Blended Learning Tools for Large Statistics and Mathematics Courses

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Motivation and challenges

Motivation:

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

Strategy:

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

Motivation and challenges

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

Motivation and challenges

	Learning	**Feedback**	**Assessment**
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Learning:

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

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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*

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.

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.

R package *exams*

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

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*, ...

Exercises

Text file: With sections for random data generation (optional), question, solution (optional), and metainformation.

Here: Static multiple-choice question in Markdown format.

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```
Question
========
Under the assumptions of the Gauss-Markov theorem the errors
of a linear regression model need to be:

Answerlist
----------
* independent
* uncorrelated
* normally distributed
* identically distributed
* homoscedastic
```

Exercises

```
Solution
========
Under the assumptions of the Gauss-Markov theorem the errors of a linear
regression model need to be uncorrelated, homoscedastic, and with mean zero.

Answerlist
----------
* False. Independence is not assumed, only lack of correlation.
* True. The errors need to be uncorrelated.
* False. No distribution assumption is needed.
* False. No distribution assumption is needed.
* True. The errors need to be homoscedastic with finite variance.
```

Exercises

```
Solution
========
Under the assumptions of the Gauss-Markov theorem the errors of a linear
regression model need to be uncorrelated, homoscedastic, and with mean zero.

Answerlist
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* True. The errors need to be uncorrelated.
* False. No distribution assumption is needed.
* False. No distribution assumption is needed.
* True. The errors need to be homoscedastic with finite variance.

Meta-information
================
exname: Gauss-Markov assumptions
extype: mchoice
exsolution: 01001
exshuffle: TRUE
```

Exams

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

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

Written exam: Printed PDF files.

- 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.

Online test: In learning management system (*OLAT*, *Moodle*, . . .).

- All exercise types.
- Optionally show complete correct solution.

Live quiz: In *ARSnova* on any computer/tablet/smartphone.

- Currently only single- and multiple-choice questions.
- Immediate feedback in lecture room.

Exams

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"
+  )
```

Written exam:

```
R> exams2nops(myexam[-(2:3)], n = 3, dir = odir,
+    language = "de", logo = "uibk-logo-bw.png",
+    institution = "Universit\\\"at Innsbruck")
```

Online test:

```
R> exams2qti12(myexam, n = 3, dir = odir)
```

Live quiz:

```
R> exams2arsnova(myexam[-(2:3)], n = 3, dir = odir)
```

Exams: Written exam

Left page

+ **Universität Innsbruck**
Exam 2016-03-14

Persönliche Daten

Matrikelnummer

Nachname:

Vorname:

Unterschrift:

geprüft

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

Scrambling
0 , 0

Belegart
005

Klausur-ID
16031400001

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
a b c d e
1 ☐ ☐ ☐ ☐ ☐
2 ☐ ☐ ☐ ☐ ☐
3 ☐ ☐ ☐ ☐ ☐
a b c d e

Right page

1. In the following 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.*)

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

(a) The slope of the regression line is about 1.
(b) The standard deviation of Y is at least 6.

Exams: Written exam

Exams: Online test

Exams: Live quiz

Discussion

Package *exams*:

- Framework for automatic generation of exams/tests/quizzes in various formats.
- 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: http://R-Forge.R-project.org/projects/exams/

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:* Reports for lecturers based on IRT models.

References

Zeileis A, Grün B, Leisch F, Umlauf N (2015). *exams: Automatic Generation of Exams in R.* R package version 2.1-0.
URL `http://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`