☐ ☐ ☐ ☐
17 ☐ ☐ ☐ ☐

More contributions welcome ...
Graphical exams manager

R/exams manager

Select exercise to be modified.

deriv.Rmd

Encoding?

utf8

Load a template. Markup?

Markdown

Type?

num

Load template

Load exams package exercises.

deriv.Rmd

Load exercise

Converter?

pandoc

✔ MathJax?
Graphical exams manager

R/exams manager

Select exercises for your exam.

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Exercises

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<tr>
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<td>deriv2.Rmd</td>
</tr>
<tr>
<td>4</td>
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</tr>
<tr>
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<td>test.Rmd</td>
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Set points and exercise number.

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Showing 1 to 4 of 4 entries

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<tr>
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</table>

Name of the exam.

Exam1

Save exam
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
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
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
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

Contributors: Zeileis, Grün, Leisch, Umlauf, Smits, Birbaumer, Ernst, Keller, Krimm, Stauffer.

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
- Twitter: @AchimZeileis

References: