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.
Motivation

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

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.
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.

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.
Example: First-year mathematics

**Structure:** Mandatory.
- 2-hour lecture (VO), 500+ participants.
- 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.

**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.

**Summative assessment:** Written single-choice exams (mid-term & end-term).
Example: Data analytics

**Structure:** Elective.

- 2-hour lecture (VU), 40–60 participants.
- 1-hour tutorial (VU), 15–40 participants per tutorial.
Example: Data analytics

Structure: Elective.

- 2-hour lecture (VU), 40–60 participants.
- 1-hour tutorial (VU), 15–40 participants per tutorial.

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.
Example: Data analytics

Structure: Elective.
• 2-hour lecture (VU), 40–60 participants.
• 1-hour tutorial (VU), 15–40 participants per tutorial.

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

<table>
<thead>
<tr>
<th>Type</th>
<th>Software</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Statistical computing</td>
<td>R</td>
<td>Random data generation, computations</td>
</tr>
<tr>
<td>Writing/reporting</td>
<td>Markdown, \LaTeX\</td>
<td>Text formatting, mathematical notation</td>
</tr>
<tr>
<td>Reproducible research</td>
<td>knitr, rmarkdown, Sweave</td>
<td>Dynamically tie everything together</td>
</tr>
<tr>
<td>Document conversion</td>
<td>pandoc, TtH/TtM</td>
<td>Conversion to HTML and beyond</td>
</tr>
<tr>
<td>Image manipulation</td>
<td>ImageMagick, magick, png</td>
<td>Embedding graphics</td>
</tr>
<tr>
<td>Web technologies</td>
<td>base64enc, RCurl, …</td>
<td>Embedding supplementary files</td>
</tr>
<tr>
<td>Learning management</td>
<td>Moodle, OpenOlat, Canvas, Particify, …</td>
<td>E-learning infrastructure</td>
</tr>
</tbody>
</table>
Exam 1

1. Question:

What is the derivative of $f(x) = x^3 \cdot 3^x$, evaluated at $x = 0$? (a) 0, (b) 6, (c) 3, (d) 9, (e) 27.

2. Question:

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

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

where

$$g'(x) = 3x^2$$

$$h'(x) = 3e^{3x}$$

Thus,

$$f'(x) = x^3 \cdot 3e^{3x} + e^{3x} \cdot 3x^2$$

Evaluated at $x = 0.88$, the answer is

$$f'(0.88) = 0.88 \cdot 3e^{3(0.88)} + e^{3(0.88)} \cdot 3(0.88)^2$$

Thus, rounded to two digits we have

A. True
B. False
C. False

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?

* 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?

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.
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

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

```{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 \( x = c \)?

```
```{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)
```

Question
========
What is the derivative of \( f(x) = x^{\text{\textasciix27\textasciix27r a\textasciix27\textasciix27}} e^{\text{\textasciix27\textasciix27r b\textasciix27\textasciix27x}} \), evaluated at \( x = \text{\textasciix27\textasciix27r c\textasciix27\textasciix27} \)?
**Dynamic exercises: .Rmd vs .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(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 $f(x) = x^{\text{\Sexpr{a}}} e^{\text{\Sexpr{b}\times x}}$, 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}

Meta-information

\begin{align}
\text{extype: num} \\
\text{exsolution: \texttt{\r fmt(res)}} \\
\text{exname: derivative exp} \\
\text{extol: 0.01}
\end{align}
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 $g(x) := x^r a$ and $h(x) := e^{r b \cdot x}$, we obtain
$$
\begin{aligned}
f'(x) &= [g(x) \cdot h(x)]' = g'(x) \cdot h(x) + g(x) \cdot h'(x) \\
... \\
\end{aligned}
$$

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)
\end{eqnarray*}
\end{solution}

\begin{verbatim}
\begin{eqnarray*}
f'(x) & = & g'(x) \cdot h(x) + g(x) \cdot h'(x) \\
\end{eqnarray*}
\end{verbatim}

\texttt{\texttt{extype{num}}} \hspace{1cm} \texttt{\texttt{exsolution{\Sexpr{fmt(res)}}}} \\
\texttt{\texttt{exname{derivative exp}}} \\
\texttt{\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) Basel
(b) Bern
(c) Zurich
(d) Geneva
(e) Lausanne

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

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

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.
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.

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

exsolution: 123.45
Dynamic exercises: Numeric

Question
Given the following information:

\[
\begin{align*}
\text{apple} + \text{banana} + \text{banana} &= 113 \\
\text{apple} + \text{banana} + \text{orange} &= 121 \\
\text{banana} + \text{banana} + \text{pineapple} &= 451
\end{align*}
\]

Compute:

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

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 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
Consider the following regression results:

Call:
\[
\text{lm(formula = log(y) ~ log(x), data = d)}
\]

Residuals:

<table>
<thead>
<tr>
<th>Min</th>
<th>1Q</th>
<th>Median</th>
<th>3Q</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>-5.490</td>
<td>-1.056</td>
<td>0.102</td>
<td>1.593</td>
<td>5.187</td>
</tr>
</tbody>
</table>

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: -0.00942
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 \textit{exstringtype}).
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
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

2. Create

- 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

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

Answer: 51.863594

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

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

$$= 3x^2 \cdot e^{3x} + x^3 \cdot e^{3x} \cdot 3$$

$$= x^3 e^{3x} (3x^2 + 3.3x)$$

Evaluated at $x = 0.757$, the answer is

$$e^{3.3 \cdot 0.757} \cdot 0.757^2 \cdot (3 + 3.3 \cdot 0.757) = 36.501945$$

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

The correct answer is: 36.59

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

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

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** = -0.0466, df = 53, p-value = 0.9984
- **alternative hypothesis**: true difference in means is less than 0
- **95 percent confidence interval**:
  - Inf, 0.0030282
- **sample estimates**:
  - mean in group Sparag: 7.668248
  - mean in group Consuma: 7.662992

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 Consuma.

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
- [ ] a. $y$ increases significantly with $x$
- [ ] a. $y$ decreases significantly with $x$

b. Estimated slope with respect to $x$: $b = 0.08$
E-Learning: Live quiz

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

- Lagos (Nigeria)
- Istanbul (Turkey)
- Zürich (Switzerland)
- Warsaw (Poland)
- New Delhi (India)

What is the derivative of \( f(x) = x^5 e^{3.1x} \), evaluated at \( x = 0.7 \)?

- 6.28
- 7.34
- 5.77
- 4.34

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.)
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.
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 \( f(x) = x^8 e^{2.3x} \), 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 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**

<table>
<thead>
<tr>
<th>Név:</th>
<th>Jane Doe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regisztrációs szám:</td>
<td>1501090</td>
</tr>
<tr>
<td>Érdemjegy:</td>
<td>5</td>
</tr>
<tr>
<td>Pontok:</td>
<td>3.1666666666667</td>
</tr>
</tbody>
</table>

**Értékelés**

<table>
<thead>
<tr>
<th>Kérdés</th>
<th>Pontok</th>
<th>Adott válasz</th>
<th>Helyes válasz</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>c</td>
<td>c</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>abc</td>
<td>abc</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td></td>
<td>ab_d</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>c</td>
<td>bc</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>d</td>
<td>ab_d</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>bc_e</td>
<td>a_c</td>
</tr>
</tbody>
</table>

**Vizsgalap**

---

**R University**

Exam 2015-07-29

---

**Universität Innsbruck**

Klausur 2015-07-29

---

**Personal Data**

<table>
<thead>
<tr>
<th>Family Name:</th>
<th>Doe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Given Name:</td>
<td>Jane</td>
</tr>
<tr>
<td>Signature:</td>
<td></td>
</tr>
</tbody>
</table>

**Regisztrációs szám: 1501090**

---

**Persönliche Daten**

<table>
<thead>
<tr>
<th>Nachname:</th>
<th>Dexter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vorname:</td>
<td>Ambi</td>
</tr>
<tr>
<td>Unterschrift:</td>
<td></td>
</tr>
</tbody>
</table>

**Regisztrációs szám: 9901071**
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.

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/](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