

How to use R package exams as a replacement for scantrons

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Contents

1	Introduction	2
2	R package exams installation and requirements	2
2.1	Installing R and RStudio	2
2.2	Install the R exams package	2
2.3	LaTeX requirements	2
2.4	Ghostscript	2
2.5	R Markdown	3
2.6	Setting the R session working directory	3
2.6.1	Note for Windows users	3
3	First steps	3
3.1	Creating individual questions	4
3.2	Adding figures to your questions	5
4	Creating an exam and answer sheet (scantrom) ready to print	6
4.1	Creating the exam	6
5	Printing the exams and the answer sheet	7
6	Conducting the exam	7
7	Scan answer sheets	9
8	Evaluation of scanned answer sheets	9
8.1	Loading and checking the scans in R	9
8.2	Creating a registration file	9
8.2.1	Converting a PAWS roster table to a registration file	10
8.3	Exam evaluation	10
8.4	Correcting errors in the scans	11
9	Generating descriptive statistics for your exam	13
10	Uploading exam grades to Canvas	14
11	Troubleshooting and other bits and pieces	15
11.1	Detecting a problem with the key of one question	15
11.2	Adding students that completed the exam on a different date	16
11.3	Merging all student evaluation HTML files in a single PDF	17
11.4	Creating an exam answer sheet from a correct answer key	17

1 Introduction

This manual is intended to facilitate the use of the R package exams as a replacement tool for scantrons. Note that, beyond creating exams and associated scantrons, the package can be used to create quiz questions that can be uploaded into Canvas (topic not covered here). In brief, the package will produce a PDF with the exam and a scantron (maximum 45 questions). Questions can be single choice (one correct answer) or multiple choice (one or more correct answers). You can easily create different versions of the exam, by shuffling or randomly selecting, or both, questions from a larger number of possible answer choices.

Students answer their exam questions on the answer sheet, the instructor then scans the answer sheets with the department's photocopy machine (so fast). The resulting PDF containing scans of all students' answer sheets is analyzed in R using functions from the R exams package. A file containing the answers, the right/wrong keys, and scans of the answer sheets is produced for each student. A text file with the information for all students is also produced.

Using this text output file, I coded a few exam diagnostic descriptive statistics to mimic the most relevant information provided by the exam center when analyzing scantrons. Below you will find detailed instructions for installing the package and its requirements, a pipeline, and a few notes to ensure your scantrons scan correctly. I will provide some suggestions for exam day, given the differences between this system and the Scantron. I will also provide links to the R package exams webpage, where you can find plenty of additional information.

2 R package exams installation and requirements

The details for the package installation can be found [here](#). I summarized the relevant information below.

2.1 Installing R and RStudio

Start by installing [Rstudio](#) if you don't have it. You will need R installed in your system for the installation to work. For Windows, the Rtools package should also be installed. [Here](#) is a great page explaining how to install R and Rtools on Windows. Essentially, install R first, then RStudio, open RStudio and look in the lower left console what the version of R is (e.g., 4.3), then install the Rtools version with the same number.

2.2 Install the R exams package

The code below should install the stable version of the package and all other R packages it depends on.

```
install.packages("exams", dependencies = TRUE)
```

In some setups (e.g., on macOS or with an older version of R), it may be necessary to add the argument type = "source" to the command above.

```
install.packages("exams", dependencies = TRUE, type="source")
```

2.3 LaTeX requirements

For producing PDF output, R/exams uses the typesetting system LaTeX internally. Suppose no LaTeX distribution (like TeXLive or MikTeX) is already installed. In that case, TinyTeX is a lightweight distribution that can be easily obtained and maintained with the tinytex R package (already installed in the step above). TinyTeX can be installed from within R with:

```
tinytex::install_tinytex()
```

2.4 Ghostscript

The photocopy machine scans the scantrons into a single PDF file, which later needs to be converted to PNG internally. For this reason, Ghostscript must be installed and available in the system path. Ghostscript is

usually installed on Linux, but might require additional installation on Windows and macOS.

For Windows, follow [these](#) instructions. For macOS, Via Homebrew (<https://brew.sh>) in the terminal.

```
brew install ghostscript
```

For Linux, if it is not already installed, install Ghostscript from your distribution, e.g., Debian/Ubuntu.

```
sudo apt-get install ghostscript
```

2.5 R Markdown

This is necessary to run the descriptive statistic R Markdown script that will produce tables and plots similar to what we get from UWM's exam center. We already took care of Latex above, which is necessary if you want to render the diagnostic plots to PDF. However, I suggest rendering to HTML for correct visualization.

```
install.packages(c("rmarkdown","knitr"))
```

2.6 Setting the R session working directory

If you haven't used R much before, you may get frustrated by the concept of the R session working directory. This is the directory in your computer associated with a particular R session you might be running. To keep things tidy, you should have different folders for each of your projects, particularly here, for other exams. Beyond file organization, this will make your life much easier when reading files into R by eliminating the need to write long file paths. If the file being read is in the working directory, these R commands will require only the file name. The same goes for writing files from R and finding them in the R session working directory without having to write long paths.

The easiest way to manage which folder is the current working directory of the R session is through RStudio's *Project* concept. Thus, follow these steps:

- Create a directory on your machine from which you want to work (e.g., BIOSCI465-Exam.I).
- Open RStudio and click on the second icon in the upper left corner (Create a Project). Select *existing directory* and browse through your files to find the directory
- Once you select the folder and hit the return key, the project is created. You can check that the working directory is correctly set with the following code:

```
getwd()
```

Inside the working directory, you will find a file with the extension *.Rproj*. You can double-click on this file the next time you want to start RStudio to resume your work.

2.6.1 Note for Windows users

For quite some time now, the Windows File Explorer program has hidden file extensions. It only shows the file name without the dot and three-character code that constitutes the extension (which are part of the file name!). R needs the entire file name to recognize files, and is case sensitive (i.e., File.txt is different from file.txt). Change the default behavior in Windows File Explorer so you can see the full names of your files. A quick browse should show you how to do this for your Windows version.

3 First steps

To check that the installed software works, try running some examples from the exercise template gallery, e.g., *dist.Rmd* or *ttest.Rmd*.

To install all the example files, use the following code:

```

library("exams") #this loads the package once installed,
#you need to load the package for each new session
exams_skeleton(markup = "markdown",
writer = c("exams2html", "exams2pdf", "exams2moodle"))

```

The code above copies all R/Markdown files to the current working directory along with demo scripts, illustrating the usage of exams2html() and exams2pdf() for customizable HTML and PDF output, respectively.

You can test that the following code opens a webpage with one of the questions created by the code above (located in the exercises folder). This is a quick test to see if the installation above worked. If you use Windows, the path in the code below should be edited to ".\exercises\ttest.Rmd".

```
exams2html("./exercises/ttest.Rmd")
```

See the [First Steps tutorial](#) for detailed instructions. Below, I will provide a shorter version using single- and multiple-choice questions as examples, since these are the types of questions on our Scantron exams. Note that you can also create numeric questions (questions that require a numerical answer) if you want to develop questions to upload to Canvas.

3.1 Creating individual questions

The text files used to create individual questions can be produced for Markdown or LaTeX. Markdown is easier, and that's what I will use here. An R Markdown file can be edited directly in RStudio. Just open a new text file and save it with a name that reminds you what the question is about. Don't forget to add a .Rmd extension to the file name (e.g., myQuestion.Rmd) and don't use spaces to name the file.

Below is an example of the code necessary for an Rmd file for a single-choice question. Further below, I will explain the different fields in this file.

If you want to use R exams from a correct answer key that matches a particular exam you have already prepared, [see the R exams from key section](#). While this could be a solution for those who want to try the package before adopting and don't want to commit time to creating the question files, in the long run, I highly recommend creating the question files, as shown in this section. For example, having the question files will save you loads of time when creating different exam versions. On that note, as of now, if you do use this workaround for an available correct answer key, you should not plan for different exam versions because the diagnostic plots and other functions explained below would need to be duplicated for each exam version.

Now back to the format of questions in the *Rmd* format.

Question

=====

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

Answerlist

=====

- * Basel
- * Bern
- * Geneva
- * Lausanne
- * Zurich
- * St. Gallen
- * Vaduz

Solution

=====

```
There is no de jure capital but  
the de facto capital and seat of  
the federal authorities is Bern.
```

Answerlist

- * False
- * True
- * False

Meta-information

```
exname: Swiss Capital  
extype: schoice  
exsolution: 0100000  
exshuffle: 5
```

First, the *Question* field is straightforward and lists seven answer alternatives under *Answerlist*. Here, the answer list can contain more possible answers than will be printed in the exam, so that you can produce shuffled versions of your exams.

The correct solution (Bern) is declared in the *metainformation* field below.

Do not alter the general formatting of the dashes and the headers, like *Question* or *Answerlist*, and do not add spaces or tabs before writing these headers. I suggest copying the code from one of the Rmd files in the exercises folder and editing it to your own questions.

The *Solution* is an optional field that can be used to provide some general feedback (that explains why Bern is correct in this question). It is also possible to have no solution, or just a general text, or just the answer list.

In the *Meta-information*, each exercise must specify at least an *extype*, and an *exsolution*, and should typically also have a short descriptive *exname*. The *extype* for single-choice questions is *schoice* (and *mchoice* for multiple correct answers). The *exsolution* is simply a binary coding of the seven answer alternatives (zero for incorrect and one for correct). The *exshuffle* is used to randomize the options in the answer list; here set to 5, the maximum number that fits in the printed exam answer sheet, but could be as low as 2, e.g., for TRUE/FALSE questions. With the choice of 5, 1 correct and four random wrong alternatives are subsampled and shuffled from the *answerlist* above, respectively.

3.2 Adding figures to your questions

You can add figures generated by R (using markdown code chunks) or imported from your computer. To import a figure from somewhere in your computer, insert and edit the following R Markdown code in the text of your Rmd question file (usually in the *Question* field).

```
begin{figure}[H]  
\centering  
\includegraphics[width=16cm,  
height=9cm]{/home/filipe/Documents/jobs/UW-Milwaukee/Teaching/Rexams/images/Correlation_sign.png}  
\caption{Draw points here to represent the associations.}  
\end{figure}
```

You can change the width and height of the figure and add a caption by editing the code above. Don't forget to edit the path to your image. Including a figure caption is optional, you can remove the caption row in the

code above. The row specifying a centered image (centering) is also optional.

Create as many questions as you would like, following these principles. Next, we will take a look at how to create exams from these individual question files.

4 Creating an exam and answer sheet (scantrom) ready to print

4.1 Creating the exam

The official R exams package tutorial on this topic can be found [here](#). Below is an abbreviated version.

Create a R script (a new text file with extension .R) in RStudio for each new exam. This will contain all the code necessary for creating the exam, evaluating the scans, and grading.

First, create a list with all the questions you want in the exam. Here we are using questions stored in the exercises folder. In practice, use files that you have authored and stored somewhere locally.

```
library("exams") #if not loaded yet

# a small only example with 5 questions
myexam <- list(
  "tstat2.Rmd",
  "ttest.Rmd",
  "relfreq.Rmd",
  "anova.Rmd",
  "cholesky.Rmd"
)
```

Next, we create a small exam with only $n = 2$ randomly drawn versions, storing the resulting PDF files (plus metadata) on disk in a new output directory, *nops_pdf*. To customize the exam, we assign different point values to the exercises and display the corresponding point values at the beginning of each question.

Before you run the code below make sure you change the R working directory to the folder where your *.Rmd* questions (used above to create *my.exam* list) are saved, if saved in a different directory. Use the *Files* tab in RStudio's lower-right window to navigate to that folder, then select the gear icon and choose *Set as Working directory*.

```
library("exams") #if not loaded yet

set.seed(403) #to make sure you could repeat these exact permutations

ex1 <- exams2nops(myexam, n = 2,
  dir = "nops_pdf", name = "Exam1", date = "2015-07-29",
  points = c(1, 1, 1, 2, 2), showpoints = TRUE, logo="uwm.png", blank=0,
  institution="UW-Milwaukee", title="BIOSCI 465, Biostatistics exam I",
  usepackage = "float", samepage = TRUE)
```

Above, you should customize the *name* argument used here to add a prefix to the output files. The *title* should be used to name the exam and will be printed on the answer sheet, e.g., "BIOSCI 465, Biostatistics exam I". You can also add a UWM logo; you will need the logo PNG file stored locally and the figure path. It is easier if you place this PNG file in the working directory of the R session and then use the code as in the example above. The *institution* argument will also be printed in the answer sheet. As mentioned above, the $n=2$ creates two versions of the exam; you can create more for large classes. The argument *dir* specifies the directory where exams and some metadata will be saved. If this directory doesn't currently exist in your working directory R will create it. Finally, the *blank* argument specifies the number of blank pages to print after the questions booklet. Students can use these for notes if you prefer to provide the blank paper yourself.

After running the function above, the output directory will then contain three files generated by the code above: “Exam_I.rds”, “Exam_I1.pdf”, and “Exam_I2.pdf”. The two PDF files are the exams (their first page is the answer sheet).

Furthermore, the metainformation about the exam (exam IDs, questions, correct and wrong answer alternatives) is stored in the “Exam_I.rds” file (serialized R data). This is crucial for evaluating the exam later.

5 Printing the exams and the answer sheet

Below are a few recommendations and warnings about printing the exams.

- I found that **setting the paper to A4** on my printer, when printing the first page (answer sheet, Figure 1), provided the correct scaling that solved issues I was having with the evaluation of scans (see below). Print the template on your own printer, then bring it to the photocopy machine to make all the copies. Print more answer sheets than the number of exams needed, in case students need a new one; they will be using a pen instead of a pencil, so no erasing is possible. To minimize the number of students requesting new answer sheets, advise them to mark the correct answers first in the exam questions’ booklet and then, at the end of answering all questions, complete the answer sheet.
- The authors recommend not to scale the printout (i.e., without “Fit to printable area”) and to staple the exams in the top-left corner. I stapled only the question part (questions’ booklet) and left the answer sheets (first page) separate. More work is required to supply the exams and answer sheets separately, particularly if more than one exam version is used. Still, way less work is needed later by not having to unstaple the answer sheet from the questions’ booklet part.
- Answer sheets for different versions of your exam (two versions in this example) have different numbers; the questions’ booklet comes printed on all pages with the matching version number.
- There is no field on the first page of the questions’ booklet section for the student’s name, only on the answer sheet. I suggest you ask the students to write their names on the first page of the questions’ booklet (if you are like me and want the questions back).
- The package uses the registration number to match grades with student names. The maximum number of digits is seven; UWM has way too many student identification numbers! I suggest using the Panther ID, which is a nine-digit number but starts with 99 for all students (I believe). Tell your students to use the last seven digits as their code in the answering sheet (see image below).
- By default, the PDFs from exams2nops() have a blank second page for duplex printing (without content on the back of the answer sheet).

6 Conducting the exam

A few key differences worth mentioning with this system, when compared with the departing Scantron, that affect the usual way we conduct this type of exam.

- The answer sheet is completed with a pen and printed on regular paper. Combined with the fact that the scan is sensitive to any marking, it is thus impossible to erase marks. **Students can correct errors by filling the whole surface of a previously crossed box with ink (i.e, a black square).** However, if they want to revert the selection to the original, they will need a new answer sheet.
- Given the last point, please require students to first complete the exam directly in the question’s booklet and only at the end fill in the answer sheet. Instruct students that if they make an error, they can cover the box entirely with ink; the scan will not detect a black square as an answer. This will minimize the number of additional answer sheets you need to give students.



Personal Data					Registration Number					
Family Name:					<input type="text"/>					
Given Name:					<input type="text"/>					
Signature:					<input type="text"/>					
					checked					
In this section no changes or modifications must be made!					Scrambling	<input type="text" value="0,0"/>				
Type		Exam ID			<input type="text" value="030"/> <input type="text" value="25102300001"/>					
Please mark the boxes carefully: <input checked="" type="checkbox"/> Not marked: <input type="checkbox"/> or <input checked="" type="checkbox"/>										
This document is scanned automatically. Please keep clean and do not bend or fold. For filling in the document please use a blue or black pen .										
Only clearly marked and positionally accurate crosses will be processed!										
Answers 1 - 15					Answers 16 - 30					
1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	a	<input type="checkbox"/>	<input type="checkbox"/>			
2	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	b	<input type="checkbox"/>	<input type="checkbox"/>			
3	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	c	<input type="checkbox"/>	<input type="checkbox"/>			
4	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	d	<input type="checkbox"/>	<input type="checkbox"/>			
-	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	e	<input type="checkbox"/>	<input type="checkbox"/>			
16 17 18 19					a b c d e	16 17 18 19	a b c d e	16 17 18 19		

Figure 1: Top part of the exam answer sheet, with instructions on how to fill the form. Note the differences from the scantrons previously used.

- If you have different exam versions, when giving students new answer sheets, remember that the answer sheets are matched with the different exam versions. Both answer sheet and questions' booklet are marked with matching numbers.
- When giving a new answer sheet to a student, immediately remove the old one to minimize the chances of cheating. It is probably not a problem if you have a few different exam versions. Removing the old answer sheet will only work if students first complete their answers on the questions' booklet and only at the end on the answer sheet; otherwise, they will want to copy from one answer sheet to the other.
- If a student forgot their ID, note their name and tell them to use a seven-digit number (of your choice) that you are sure to be unique, like 9999999 (give different numbers to different students facing this issue). Note the “new” number too because you will later need it to edit the registration file (see below).

7 Scan answer sheets

After students complete the exam, bring the answer sheets and a USB stick to the photocopy machine. You can also bring a laptop (or use the computer in the room) to quickly review the resulting PDF. The scanner will produce a single PDF containing scans for all students. The code allows for some rotation due to how well the machine fed the answer sheets (try to observe the feeding process to detect if any excessive rotation occurs; it's fast). Once the scan is complete, you can quickly view it on a computer. The scan is quick, but if you see any excessive rotation, scan it all again. If you have many students, you can repeat the scan only for those who showed excessive rotation. You can then use Adobe Acrobat or other software later to delete and replace pages, and produce a single PDF containing all the students' scans. (I add that in my limited experience, the machine swallowed my 40 answer sheets in seconds without creating any rotation.) Below are some notes on what I have learned when using our photocopy machine for this purpose.

- Place answering sheets on the top feeder.
- Insert your USB drive on the machine.
- After logging in, in the screen options, select **scan**, then scan into **Memory media**, then select your drive.
- I could not find an option that is a single-sided scan; therefore, to avoid ending up with a PDF file that has a blank page every other page, choose **Options** (lower right corner of the screen) and then **Skip Blank originals**.
- Start the scan and wait for the screen to show that the recording to the memory stick is completed. Safely remove the USB stick from the machine by following the on-screen instructions.

8 Evaluation of scanned answer sheets

8.1 Loading and checking the scans in R

There is a dedicated function to read the PDF containing all the scans and report any errors.

```
nops_scan(dir="scans")
```

The argument *dir* specifies the folder name (*scans* here) in the R working directory where the PDF file containing all the answer sheets was saved.

Next, we evaluate the scans, but before that we need to create a registration file.

8.2 Creating a registration file

The registration file enables the package to reconcile the registration numbers that students entered on the answer sheets with their names. This should be a file with fields separated by semi-colons (;). The registration file should have the format shown below, when viewed in a text editor, showing only the first three students.

```

registration;name;id
1234567;John Mitchel;John_Mitchel
2345678;Jane Miller;Jane_Miller
3456789;Maria Baptista;Maria_Baptista

```

The *registration* field should have the last seven digits of the student's Panther ID. This ID is shown in PAWS, from where you can export the roster table (in the upper-right corner of the Paws roster table). You can either edit this file from what you get from PAWS or you can use the *createRegister* function in R to convert from this format to the *exams* registration format. We will look at the latter option next.

8.2.1 Converting a PAWS roster table to a registration file

The function *createRegister* can be used to create the registration file from a PAWS roster table download. A few notes below.

- First, the function is not part of the *exams* package. Therefore, to make it available in R, after you download the materials from GitHub, open the script containg the function *createRegister.R* in RStudio. Select all code and run (Control+Enter or the Run icon on the top right corner on the top bar of RStudio script window).
- Second, the file downloaded from PAWS has an odd format once open in a text editor or Excel. Each student takes two rows of the table, and there are merged cells (in Excel). Open the file in Excel to check if this is the case. The downloaded file from Canvas should look like below (only three imaginary students shown), showing two rows used by student. The conversion function will read the file in the odd format.
- If you have a U/G class don't forget to download the roster tables for both classes and add them into a single file in Excel.

```

Notify, ID, Name, Campus ID, Audit, Units, Program and Plan, Level, Status Note, Phone
,1740226, "Mitchel, John", 99-123-4567,,3,Letters & Science Undergrad -, Senior,,414/999-9999
,,,,,, Biological Sci BS/Pre Veterinary Med,,
,1544567, "Miller, Jane", 99-234-5678,,3,Letters & Science Undergrad -, Junior,,414/414-7777
,,,,,, Biological Sci BS/Neuroscience BS/Pre Medicine,,
,1249531, "Baptista, Maria", 99-345-6789,,3,Letters & Science Undergrad -, Junior,,262/888-3194
,,,,,, Biological Sci BS,,

```

- From Excel save the file as a comma-separated file (*.csv*). In the function *createRegister* run example below, we named this file *Canvas Download.csv*. The function *createRegister* will take care of converting the format to what is required by *nops_eval* function.
- Below, an example of using the function to convert between formats. The only two parameters are the file name downloaded from Canvas and the output file name. The output file is written to the working directory, ready to be used by *nops_eval* in **the next step**.

```
createRegister(PawsF="Paws Download.csv", resgisterOut="Exam-2025-10-23.csv")
```

If you **had to provide a *ad hoc* ID number to a student who did not have their number during the exam**, you will need to edit this file with that number for the scan to work correctly.

8.3 Exam evaluation

We are now ready to use the function *nops_eval* to evaluate the exams and produce the output files.

```

ev1 <- nops_eval(
  register = "Exam-2025-10-23.csv",
  solutions = "Exam_I.rds",
  scans = Sys.glob("scans/nops_scan_20251013182655.zip"),

```

```
eval = exams_eval(partial = TRUE, negative = FALSE, rule="false"),
interactive = FALSE)
```

- In the code above, I assume the registration file was named *Exam-2025-10-23.csv* and is saved in the R session working directory. This file name is given to the function argument *register*.
- The *solutions* argument is an *.rds* file created above by the *exams2nops* function when creating the exam.
- The *scans* argument specifies the path to the *zip* file in the same folder as the PDF files with your scans, here named *scans*.
- The *eval* argument defines if multiple choice questions (one or more correct answers) are to be evaluated as “all or nothing”, where all correct answers and no incorrect answer need to be selected to get full points, or partial credit can be given. You can read more about partial credit for multiple choice in the *exams_eval* function’s manual. Above, I used partial points with a rule that penalizes conservatively wrong choices. I have yet to explore the options here fully, but there are different rules you can apply if you select partial credit. If you import questions to Canvas (a topic not covered here), partial credit is always given following Canvas rules. You can learn more by reading the function’s manual using the command below.

```
# Opens the function manual page in RStudio's lower right window
?exams_eval
```

This function might detect errors and ask you to correct them.

8.4 Correcting errors in the scans

The *nops_eval* function might report an error that can be fixed using the *nops_fix* function. The error will report the exam number(s) where the error requiring your attention was found. The numbers correspond to the page order in the PDF file containing the scanned answer sheets for all students (saved in the *scans* directory). Essentially, *nops_fix* launches an interactive web page where you can see the exam scan and mark yourself the boxes where there were doubts or absent data, by using your mouse to click through a digital version of the answering sheet boxes. It requires the name of a *.zip* file that is created by the *nop_scan* function and written to the same directory where the scans were recorded.

```
nops_fix("scans/nops_scan_20251012115937.zip", exam=34, field="answers", display="interactive")
```

The code above will open an interactive page showing, on the left side, the scan of exam number 34, and, on the right side, an interactive representation of all the fields and information detected by the scan (Figure 2). You can correct the “Registration number” by typing or editing directly in the box that shows the scanned number. For the answers, you can click or unclick the selections shown to make your corrections.

When you are done with your interactive corrections on the interactive browser page, return to RStudio. Usually, in RStudio, you only need to hit return after selecting the R console (the lower-left box) once you’re there. However, in my system, I got a message saying that the clipboard could not be copied. The solution was easy: press Ctrl+V (paste) directly into the RStudio console (make sure you click on the console). A lot of code is pasted from the browser output into the R console, then hit return, and that’s it.

The *exam* argument in the code above can take a vector of all the exams where problems were detected, rather than just exam 34 (e.g., *exam=c(34,36,45)*). Like this, RStudio will iterate over the process for exams 34, 36, and 45, without you having to run the function multiple times.

Another type of error may arise if the scan detected more than one box marked for a single-choice question. The scan is very sensitive to any markings on the boxes, even if they are just part of a single line. To check these you can run the code below. Note how the argument *answer* is being used to include only single choice questions. In this exam, questions 13 and 14 were multiple choice questions and they are not part of the numbers given to the *answer* argument.

Figure 2: Example of the interactive webpage created by the function `nops_fix`. The student information was redacted for confidentiality. Note how this student made some rough crosses that went beyond the box bounds, resulting in some answers for which no answer was detected (questions 10 and 17). The user can correct this by clicking the boxes the student marked on his answer sheet, conveniently shown on the left side.

```
nops_fix("scans/nops_scan_20251012115937.zip", check="schoice", answer=c(1:12, 15:31))
```

The RStudio plot window will zoom in on the scan region of the answer boxes where multiple answers were selected (one at a time). Upon visualizing the student's answer, you can change the answer in the R console, where a question pops up prompting you to enter the correct value using numbers (1-5) or letters (a-e). If you confirm that the student selected multiple answers, you can press to keep the answer as is.

You can also check whether the scan failed to detect any selections (i.e., empty answer boxes) with the following command.

```
nops_fix("scans/nops_scan_20251012115937.zip", check="missing")
```

Once all errors are corrected, `nops_eval` can now run to completion; **don't forget to run it again** (see code above). The evaluation will produce two output files. First, a `nops_eval.zip` file that, once uncompressed, contains one subfolder per student name. Inside these folders, you will find an HTML file containing a summary table showing which answers the student got right or wrong (Figure 3). If you prefer to have all the student evaluation tables in a single PDF you can follow the instructions [here](#).

The second file produced by the `nops_eval` function is a text file named `nops_eval.csv` containing the evaluation data for all students. Although this file contains the answers and key data for all questions and students, the format is in a sequence of zeros and ones. You should be careful when opening it in Excel so that leading zeros don't disappear. Overall, this file is only useful as raw evaluation data from which to run other descriptive statistics (see below).

Exam Results			
Name:	Michael Jackson		
Registration Number:	0111111		
Exam ID:	25102300002		
Mark:	5		
Points:	5		

Evaluation			
Question	Points	Given Answer	Correct Answer
1	1	a_____	a_____
2	0	a_____	d_____
3	0	a_____	b_____
4	0	e_____	c_____
5	0	e_____	d_____
6	1	b_____	b_____
7	0	b_____	c_____
8	0	a_____	d_____
9	1	d_____	d_____
10	0	b_____	a_____
11	0	b_____	c_____
12	0	c_____	d_____
13	0	b_____	c_____
14	0	a_e	a_de
15	0	a_c	b_____
16	0	a_____	b_____
17	0	a_____	b_____
18	0	b_____	c_____
19	1	c_____	c_____
20	0	b_____	d_____
21	0	a_____	b_____
22	0	c_____	b_____
23	0	a_____	c_____
24	0	b_____	a_____
25	0	_____	a_____

Figure 3: Top part of the `nops_eval` HTML output for a given student. A second part of this HTML file (not shown here) contains the scan of the answer sheet.

9 Generating descriptive statistics for your exam

Here, you will run an R Markdown script (`markdown for evaluation.Rmd`) directly in RStudio. This script will load `nops_eval.csv` and `Exam_I.rds` files, create a series of diagnostic tables and plots from these data, and save it to an HTML file. You can visualize how this HTML output looks like by opening the example file `markdown-for-evaluation-dem-oct31.html`.

First, this script requires a few R packages that you might not have installed yet. During the installation of package `kableExtra` you might get a message asking if you want to install packages that require compilation; say yes.

```
# remember that you only need to install packages once
install.packages(c("DT", "kableExtra"))
```

We are now ready to run the script.

- Save the RMarkdown script `markdown for evaluation.Rmd` in the R session working directory that you have been working from.
- Start by opening the script `markdown for evaluation.Rmd` in RStudio and change the names in the `r setup` chunk to match your file names. This section is found at the top of the script. You want to change the “`nops_eval.csv`” and the “`Exam_I.rds`” to match the names you used above.
- If you have to correct an answering key from your exam, see [advanced troubleshooting below](#) and rename the `rds` file in the process (recommended), don’t forget to replace the new name in here (you probably ran this RMarkdown script already once before with the original `Rds` file and then looking at the stats discovered the problem with the key).

```
{r setup, include=FALSE}
knitr::opts_chunk$set(echo = TRUE)
knitr::opts_chunk$set(warning = FALSE, message = FALSE)
```

```
nops_eval.file<- "nops_eval.csv"
rds.file<- "Exam_I.rds"
```

- Next, look for the *knit* icon on the RStudio top bar. Use the down-pointing arrow in the icon to make sure it is selected to *knit to HTML*. Then press the knit button. An RStudio webpage preview window will open if there are no errors, showing a preview of the HTML with all the diagnostics. At the top of the window, press *Open in Browser*. An HTML file and an associated folder are recorded in the R session working directory. Running this script will also write a text file named *Results table.txt* to the working directory. The file contains the points per student, total percentages, and registration ID (the first table in the HTML file). This file is handy to prepare your Canvas upload.

10 Uploading exam grades to Canvas

A function, named *import2Canvas*, can assist with this annoying task.

- After download from GitHub, open the function script in RStudio (file *import2Canvas.R*), select all and run it (Control+Enter or the Run icon on the top right corner of RStudio's script window).

Below an example of using the function, with more details about its arguments below the R code.

```
import2Canvas(PawsF="Paws Download.csv",
              EvalResults="Results table.txt",
              CanvasDownload="2025-11-03T1154_Grades-BIO_SCI_465_examI.csv",
              outputF="grades to upload.csv")
```

- The function requires only the names of three input and one output files. The first argument *PawsF*, takes the Paws roster file that was used above to **create the registration file**. This is the odd format file with two rows per student. Use the same exact file as above. **Do not forget to merge undergrad and graduate student roster files** from the PAWS downloads for each class roster.
- The second argument *EvalResults* takes the file that is produced by **running the RMarkdown diagnostic script**. Once you run that script, this file should be found in the folder where the RMarkdown script is saved (often the same as the R session working directory).
- The *CanvasDownload* argument takes the name of the file exported from the Canvas grade book. For simplicity, in Canvas, select only the grade item that corresponds to this exam. Then do “export current gradebook view”. Open the exported file and select the table that contains all the left columns until, and including, the exam item. Select and copy to a new file and save as a comma-separated file.
- The last argument, *outputF* can be used to modify the name of the exported file. In this example, the function will write a file named “*grades to upload.csv*” to the working directory.
- Once you run the function **you need to replace the header of the output file by the original header** in the file exported from Canvas. This is because R modifies the header names that include spaces. Do this in Excel and then save, keeping the *.csv* format.
- Inspect the output file grades showing as NA. You might have their values (e.g., students that took the exam in a different date) that should be edited here. Replace any other NAs with the value zero.

The file should be ready to upload now. Canvas will recognize the exam name and ask you to confirm. You can use this to upload an item that is still not part of your grade book, by naming the last column with a new name not used in your graded assignments.

11 Troubleshooting and other bits and pieces

11.1 Detecting a problem with the key of one question

I wish I had never had to correct my exam evaluations after looking at the results from the exam center. Unfortunately, I have found errors with my correct answer keys more than once. Using the exams R package and upon visualizing the descriptive statistics generated in the previous point, you might find problems with the correct answer key for one or more questions. The last table in the HTML, under *Test report by exam type*, is a good place to look for problems, as wrong (in your key) answers predominantly selected by students as correct are highlighted in red with a yellow background. The code and steps below are intended to correct the answer key.

The correct answer key is represented internally in R exams as a binary variable made of TRUE or FALSE values.

Create a small R script and run the code below:

First, read the *Rds* file.

```
rdsExamdata<-readRDS("Exam_I.rds")
```

You probably know from the diagnostics which question had the wrong key. You access the correct answer key with the following code:

```
rdsExamdata[[1]][[14]]$metainfo$solution
```

In the code above the first [[1]] is accessing the first version of the exam (here, *Exam_I.1*) while the second [[14]] is accessing the data for question 14. The specific information for the correct key is recorded in the metadata/solution slot.

In my example, the code above produced the following result:

```
[1] TRUE, FALSE, FALSE, FALSE, FALSE
```

Let's say the last option was actually the correct one for this single-choice question. You could correct the key with the following code:

```
rdsExamdata[[1]][[14]]$metainfo$solution<-c(FALSE, FALSE, FALSE, FALSE, TRUE)
```

The correction is now saved in the R object *rdsExamdata*. We need to export it to the working directory so that we can repeat the exam evaluation. **Don't forget to rename the Rds file.**

```
saveRDS(object=rdsExamdata,file="corrected_Exam_I.rds")
```

Next, we need to repeat the scan evaluation. But before that, **delete or move from the working directory** the *nops_eval.zip*, the folder *nops_eval* you extracted from it, and the *nops_eval.csv* file that contains the raw results table. I found that if these files are present, rerunning the function will not update the results, without any warning to the user. Do not forget to **update the name of the corrected Rds file** in the code below.

```
ev1 <- nops_eval(
  register = "Exam-2025-10-23.csv",
  solutions = "corrected_Exam_I.rds", #change this to corrected file
  scans = Sys.glob("scans/nops_scan_20251013182655.zip"),
  eval = exams_eval(partial = FALSE, negative = FALSE),
  interactive = FALSE
)
```

The function will run fast. You don't have to redo any of the scan corrections you might have previously made, because all of that is saved in the original *Rds* file, and all we did was change a single field in the first version of the exam for question 14's solution key.

You can now rerun the R markdown file to get updated descriptive statistics. **Do not forget to update** the *Rds* input file at the top of the R Markdown script before you rerun the descriptive statistics with the question key corrected.

Finally, **update the key in the original *Rds* file for that question** (see above in [Creating individual questions](#)), or you will have the same problem the next time you use this question to create an exam.

11.2 Adding students that completed the exam on a different date

More often than not, one or more students will need to complete the exam after the scheduled date. Often I grade these exams “manually” and post the final grade directly on Canvas. The code below is useful to add the evaluation of these late exams to the *nops_eval* file so that you can include the new data in the [exam descriptive statistics output](#).

You could scan the answer sheet of late exams and then add the new scanned answer sheets to the PDF document for the rest of the class. However, you would need to redo all the corrections that you might have done previously. A more efficient way is to score “manually” the late exams into an excel file and use the function *Add2nops_eval.R* to create an updated (and renamed) *nops_eval.csv* file. Then run the [descriptive R markdown script](#) file again. Note that the function *Add2nops_eval.R* is not part of the *exams* R package. To make it available in your system open the function file, select all and run it in R.

- First, you need to create an input file with the evaluation of the late exams. Prepare a file with the format below in Excel:

registration	name	exam	scrambling	Q.1	Q.2	Q.3	Q.4	Q.5	Q.6	Q.7	Q.8	Q.9	Q.10
7676551	John Sick	25102300001	"00"	a	b	c	b	c	c	b	d	a	ae
9876543	Mary Flu	25102300002	"00"	a	b	b	b	d	c	d	b	a	ad

- The fields include registration, name, exam, scrambling (I don’t know what that is, just use “00”), and questions. In the name field, use one or more spaces (NOT a tab) to separate given and family name. For questions, fill with low case letters with the answer students selected. Note that for multiple choice answers (last question, Q.10) the letters corresponding to the students’ answers are concatenated. Save this file as a tab delimited text file. Alternatively, if creating this table in Excel, select the table and copy it to a text editor, for example by creating a new text file in RStudio, and save it there. Cell separation in Excel is interpreted as tab separation between values in a text file.
- In the function run example below, we named the late exam evaluation file as *LateExam.txt*.

```
Add2nops_eval(eval.F="nops_eval.csv",
              late.eval.F="LateExam.txt",
              output="nops_eval_updated.csv",
              rds.file="CorrectedExamI.Rds",
              mark= c(0,0.5, 0.6, 0.75, 0.85,1),
              partial=TRUE,negative=FALSE,rule="false")
)
```

There are a few arguments to the *Add2nops_eval* function:

- The *eval.F* takes the name of the *nops_eval.csv* file with the raw evaluation for all students.
- The *late.eval.F* takes the name of the tab-delimited text file (*LateExam.txt*) with the “manual” evaluation of late exams (see above in this section).
- The *output* is the name of the output file containing the merged *nops_eval.csv* and late exam data. This dataframe is returned by the function and also written to the working directory so that you can rerun the [descriptive statistics script](#).
- The *rds.file* takes the name of the *Rds* file containing the metadata used for this exam.

- The *mark* contains a vector of thresholds to convert from points to a mark ranging from 1 (best) to 5 (worst). I kept the same thresholds as used by the exam evaluation function. If you change this argument when evaluating your exams don't forget to change here. I don't use these marks to grade but had to include this since it is a column in the *nops_eval* file.
- The arguments, *partial*, *negative*, and *rule* need to match the values used by function *nops_eval* above, so that multiple choice questions in late and original exams are evaluated with the same rules.

11.3 Merging all student evaluation HTML files in a single PDF

The code below will convert the individual HTML files into a single PDF for all the students to facilitate their inspection. Note the use of paths to locations in your computer that will need to be edited. Also, paths in Windows use a backward slash " \ ", while in macOS and Linux a forward slash" / " is used (like shown below).

```
install.packages("psycModel") # only need to do this once
library(psycModel)

#Below, use full path to your nops_eval folder
files<-list.files("/home/filipe/Documents/jobs/UW-Milwaukee/Teaching/Rexams/Exam.I.F.25/nops_eval/")
#Below, match the name of the registration file but replace the csv by html extension
Cstring<-"registration.html"
#likewise but with pdf extension
CstringPDF<-"registration.pdf"
nstudents<-length(files)

for(f in 1:nstudents) {
  html_to_pdf(file_path = paste0("./nops_eval/",files[f],"/",Cstring))

  system2("cp",args=c( paste0("./nops_eval/",files[f],"/",CstringPDF),
                      paste0("./nops_eval/",files[f],".pdf") )
  )
}
print(paste0("Completed conversion from html to pdf of ",files[f]," evaluation"))
}

#merge all pdfs into a single file
install.packages("qpdf") # only need to do this once
library(qpdf)

# CHANGE the R directory temporally to the nops_eval folder
# In RStudio's lower right box click on the Files tab to navigate to nops_eval
# click on the blue gear-like icon on that box's top menu and select "Set as working directory"

PDFfiles<-list.files(pattern=".pdf")
qpdf::pdf_combine(input=PDFfiles, output = "merged evaluation forms.pdf")

#Don't forget to change back to the original R session working directory
```

A file named *merged evaluation forms.pdf*, containing the pdfs for all the exams, should now be written in the *nops_eval* folder.

11.4 Creating an exam answer sheet from a correct answer key

This is a workaround for those wanting to test the package before adopting it and prefer not to spend time creating the question files in the package's format, [as explained above](#). The function *key2Rexams* can be used

to create an exam answer sheet (scantron page) and associated metadata (RDS) file to match your exam prepared in Word. This function is not part of the R exams package; therefore, after downloading the file named `key2Rexams.R` from GitHub, open it in RStudio, select all, and run all the code. The function will now be available in R. The code to run the function is the following:

```
key2Rexams(Key.in="key.input.txt",
            name="Test.exam.from.key", #don't use spaces for this name!
            title="Test exam",
            institution="UW-Milwaukee",
            date="2025-11-27", #keep the date format, year-month-day
            dir="ExamsFromKey") #don't use spaces for this name!
```

Let's go through the arguments used here.

`Key.in` takes the name of a tab-delimited text file with the correct answer key. The contents of this file, for only the first four questions in an exam, are shown below. Three columns, named *Choices*, *Key*, and *Points*, are required. *Choices* is for you to write the number of answer choices for each question (1-5). In *Key* write the correct choice (a-e), note that if you want to create a multiple correct answer choice question, concatenate the letters, e.g., abe (see fourth row in example below). Lastly, *Points* is the number of points per question; in the example, all questions are given 1 point.

Choices	Key	Points
4	a	1
4	b	1
5	c	1
5	abe	1

The following arguments `name`, `title`, `institution`, `logo`, `date`, and `dir` are used by the function `exams2nops`, which runs internally here as part of this workaround. These arguments are explained above in the section [Creating the exam](#). Here, it is essential to name arguments `name` and `dir` without spaces. For `date`, keep the year-month-day format. Finally, the argument `pdftk` should be turned to TRUE (default) if you have `pdftk` installed on your computer (outside R). `pdftk` will be used to extract the first page of the exam, containing the answer sheet. If you do not have `pdftk` installed, set this argument to FALSE, then print only the first page of the resulting exam. The function will write the exam, either the answer sheet-only version or one with the answer sheet on the first page, into the folder named in the `dir` argument.