DataCamp: An Interactive Learning Tool for Programming

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1. Introduction

It is no surprise that technology plays a vital role in the field of statistics. As the technological revolution continues to unfold, the use of statistical software has become increasingly emphasized in education (**?**). By integrating the capabilities of technology in statistics courses, students can explore fundamental concepts by analyzing and interpreting real data sets (**???**), giving them an authentic view of how statistics is practiced outside of the classroom (**?**).

As the stated goal of a statistics course is to help students develop the ability to think statistically (**?**), introducing technology into the curriculum can greatly strengthen this ability by illustrating concepts such as variability, randomness and hypothesis testing. Although numerous statistical technologies exist, R and RStudio provide extensive computational abilities (free of charge) and are commonly used in statistics courses. R allows students to explore real-world data sets which can not only enhance their understanding of concepts, but can also spark an interest in the domain of statistics (**?**).

Discuss benefits of 'learn by doing' or repetition? Ie, this incorporates more student practice with typing code.

1.1. Interactive tools to learn R

With the increased use of R in classrooms, an effective tool to familiarize students with statistical software is needed (**?**). While R software provides users with extraordinary statistical capabilities, there is certainly a steep learning curve. To facilitate this transition to R programming, popular interactive teaching technologies have been created including Try R, `swirl`, `learnr`, and DataCamp. Interactive tools allow students to actively work through coding problems and receive immediate feedback. See Table 1 for a comparison of existing technologies.

Best placement for this table?

Feature	Try R	`swirl`	`learnr`	DataCamp
Web-based	✓	✗	∼	✓
Tracks student progress	✗	∼	✗	✓
Integrates with LMS	✗	✗	✗	✓
Variety of lessons available	✗	✓	✗	✓
Educators can create content	✗	✓	✓	✓

Table 1: Comparison of interactive technologies to learn programming in R. For web-based applications, R installation is not required.

Try R

Try R is web-based interactive R programming course that consists only of codding exercises (?). The RStudio console can be intimidating to new statistics students so an advantage of a web-based teaching tool is the clean and easy to use interface. User-friendliness is an important quality given that students often struggle more with the software used than the statistical concepts themselves (?). When students only need their web browser to participate, all installation complications are avoided and valuable class time can be focused on the lesson. However, Try R is not open source so public content authoring is not available; educators are limited to the existing lessons available on the Try R website. Lastly, Try R does not currently integrate with learning management systems (LMS).

swirl

`swirl` is an open source R package where students can learn R programming directly in the R console (so it requires a local R installation) (?). This interactive learning tool incorporates both code exercises and multiple choice questions. `swirl` contains several pre-existing lessons, and educators can also create their own lesson content to fit specific curriculum (?). While `swirl` can be linked to Massive Open Online Courses (MOOCs) like Coursera, integration of LMS is not currently available.

learnr

`learnr` is an open source R package that converts R Markdown documents to programming tutorials using Shiny (?). These tutorials can consist of code exercises, multiple choice questions, videos, and interactive Shiny components. `learnr` enables instructors to write their own programming tutorials, but there is not a collection of readily available lessons. Although the "hint" options in `learnr` are minimal, the `checkr` package works with `learnr` to provide tailored feedback (?). `learnr` tutorials can be deployed either locally on a user's computer (requires R installation) or through a Shiny Server (web-based). This interactive tutorial does not allow for tracking of student progress.

2. Introduction to DataCamp

Weston - insert background here DataCamp (www.datacamp.com) was first created in 2013 with the mission to "democratize data science education world wide". DataCamp provides a comprehensive web-based platform to interactive lessons on various coding languages. The DataCamp website offers free 'community' courses as well as more specialized *Premium* classes that require a fee. However, when used for academic purposes the *Premium* DataCamp content is free for up to six months. Currently, DataCamp has 2.5 million users across virtually all countries.

2.1. Accessibility

DataCamp lessons are available through the both the DataCamp website and a mobile app (https://www.datacamp.com/mobile) so students can access lessons through their web-browser on a laptop, tablet or mobile device. This makes learning programming accessible to anyone with an internet connection and negates the barrier of software installation.

2.2. Courses

There are currently 114 premium courses created by 82 instructors, and this number is constantly growing. Courses span a wide range of languages (R, Python, SQL, Git, and shell) as well as topics (programming, data manipulation, data visualization, statistical methods, etc.). The breadth of courses offered makes DataCamp suitable for novice students to advance programmers. If there is not a course that quite fits your needs, you can also create your own community course (see Section 3).

2.3. Modularity

DataCamp courses are broken up into chapters and each chapter is composed of modular exercises. Modularity is a critical component in designing a learning tool because it allows independent pieces to be added, modified or removed from the entire functionality (**?**). This is particularly useful when creating your own course as DataCamp course exercises can be added, modified, or deleted as new topics arise and instructors can tailor these exercises to meet the needs of a particular class.

2.4. Gamification

Each exercise is given a specified number of redeemable points which the students can see when they begin the exercise, introducing a gamification feature to the learning experience. When in a classroom group, students can view their progress (points and chapters completed) as well as the progress of their peers - verify. Furthermore, when students can see the number of available points for an exercise it can motivate them to meet their personal achievement goals (**?**). If the student completes an exercise without any assistance, they will receive the full points. If the student is having difficulty, they can view the exercise 'hint' option and 30 percent of the available points are deducted. Lastly, if the student is completely stuck the student may view the solution; however, all points are deducted.

2.5. Tracking student progress

A notable feature that sets DataCamp apart from competing technologies is the ability to track student progress. This means that programming courses can be used in the classroom in a number of ways: as traditional homework assignments, as an activity during lab periods, as pre-class assignments for a flipped classroom, and even as a test or assessment tool.

In order to utilize DataCamp's *classroom* benefits, first create an academic group on the website https://www.datacamp.com/groups/education. After your university information has been verified and the classroom account has been approved, access is facilitated by either creating a group through the DataCamp website or linking directly to your LMS.

If using the group functionality on the DataCamp website, you can add students to the course by their university email address on the *Members* tab. You can also set deadlines for assignments (entire courses or individual chapters) and view downloadable grade reports.

Alternatively, students can be linked to DataCamp assignments via an LMS (including Blackboard, Moodle, Sakai, Canvas, EdX, Coursera, and Schoology) in the *Settings* tab. With direct LMS integration educators do not have to add students via their email address. Furthermore, they can link directly to specific assignments in their LMS, and grades are automatically recorded in the LMS grade book.

3. Creating a DataCamp course

To build a course on DataCamp you need both a DataCamp account and a GitHub account (https://github.com). Once logged into DataCamp as user, it is hard to find a link to the *teach* site - just go to www.datacamp.com/teach/. Every DataCamp course is linked through GitHub version control, allowing educators to easily collaborate and maintain code. While comprehensive documentation is provided through the *teach* website, we will discuss the basics.

The simplest way to begin building the course is to use the template course files from the *Create Course* dialog. This will automatically create a GitHub repository that is linked to DataCamp.

3.1. Initial repository

The newly created GitHub repository will contain three files:

1. `README.md`

   Contains helpful information on how to get started and cites resources to learn more about the process.

2. `course.yml`

   Contains general information about the course you are creating: title, university, description, difficulty level, etc.

3. `chapter1.Rmd`

   A template chapter file with examples of 'normal' iterative coding exercises and multiple choice questions. To add more chapters to an R course, create new files in the repository and name them `chapter1.Rmd`, `chapter2.Rmd`, `chapter3.Rmd`, etc.

3.2. Course editing

Course creators can edit their courses through either GitHub or the *Teach Editor* accessed through the DataCamp website. The *Teach Editor* allows content creators to edit, preview, save changes, and synchronize to the GitHub repository. Editing completed via GitHub does not allow for automatic content viewing. Any changes that are made through the DataCamp *Teach Editor* will update the GitHub repository and vice versa.

3.3. Components of a DataCamp lesson

DataCamp lessons can consist of coding exercises, multiple choice exercises, and videos. Each exercise is presented as a multi-panel layout that consists of an exercise body, instructions, script editor, and R console. Exercises can be initiated through creation buttons available in the `Teach Editor`, which automatically create an exercise template.

Exercise layout

Figure 1 is an example of "normal exercise" syntax and Figure 2 is the corresponding student interface. Students read the lesson information and instructions, answer the question, and submit their code.

It looks like the exercise header (yaml) has updated since last summer - update this?

Take all examples from Intro to R course rather than personal course?

Exercise header

When creating a new exercise, DataCamp automatically produces the header (the first line of syntax). The header specifies the type of exercise (`type`), programming language (`lang`), available points (`xp`), skills learned (`skills`) and a `key`. By default, DataCamp assigns 100 points to normal coding exercises, but this value can be modified. The `skills` portion of the header refers to DataCamp's eight different skill sets, defined by numbers 1-8. Skills and their corresponding numbers can be found in the DataCamp documentation `https://www.datacamp.com/teach/documentation#tab_gamification`. Lastly, the `key` acts as a unique identifier for that exercise, allowing you to modify content without losing any student data. In Figures 1 and 2, the `type` is Normal, the language is R, the available points is 100xp and the skills learned is 1 (which corresponds to R Programming).

skills not used anymore? - link goes to a different page

Exercise body

In the *lesson* portion of the exercise (not labeled but below the header), instructors can add additional information about the assignment that will help students understand and complete the instructions. The *instructions* section contains the actual task required; instructors can also include a *hint* for extra guidance (optional). The *pre-exercise code* sets up the R work space for the student - here, you can automate tasks for the students such as loading packages, importing data sets, or pre-processing data. The *sample code* section contains comments and code that will be visible to students in the R script panel, which is where students submit code. The correct answer to an exercise is coded in the *solution* section. After student clicks the `Submit Code` button, their answer passes through the *submission correctness test* (SCT) where the submission is assessed for accuracy.

Submission correctness test

The SCT automatically assesses if the correct code was submitted (**?**). If a student sub-

~~~
--- type:NormalExercise lang:r xp:100 skills:1 key:9a4fea2da0

## Visualizing quantitative data in R

We can visualize quantitative data with a *histogram*.

- use `hist(dataset$quant_var)` to create a histogram

*** =instructions
- Create a histogram of the `wage` variable from the `CPS85` data set
using the `hist()` function.
- Click the 'Submit Answer' Button and take a look at the R output in the
console.

*** =hint

*** =pre_exercise_code
```{r}
library(mosaicData)
~~~

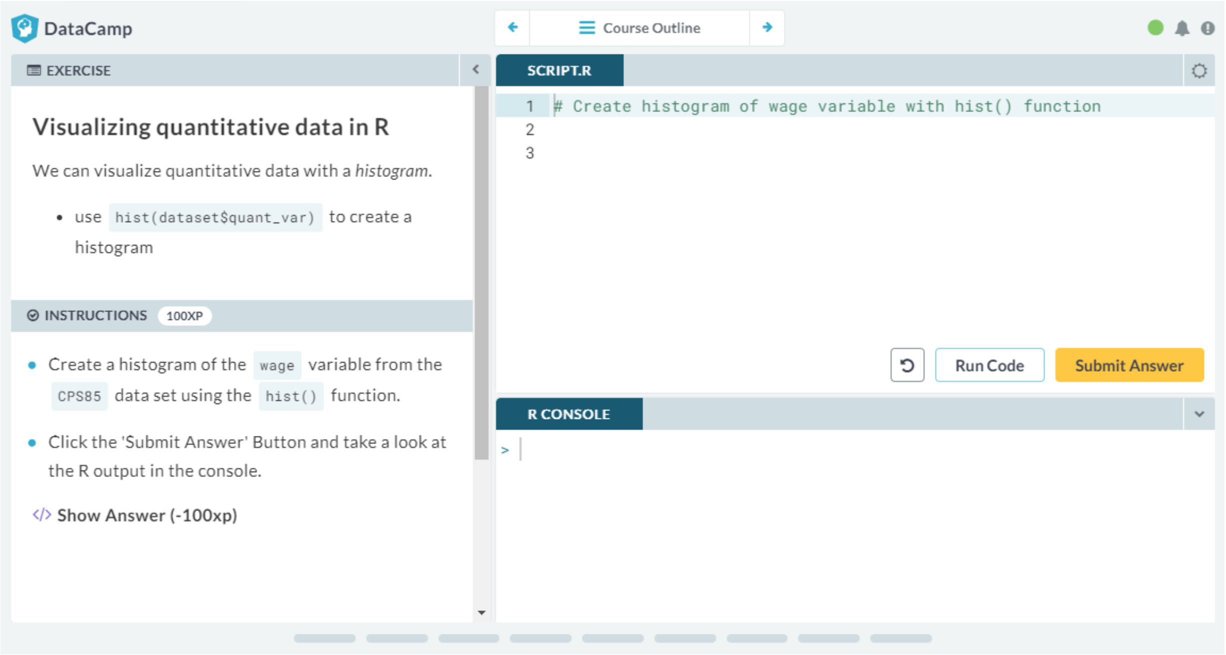
*** =sample_code
```{r}
# Create histogram of wage variable with hist() function

```

*** =solution
```{r}
# Create histogram of wage variable with hist() function
hist(CPS85$wage)
```

*** =sct
```{r}
test_function("hist", args = "x",
              incorrect_msg = "Follow the format: `hist(dataset$variable)`
                               with specified dataset and variable.")
```
```

Figure 1: Syntax to create a “normal exercise” on DataCamp. In DataCamp’s `Teach Editor`, the syntax is color-coded. Just include screenshot here instead of verbatim so color coding is visible?
```



Visualizing quantitative data in R

We can visualize quantitative data with a *histogram*.

- use `hist(dataset$quant_var)` to create a histogram

- Create a histogram of the `wage` variable from the `CPS85` data set using the `hist()` function.
- Click the 'Submit Answer' Button and take a look at the R output in the console.

Show Answer (-100xp)

```
# Create histogram of wage variable with hist() function
```

Figure 2: Preview of the rendered result of the "normal exercise" syntax displayed in Figure 1.

mits an incorrect answer, they will receive immediate feedback and guidance towards the correct answer. The SCT is executed through DataCamp's `testwhat` R package (`https://github.com/datacamp/testwhat/wiki`). The *testwhat* package contains functions that test different types of problems including multiple choice exercises, what students typed, and output generated. The SCT compares the ideal answer (from the solution code) to the student's answer. Various arguments can be added to the test functions to adjust the testing process and feedback. Instructors can either use the default feedback that DataCamp automatically generates or write their own custom messages. For example, Table 2 contains the default feedback for a few possible incorrect submissions of the `hist()` function from the example exercise *Visualizing quantitative data in R* shown in Figures 1 and 2.

I don't think I have fully utilized the power of SCT in my example because you can link multiple SCTs together, right? Could use a different example.

3.4. DataCamp exercises

DataCamp courses currently have six different exercise types available (see Table 3).

Student submission	R console	SCT feedback
`histogram(CPS85$wage)`	Error: could not find function “histogram”	Have you called hist()?
`hist(wage)`	Error: object ‘wage’ not found	Follow the format: hist(dataset$variable) with specified dataset and variable.
`hist(CP85$wage)`	Error: object ‘CP85’ not found	Follow the format: hist(dataset$variable) with specified dataset and variable.
`hist(CPS85$wage)`		Great work!

Table 2: Feedback provided in the R console and in the DataCamp lesson through the SCT for the exercise shown in Figures 1 and 2.

Type	Description
`VideoExercise`	Displays a video exercise
`NormalExercise`	Instructions, exercise, code editor, and console
`MultipleChoiceExercise`	Multiple choice question and console
`PureMultipleChoiceExercise`	Multiple choice question without a console
`TabExercise`	A series of connected sub-exercises
`BulletExercise`	A series of connected sub-exercises

Table 3: Exercise types currently supported in DataCamp

Video exercise

A `VideoExercise` displays as instructional video while relevant slides appear in the background.

Normal exercise

A `NormalExercise` prompts students to submit code. The components of this include: lesson section, instructions, pre-exercise code, sample code, hint, solution and submission correctness testing code (SCT). The students interface consists of the lesson, instructions, R script panel and R console (Figure 1).

Multiple choice exercises

The `MultipleChoiceExercise` contains a question and a list of various answers. This exercise is accompanied by the R console and R output, and allows instructors to preprogram objects or plots that the student needs to access to answer the question. The `PureMultipleChoiceExercise` contains a question and a list of various answers - this exercise type does not include the R console and output. Instructors write the questions in the lesson portion of the exercise, present options in the *Instructions* section, and can specify a *hint* as well. The `MultipleChoiceExercise` utilizes SCT for assessment, whereas the `PureMultipleChoiceExercise` utilizes simpler syntax.

Connected sub-exercises

Both `TabExercise` and `BulletExercise` are a series of connected sub-exercises and are suitable for problems that require several steps in a sequence. DataCamp documentation provides advice on which exercise is appropriate for a given situation.

3.5. Builds

Once you have executed and saved changes to your DataCamp course, DataCamp will initialize a “build” attempt. A build performs validity checks on exercises, provides warnings and recommendations, and makes the updates available on the learning platform. Possible build status’s include: *in progress*, *warning*, *pass*, and *fail*. In the event that a build fails, a build log can help you to identify the source of the error and make corrections. Warnings can include helpful suggestions based on design recommendations from DataCamp, including items such as “The course shouldn’t have more than 5 chapters” or “Exercise X should have at least one submission correctness test”.

3.6. Advice for course development

While the documentation provided by DataCamp is comprehensive, here are some tips and things to consider as you get started with course development.

Can I do this? How long does it take?

Of course time to build a course will vary from instructor to instructor. But to put it in perspective, at California Polytechnic State University, San Luis Obispo a faculty member collaborated on a DataCamp course for introductory statistics with an undergraduate research assistant over 8 weeks in the summer (no video content was created). The undergraduate research assistant took the lead on course creation, had no prior experience with DataCamp, had never used GitHub, and was minimally familiar with the course content. So yes, you can do it!

Collaborating on course development

Each DataCamp course is associated with a primary content creator, but multiple individuals can contribute simultaneously to the course. To do so, go to the course repository on GitHub and under *Settings* enter the Github user names of collaborators. One note of caution here - to deploy the course to your class, the primary content creator needs to be listed as member of the course in the DataCamp group.

Learn from other courses

When creating your first DataCamp course, it is helpful to view the code from existing community courses. The DataCamp GitHub account (`https://github.com/datacamp`) contains repositories for premium courses. A useful repository to examine for beginners is the Introduction to R course (`https://github.com/datacamp/courses-intro-to-r`). You can use these files as a guide to build your own course or even duplicate the repository and tailor the content to fit specific needs.

Typesetting

Exercise syntax adheres to some Markdown and some LaTeXtypesetting. This means that `##` creates a bold header and `$\neq$` renders as $\neq$. However, sometimes the mix of the two produce conflicting results. For example, when we initially created the course, `$H_0$` rendered the `0` in italics rather than as a subscript. The solution was to use the backslash escape (`$H\_0$`) for correct rendering.

4. Experiences in the classroom

4.1. Traditional classroom

At California Polytechnic State University, San Luis Obispo we utilized DataCamp in three sections of 35 students enrolled in an introductory statistics course for non-statistics majors with no programming background. This course meets in a traditional classroom three days a week and a computer lab classroom one day a week.

Students spent their first lab class completing the first chapter of our community DataCamp course assigned via Moodle, and most students finished in about 20 minutes. The in-class time for the first chapter was beneficial as it allowed the instructor to be present to answer questions and help some students overcome their initial apprehension at typing code.

For subsequent weeks, DataCamp chapters were assigned as pre-lab homework assignments (completed outside of the classroom) so that students could familiarize themselves with code prior to attending lab. Then the lab period was spent working on a lab exercise completed in RStudio and compiled as an R Markdown document.

What went well

Integration of DataCamp assignments with Moodle was easy. A link with the assigned chapter was posted on the course site, and then students were taken directly to the first page of the assigned chapter (no additional log-in required!). Grades were available in the Moodle grade book immediately after students completed the assignment. DataCamp computes scores as experience points (`xp`), but Moodle automatically converted this a percentage completion as desired. In addition, students were able to re-visit the chapter as many times as they wanted.

Although it was not formally evaluated, it appeared that students were able to complete in-class lab assignments easier with the DataCamp preparation, as opposed to previous course iterations which only had assigned readings and videos on code lessons.

While there will always be some students (among non-statistics majors) that grumble about having to learn R, overall student feedback was positive (see Table 4 in the Appendix for comparison of course evaluations with and without DataCamp). Student comments included:

- *DataCamp is really easy and fun to use. It is useful because it resembles the actual lab itself and we are still trying to figure out how to code ourselves but we are not penalize if we get the wrong answer.*
- *Data camp was helpful because it was actually like R.*
- *I think it's pretty good because it gives you an interactive way to look over what you'll need to do in class, but doesn't take super long.*

Clearly, I am cherry-picking here and there were criticisms of DataCamp as well. How best to present?

What could be improved

With integration via Moodle, one chapter was assigned at a time. Although it was possible to specify a recommended deadline for assignment completion, this was not enforced via Moodle. This meant that students could complete the assignment after the deadline and still receive full credit. Moreover, because students are able to re-visit a chapter, the grade recorded in the Moodle grade center was always the highest grade recorded for the student, regardless of the completion iteration (first, second attempt?) or date of completion. However, this is more of a Moodle integration issue than a DataCamp issue.

DataCamp does not implement clear and strong delineations between chapters, and the default is for lessons to continue immediately to a next chapter after chapter completion. (It was very easy for students to miss the notification of Chapter 1 completion, and they would keep going on to Chapter 2.) This had two consequences. First, students may be learning more material than required for a given week, which could overwhelm them. Second, a student who completed Chapter 2 via the Chapter 1 Moodle integration would not have a grade assigned to Moodle for Chapter 2. The only way a grade would be assigned for Chapter 2 was if the student accessed Chapter 2 via Moodle directly from the Chapter 2 integration link.

Lastly, there were occasional issues where students said they completed an assignment and their grade was not recorded or that they could not complete the assignment because the DataCamp session expired. It was unclear if these problems were due to local internet connectivity issues or due to interruptions on the DataCamp website. However, in general, work from previous DataCamp sessions was saved for each individual student, and so to rectify the situation the student simply needed to re-access the integration link and re-submit their saved solutions.

4.2. Massive open online courses

Mine - insert here

4.3. Other possibilities

Although we only discussed DataCamp classroom experiences for non-majors, this platform is also well-suited and appropriate for undergraduate students in statistics and data science, as well as graduate students in statistics or even other disciplines. In addition, DataCamp can be a great learning tool for students as they embark upon independent student research.

5. Using metadata for iterative course development

In addition to tracking data on individual users, DataCamp also tracks metadata about the course overall. Currently, the metadata is readily available to educators utilizing premium courses but not to those utilizing community courses. However, educators utilizing community courses can correspond directly with DataCamp to request metadata for their course. Metadata includes the following for each exercise in a course:

- identifying information
- number of individuals who started the exercise
- number of individuals who completed the exercise
- the percent that completed the exercise
- the percent that asked for a hint
- the percent that asked for the solution

This information can be used to refine and improve exercises. A guideline used by DataCamp is to flag and modify exercises that have exceed 20% on hint or solution requests.

Mine - can you add in here?

6. Discussion

While DataCamp is an incredible interactive tool to learn coding, there are some pedagogical disadvantages. First, DataCamp can be fast-paced. Of course, the each user advances through the tutorial at their own speed; however, DataCamp lessons are designed to keep moving forward with no clear pauses for reflection. Another consequence of this is that DataCamp courses tend to assess correct input of code, but not correct interpretation of results. Educators building their own course content can incorporate interpretation questions based on achieved output; however, due to the modularity feature of DataCamp sessions are not cumulative (every exercises begins with a clear workspace) so that an object created in a coding exercise would need to be re-defined for the student in a multiple choice exercise. Lastly, due to the fast-paced nature, it is easy for students to feel like they "get it" in the moment, but have little recall as to what they did the next day. Educators can overcome this by encouraging or requiring note-taking, or by providing quick reference guides of syntax learned for later use.

While DataCamp provides a platform to learn coding in R, it does not enable users to fully utilize the reproducible and version control capabilities of RStudio. Although it does contain courses such as *Reporting with R Markdown* and *Introduction to Git for Data Science*, it does not enable users to generate Markdown style reports from the web-based interface. (Can you imagine if there was a Markdown button at the end of a lesson to generate a report of what you learned?) For this reason, educators may want to use DataCamp as a learning aid, but not as a primary mode for student activities.

DataCamp is a private, for-profit company that has gracefully allowed the academic community to utilize their resources for free. However, this means that both the website and way in which lesson content is created is constantly changing. For example, between September of 2017 and April of 2018, DataCamp:

- Changed exercise headers from single text line to a `yaml`
- Changed the naming of the exercise `PlainMultipleChoice` to `PureMultipleChoice`
- Added new exercise options (the connected sub-exercises)
- Changed the *teach* documentation
- Changed the web-site interface for *groups*

While rapid and continuous development of DataCamp products is beneficial to both educators and learners, it can be jarring for a new educator who just got accustomed to the platform. Moreover, community content creators are not notified when these changes are deployed. Thankfully, for now, lessons created under older formats (i.e., with `PlainMultipleChoice` or headers in a single text line instead of a `yaml`) still render correctly and no updates are required to lesson syntax. This also means that any specific weblinks listed here or exercise syntax may already have changed by the time you read this.

7. Conclusion

DataCamp fills a much needed void for interactive coding exercises that allow for tracking of student progress. Due to the breadth of courses already offered as well as the ability to create your own course content, DataCamp is a learning platform that can be used by any instructor that incorporates coding into their course content. A bit more here?

8. Appendix

Is this table even worthwhile or of interest to include? If so, I can work on better formatting. Include SDs? Present graphically instead?

	Winter 2017 ($n = 63$)	Winter 2018 ($n = 59$)
How do you rate the following items in terms of building your knowledge of introductory statistics?		
1 = Not valuable/ did not contribute; 4 = very valuable/highly contributed		
Lab videos	3.24	N/A
DataCamp assignments	N/A	2.47
Lab assignments	2.86	2.81
How well did the course address the following learning objectives?		
1 = poor; 5 = great		
Use R as a tool to perform statistical analysis	3.84	3.90
How were the pre-lab and lab assignments?		
1 = strongly disagree; 5 = strongly agree		
I had difficulty understanding the connections between lecture and lab.	2.60	2.88
The pre-lab assignments sufficiently prepared me for lab	4.00	3.80
The lab assignments helped me see how statistical analysis is done in the real world.	3.63	3.51
DataCamp was easy to use	N/A	4.15
I enjoyed learning how to code on DataCamp	N/A	3.32
How did you like using R in this class?		
1 = strongly disagree; 5 = strongly agree		
R was challenging to use the entire term	3.05	2.76
R became easier to use as the term progressed	4.08	4.00
Using R made it hard to learn how to do statistical analysis	2.46	2.32
Using R helped me understand how to do statistical analysis	3.17	3.39
I enjoyed using R	2.87	2.92
I am glad I learned R	3.46	3.61

Table 4: Course evaluations from two sections of STAT 217 in Winter 2017 (without DataCamp, response rate = 90%) and Winter 2018 (with DataCamp, response rate = 82%) taught by the same instructor with otherwise virtually no changes.