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

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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
- **\texttt{Sweave}** or \texttt{knitr/rmarkdown} for tying everything together.

Exercises:

- Dynamic templates if R code is used for randomization.
- Each exercise is a single file (either .\texttt{Rnw} or .\texttt{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, …*
Text file: With sections for random data generation (optional), question, solution (optional), and metainformation.

Here: Static multiple-choice question in Markdown format.
Exercises

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

**Here:** Static multiple-choice question in Markdown format.

**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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* 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.

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

Written exam:

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

Online test:

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

Live quiz:

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

Question

In Figure 1, the distributions of a variable given by two samples (A and B) are represented by parallel box plots. Which of the following statements are correct? (Comment: The statements are either 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
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 location of both distributions is about the same.
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.

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.
