

# Moodle tests: not so much of a fuss when you have R

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## ABSTRACT

One of the least motivating parts of the teaching-learning process is evaluation. It is a task done with some periodicity and one of the aspects that teachers seek to improve. In higher education institutions, evaluation consolidates the learning process and it is an important tool that permits the accountability and certification of the results. During that process teachers aim to achieve equity, suitability, reliability, and efficiency. The preparation of different components of evaluation is one of the most time-consuming activities and so it is highly desirable to reduce the time used in that process, namely, in the preparation of written exams. All over the world, educational institutions of all degrees have adopted some mixed models of communications between the agents of the process of learning-teaching. The digital way is largely spread using suitable platforms. One of the top preferences among a great part of those institutions is Moodle. Moodle provides some tools to perform formative as well as summative evaluation. We've seen how Pandemic disease increased the need for the use of such tools. Recent studies show new problems raised with home evaluation tests, one of which is the easier possibility of fraud. As a response to this problem, one can increase the number of different questions presented to different students. With particularly advantages to statistics teachers (familiarized with R), the R package exams is a powerful tool that provides some answers to those problems: it produces questions that can be exported directly to Moodle quiz format (as well as in paper format) and it allows for random generation of parametrized questions. This way, one rapidly obtain a number of multiple questions, all of them with the same level of difficulty and related to the same topics, ready to include in the Moodle bank of questions. This paper aims to show how these tools combined with latex and markdown environments may contribute to help Statistics teacher's activity.

**Keywords:** Assessment, Moodle, R project, Markdown, Statistics.

## INTRODUCTION

Assessment is one of the least motivating tasks of the teacher's activity. In Europe, after Bolonha implementation, there has been an increase in the adoption of different methods for evaluating students. Seeking ways of turning the assessment process more efficient, teachers often propose new activities and split the traditional exam into multiple and smaller tests as an option. In the case of the traditional written tests, extra difficulties arise

with those new models, resulting in a greater number of tests to create and evaluate. Apart from the inherent effort of the increased number of proofs, teachers face problems of equity between different class's exams. Moodle represents an important contribution to turn easier the process, but some problems remain to solve. With the R exams package, it is possible to export written tests directly to Moodle and to implement dynamic exercises. This way, we witness significant improvements regarding the efficiency of the process and we give a step more towards reducing the odds for fraud, either in alive or e-learning forms of evaluation.

## MOTIVATION

In the process of evaluation, one of the most frequent components is the realization of a written exam. In either of its forms (formative or summative), teachers aim to achieve equity, suitability, reliability and efficiency among other.

The quality of assessment tasks is fundamental for the process of learning [1]. Teaching Statistics has evolved to an actual scenario where almost all the courses use some kind of computational software, from the ordinary *EXCEL* to some more sophisticated tools. It is desired that students can use those same tools when they are evaluated. Since they have to use the computer, why not perform the entire task within the same environment?

Aiming to increase student's success, teachers tend to offer different types of evaluation forms. This results in shorter and more frequent exams, large number of tests to evaluate and difficulties with deadlines to publicise the results.

Multiple classes require different exams with the same level of difficulty. It is meant to perform the assessment concerning the same contents to evaluate. The pandemic increased the need for different exams to different students to avoid fraud. With digital platforms there is a huge reduction in paper expenditures, contributing to the planet sustainability.

The combination of Moodle platform and the R-package exams present a solution that answers to all of the precedent questions. The way a teacher faces the evaluation process of their students climbed to a new step in terms of quality and efficiency.

There are several tools to help teachers executing their assessment tasks. A brief net search provides some examples like Gauge (<https://gaugeonline.com/>), Flexiquizz (<https://www.flexiquizz.com/>) or Help teaching (<https://www.helpteaching.com/>), among others. The

Mathematics Exercise Generators (MEGs) [7] has been an example of one of the most complete and successful instruments to self-study and self-assessment for students. It is also used for summative evaluation purpose and it also makes possible to implement parameterized exercises. But, unlike the R exams package, it works in an independent way, not communicating with Moodle platform. Using the R exams package means that a math or a statistic teacher may implement those type of exercises without extra efforts. Almost all statistic teachers are well familiarized with R and many math teachers too. R-Studio turned easier the use of the R language and so it has become more popular among the scientific community of exact sciences. The fact that R exams features interact directly with platform Moodle represents a major advantage comparing to other similar tools.

## WHY MOODLE

Moodle was developed in 2002 by Martin Dougiamas, Moodle. It is the world's most popular and most used Learning Management System.

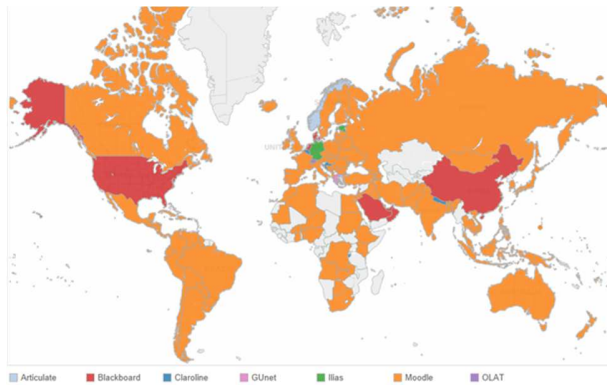


Figure 1 Moodle users in the world (Font: stats.moodle.org)

## Advantages

One of the advantages of the use of Moodle platform to perform in the class exams is the fact that the necessary tools are available in the same device. This way, students can answer the exam questions and perform the necessary calculus with the chosen statistical software in the classroom. In moments like the ones we have been through recently, with pandemic restrictions where e-learning features had to be temporarily extended, teachers had to adapt their methods and practices. For some time there was the need of on-line evaluation which was made possible by using Moodle.

Another important advantage is reflected on saving time. One of the most time consumption teacher's tasks is the analysis and correction of the exam responses. The possibility of making an exam with many types of self-evaluated questions turns this phase much better in terms of the time required to perform it.

Through the years, a teacher tends to collect groups of questions appropriated to assess the learning capabilities of their students and many of them are reusable within a considerable interval of time. Moodle makes it possible to unify and classify the questions, so teachers may select some set of questions from a

bank of questions. This bank of questions may (and should) be organized among suitable and hierarchical categories so the user may quickly and conveniently choose the most adequate set for testing some particular skills with a given level of difficulty.

One other relevant feature of the use of Moodle platform in evaluation tasks is that it can provide students with training questions, similar to the ones that are to be included in the assessments. Those training questions may be supplied with an immediate feedback that helps the student to assess if he or she is in the trail to achieve the correct answers. So, the self and autonomous study and practice are facilitated with the Moodle tools.

## Limitations

In spite of the major referred advantages, Moodle presents some limitations. It is a good practice for teachers to have records of the proofs they present to their student. This type of documents might be of interest when evaluating the course or the educational institution. With Moodle it is not easy to extract or make a copy of some given exam.

Also, some conflicts were found with popular browsers like *Google Chrome* or *Internet Explorer*. In particular for math teachers, some problems arise frequently with types of question options that don't properly show symbols and equations written in *latex*.

The moment of conception of the idea for some problem to be solved is distinct and distant from the moment of the output. This discrepancy often originates some errors. If the values are changed for pedagogical reasons, for instance, it is easy to forget to the correct all the exercise text accordingly and filling the correct changed answers. Plus, to replicate questions with different values it is necessary to perform new computations. So, multiple an different exams, with the same level of difficulty require time and concentration.

## R-EXAMS PACKAGE

### History

The *exams* package was designed at the Vienna University of Economics and Business [2] (<https://www.wu.ac.at/en/>) in 2006/07. The introductory statistics lecture had a number of students between 1000 and 1500. Several teams from the Department of Statistics and Mathematics were organized to re-design the course and to produce new materials in a collaborative manner. This way, they expected to improve efficiency and consistency of the format courses.

R-exams package is the result of a technical response to those problems, aiming to provide adequate solutions for the need of large number of different exams, similar materials for training and multi-author contributions. Although the initial goal was to produce large scale and different *pdf*/printable paper exams, actual features make possible to obtain different output formats for the same exercise. One may choose to publish the exam in a *pdf* file for classroom distribution, or *HTML* (Hyper Text Markup Language) for on-line materials and *XML* (Extensible Markup Language) for learning platforms like Moodle.

The site <http://www.r-exams.org/> contains different question templates. These are available in different formats of files like *sweave* [3], *tex* [4] or *markdown* [https://en.wikipedia.org/wiki/John\\_Gruber](https://en.wikipedia.org/wiki/John_Gruber).

Each exercise is a *file.rmd* or *file.tex* which mixes R-code with *markdown* text and/or *latex* code for math display. An example of question code available at [r-exams.org](http://www.r-exams.org) site is showed in Figure 2:

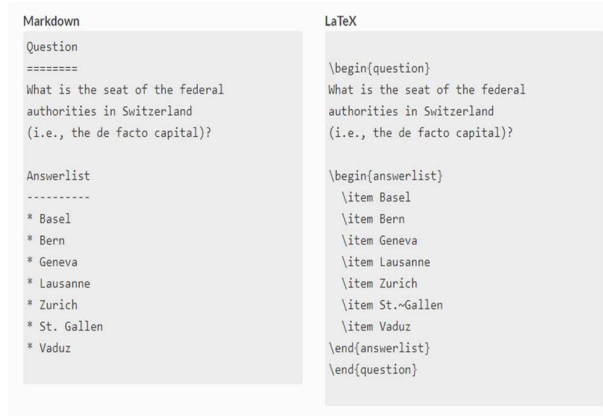


Figure 2 Example of question code available at [r-exams.org](http://www.r-exams.org).

The idea is to build a pool of dynamic exercises. Each exercise/question includes:

- a problem;
- a solution;
- some data-generating process (DGP) [5].

### Questions

Suppose we want to test if students know how to build a confidence interval for the mean value of a Normal distribution with known variance and with some degree of confidence. we could provide one file with some sample in Moodle and all the students would obtain the same solutions for a chosen confidence level. The look of the resulting question would be similar to Figure .

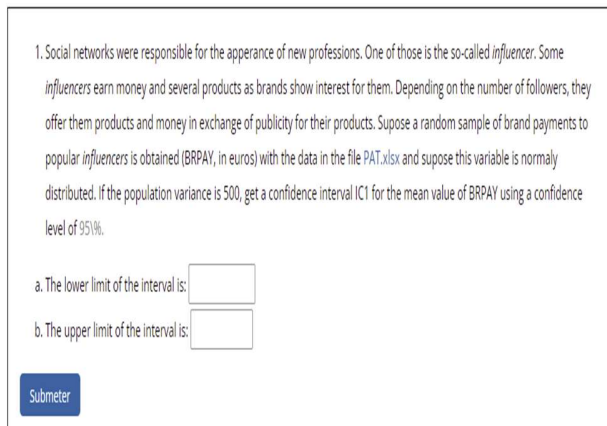


Figure 3 A Moodle question.

For the example in Figure 3 we would have:

- a cloze type question in Moodle with two numeric solutions;
- to supply the file *PTA.xlsx* in Moodle;
- to choose a confidence level;

Turning this exercise in a dynamic one means we have three parameters which we may control in order to obtain different versions of the same exercise:

- the sample file that you may randomly generate;
- the sigma2 value (where sigma2 represents the population variance);
- the confidence level (1-alpha);

This would correspond to the part of the question designated to generate the data as in the next code lines in Figure 4:

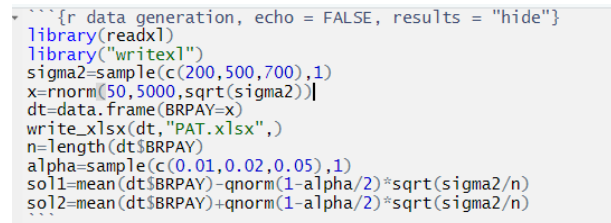


Figure 4 Example of data generation code lines.

### Description

A part entitled *Question* contains a description of the problem. We write here the text of the question and describe the nature of the variables, their features and eventual relations. In the present example, this is the text below:

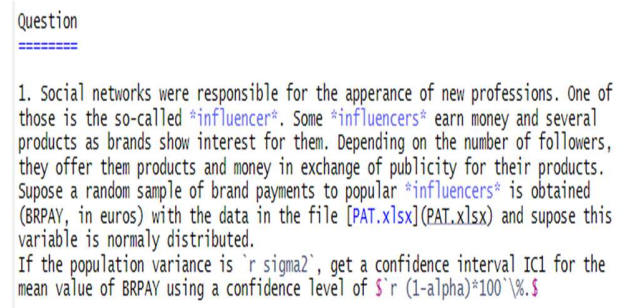


Figure 5 Example of question description.

### Solution

Optional a question may include detailed explanation of the solution for the question. This is particularly relevant when the exercise is meant for self-learning process. This way students see some lights about the resolution or even the whole correct answer with explanations about the choices made. In the present example, the solution could be something like the following in Figure 6:

Solution

The interval estimates the mean value of a population normally distributed with known variance  $\sigma^2$ . With a confidence level of  $(1-\alpha)\times 100\%$ , it is obtained with

$$\left[ \bar{X} - z_{1-\alpha/2} \frac{\sigma}{\sqrt{n}}; \bar{X} + z_{1-\alpha/2} \frac{\sigma}{\sqrt{n}} \right];$$

For the observed sample we get  $n = \text{r n}$  and  $\bar{x} = \text{r mean(dt$BPAY)}$  and the quantile of order  $1-\alpha/2$  is  $\text{r qnorm}(1-\alpha/2)$ , so

```
IC_l = `r fmt(sol1,3)`
```

```
IC_u = `r fmt(sol2,3)`
```

Figure 6 Example of a question solution text.

### Meta information

The Meta-information part of the question includes several specifications about the exercise. As we may see in Figure 7, it includes:

Meta-information

```
extype: cloze
exsolution: `r fmt(sol1)`|`r fmt(sol2)`
exclozetype: num|num
exname: IC2
extol: 0.001
```

Figure 7 Example of Meta information of a question.

- the type of question that can be one among choice, mchoice, numerical, cloze or string;
- the solution (optional);
- in this case, as it is a cloze type question, it requires to specify each cloze item type;
- name of the question (optional, helps to later identify the question);
- tolerance for numeric answers, meaning the degree of acceptable error.

Other functions allow for extra options like *exshuffle* for mixing the order of the questions, *exams\_eval* for establish the assessment points in partial credits. Further details can be found in [5].

### A precious help to start

The <http://www.r-exams.org/> site provide precious tools to begin with, using the *r exams* package. Apart from a set of different exercise templates with illustrative examples in various formats, one can find tutorials, a blog for discussion and some other resources. Pedro Calvo [6] offers a Spanish version of help also with many tips. The best way to start is perhaps to run the function *exams\_skeleton* after installing the *exams* package. This function creates a directory with an example of a structure to organize the work providing examples and demos of different types of files and templates (see the *exams* vignette in <https://cran.r-project.org/web/packages/exams/exams.pdf>).

## Exams generator

### Rendering an exercise/exam

The part of building the bank of questions demands some creativity, besides the knowledge of the types of possible questions to produce. Also realize, that is important to conveniently name them so they can be picked later on, knowing what is meant to evaluate. The way they are created, as simple, independent files, turns easier the work of multiple collaborators.

Once the question is finished we have a

- a *.rmd* file if written in Markdown <https://daringfireball.net/projects/markdown/>,
- a *.rnw* file if written with Sweave <https://stat.ethz.ch/R-manual/R-devel/library/utils/doc/Sweave.pdf> was used.

Each question corresponds to a file which will be turned into a chosen output format like *PDF*, *HTML* or *XML*. One may want to make a single question, a list of questions or randomly pick a list from a selected group of questions.

First we set the exercise or list of exercises, e.g.:

```
Teste_1 = list("perguntas/IC1.Rmd")
```

In this case, the R-project contains a folder named *perguntas* where the questions are saved.

An example of a test would be a list of questions like the following:

```
Teste_2 = list(
  "perguntas/desc2.Rmd",
  "perguntas/MomentosD2.Rmd",
  "perguntas/Normal12.Rmd",
  "perguntas/IC2.Rmd",
  "perguntas/biv1.Rmd"
)
```

The next step is to use the *exams2xxx* function, replacing the *xxx* by the wanted output format. If Moodle is the chosen one, using *exams2moodle*, makes a new *xml* file that will be ready to import from Moodle platform. This file will appear in a folder previously created to keep this type of files. In a similar way we may obtain the written question in a pdf file, or ready to visualize in a web browser.

```
exams2xxx
# turning "Teste_1" into a pdf file
exams2pdf(Teste_1, n = 1, dir="out_pdf",
name = "Teste_data",
template = "templates/plain8.tex")

# turning "Teste_1" into a html file
exams2html(Teste_1, n = 1, dir = "out_html",
template = "plain.html", name="Teste_data",
mathjax = TRUE, encoding = "uft8")

# turning "Teste_1" into a xml file (moodle im port)
exams2moodle(Teste_1, n=1, name = "SPE",
encoding = "UTF-8",
dir = "out_moodle",
```

```
edir="perguntas",iname=TRUE
)
```

### Working within a team

Different members of one team may work independently to contribute to build a bank of questions for each subject of one course. While developing the work it might be useful to play a quick HTML preview. This way it is possible to realize if everything is running as expected. With everything running as expected, the XML file is generated and then imported from Moodle.

### Multiple exams

With the value of the parameter  $n$  in the exams generator we obtain multiple versions of the dynamic exercise,  $n$  different versions of the same question. In the presented example, each one corresponds to different sampled values, different variance value and different confidence level.

```
# turning "Teste_2" into a xml file (moodle import)
exams2moodle(Teste_2, n=3, name = "SPE",
  encoding = "UTF-8",
  dir = "out_moodle",
  edir="perguntas",iname=TRUE
)
```

In the previous example, the file would include five versions of the IC1 question because *Teste\_1* only contains one question. In the case of *Teste\_2*, the produced file would have a total of  $3 \times 5$  questions, 3 versions of each question.

### Import questions/exercises to Moodle

Before importing the questions it is important to organize the categories in Moodle and prepare different issues and hierarchical options. After doing so, it is possible pick the category between those ones that were previously created or to adopt a new one, referred in the options of the question being imported. This way, a new category will be defined. One single file created with  $n$  exams package may turn into  $n$  Moodle replicated questions.

## CONCLUSIONS

The use of the *exams* package conjoint with *R studio* and *Moodle* platform highly contributes to the quality and efficiency of statistics teachers. It becomes easier for those who already know latex and markdown languages. It's important to organize the folders where to keep questions, exams and output files. Exams package helps to produce multiple similar questions/exams. In doing so, it helps to fight fraud and creates adequate training materials for self-study. It also turns the manipulation of questions and exams in Moodle more user friendly. The flexibility of the different outputs possible to create turns easier to keep records for future memory and/or replication. *R exams* package represents a fundamental tool for teachers, in particular for math teachers and especially for statistics teachers. Every future math teacher should learn how to use the R-exams package. Her/his action will benefit a lot and so will their students.

Another great feature to be explored is the potential of R exams to produce digital assessment materials that can be part of an e-book, for example. A proper bank of quizzes improves the process of digital learning, and digital learning is something that all students look for nowadays, either eLearning students or traditional in-class students.

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## REFERENCES

- [1] Ibarra-Sáiz, María Soledad, Gregorio Rodríguez-Gómez, and David Boud. 2021. "The Quality of Assessment Tasks as a Determinant of Learning." *Assessment & Evaluation in Higher Education* 46 (6): 943-55. <https://doi.org/10.1080/02602938.2020.1828268>.
- [2] Grün, Bettina, and Achim Zeileis. 2009. "Automatic Generation of Exams in R." *Journal of Statistical Software* 29 (10): 1-14. <https://doi.org/10.18637/jss.v029.i10>.
- [3] Leisch, Friedrich. 2002. "Sweave: Dynamic Generation of Statistical Reports Using Literate Data Analysis." *Compstat*, 575-80. [https://doi.org/10.1007/978-3-642-57489-4\\_89](https://doi.org/10.1007/978-3-642-57489-4_89).
- [4] Knuth, Donald E. 2017. *The Texbook*. American Mathematical Society.
- [5] Zeileis, Achim, Nikolaus Umlauf, and Friedrich Leisch. 2014. "Flexible generation of E-learning exams in R: Moodle quizzes, OLAT assessments, and beyond." *Journal of Statistical Software* 58 (1): 1-36. <https://doi.org/10.18637/jss.v058.i01>.
- [6] Pedro Luis Luque Calvo (us.es) <http://destio.us.es/calvo/#informacion>
- [7] Oliveira, P. and Carvalho, P. 2020. Mathematics Exercise Generator: The Language of Parameterized Exercises. In: *Developing Technology Mediation in Learning Environments*. IGI Global.