Teaching Statistics to Psychology Students using Reproducible Computing package RC and supporting Peer Review Framework

Ian Holliday
(Aston University, UK)
Patrick Wessa
(K.U. Leuven, Belgium)
Background

• Statistics is a requirement of the BPS GBR (British Psychological Society Graduate Basis for Chartership – the first stage towards professional status).
Background

• Statistics is a requirement of the BPS GBR (British Psychological Society Graduate Basis for Chartership – the first stage towards professional status).
• Undergraduate course typically include 20 credit modules in stats in both years 1 and 2 (1/6th.)
Background

• Statistics is a requirement of the BPS GBR (British Psychological Society Graduate Basis for Chartership – the first stage towards professional status).
• Undergraduate course typically include 20 credit modules in stats in both years 1 and 2 (1/6th.)
• Final year must include an experimental research project work (typically 30 credits = 1/4)
Background

• Statistics is a requirement of the BPS GBR (British Psychological Society Graduate Basis for Chartership – the first stage towards professional status).

• Undergraduate course typically include 20 credit modules in stats in both years 1 and 2 (1/6th.)

• Final year must include an experimental research project work (typically 30 credits = 1/4)

• Many student’s still struggle with stats: final year dissertations reveal many students have a poor grasp of basic stats concepts
Background

• Statistics is a requirement of the BPS GBR (British Psychological Society Graduate Basis for Chartership – the first stage towards professional status).

• Undergraduate course typically include 20 credit modules in stats in both years 1 and 2 (1/6th.)

• Final year must include an experimental research project work (typically 30 credits = 1/4)

• Many student’s still struggle with stats: final year dissertations reveal many students have a poor grasp of basic stats concepts

• Up to 11% of published psychology research articles contain 1 or more statistical errors.
GAISE*

- The American Statistical Association (ASA) GAISE report made six recommendations:
  - Emphasize statistical literacy and develop statistical thinking

* Guidelines for Assessment and Instruction in Statistics Education
GAISE*

• The American Statistical Association (ASA)
  GAISE report made six recommendations:
  – Emphasize statistical literacy and develop statistical thinking
  – Use real data

* Guidelines for Assessment and Instruction in Statistics Education
GAISE*

- The American Statistical Association (ASA) GAISE report made six recommendations:
  - Emphasize statistical literacy and develop statistical thinking
  - Use real data
  - Stress conceptual understanding rather than mere knowledge of procedures

* Guidelines for Assessment and Instruction in Statistics Education
GAISE*

• The American Statistical Association (ASA) GAISE report made six recommendations:
  – Emphasize statistical literacy and develop statistical thinking
  – Use real data
  – Stress conceptual understanding rather than mere knowledge of procedures
  – Foster active learning in the classroom

* Guidelines for Assessment and Instruction in Statistics Education
GAISE*

- The American Statistical Association (ASA)
  GAISE report made six recommendations:
  - Emphasize statistical literacy and develop statistical thinking
  - Use real data
  - Stress conceptual understanding rather than mere knowledge of procedures
  - Foster active learning in the classroom
  - Use technology for developing conceptual understanding and analyzing data

* Guidelines for Assessment and Instruction in Statistics Education
The American Statistical Association (ASA) GAISE report made six recommendations:

- Emphasize statistical literacy and develop statistical thinking
- Use real data
- Stress conceptual understanding rather than mere knowledge of procedures
- Foster active learning in the classroom
- Use technology for developing conceptual understanding and analyzing data
- Use assessments to improve and evaluate student learning
“It is one thing to state that statistical thinking and reasoning should be the focus of a course, or should be the desired course outcomes. It is another matter entirely to achieve this...”

• “It is one thing to state that statistical thinking and reasoning should be the focus of a course, or should be the desired course outcomes. It is another matter entirely to achieve this…”

• “We believe that appropriate content, a focus on data analysis and real problems, and careful use of high quality technological tools will help students better achieve the suggested course goals and outcomes.”
Enhancing Stats Education with New Technology ‘80s Style

The Classroom Calculator

Finally, a front-of-the-room calculator that lets students observe both the keystroke sequence and displayed answer.

Model 30
$1,495

Easily viewable from up to 60 feet.

Other popular models available.

Watch student enthusiasm grow as you use The Classroom Calculator!

The Classroom Calculator puts an end to dull blackboard listings and allows students to see the logic of each step in a calculation.

Size: 46½" x 23" x 3"
Weight: Approximately 6 lbs.
Power: 110 Volt AC
Mounting strip included.

PureTech Inc.
1700 Duncan Avenue
Technology Park
Hubbell, MI 49934
(906) 487-2494

Complete documentation included with each unit.
The Reform of [Statistics] Pedagogy

• Goals:
  – Higher-order thinking, problem solving, flexible skills applicable to unfamiliar settings.

Moore 1997
The Reform of [Statistics] Pedagogy

• **Goals:**
  – Higher-order thinking, problem solving, flexible skills applicable to unfamiliar settings.

• **The old model:**
  – Students learn by absorbing information; a good teacher transfer information clearly and at the right rate.

Moore 1997
The Reform of [Statistics] Pedagogy

• **Goals:**
  – Higher-order thinking, problem solving, flexible skills applicable to unfamiliar settings.

• **The old model:**
  – Students learn by absorbing information; a good teacher transfer information clearly and at the right rate.

• **The new model:**
  – Students learn through their own activities; a good teacher encourages and guides their learning.

Moore 1997
The Reform of [Statistics] Pedagogy

• **Goals:**
  – Higher-order thinking, problem solving, flexible skills applicable to unfamiliar settings.

• **The old model:**
  – Students learn by absorbing information; a good teacher transfer information clearly and at the right rate.

• **The new model:**
  – Students learn through their own activities; a good teacher encourages and guides their learning.

• **What helps learning:**
  – Group work in and out of class; explaining and communicating; frequent rapid feedback; work on problem formulation and open-ended problems.

Moore 1997
Encourage “statistical thinking and literacy”.

• The ‘professional’s fallacy’
  – [Psychology] Students are not trainee statisticians.
Encourage “statistical thinking and literacy”.

• The ‘professional’s fallacy’
  – [Psychology] Students are not trainee statisticians.
  – Moore: must abandon "information transfer" and adopt "constructivist" view of learning
    • Emphasise statistical and conceptual thinking
    • be data-focussed
    • be less formulaic
    • emphasise graphical concepts and automate calculation
    • foster active learning

Moore 1997
Encourage “statistical thinking and literacy”.

- The ‘professional’s fallacy’
  - [Psychology] Students are not trainee statisticians.
  - Moore: must abandon "information transfer" and adopt "constructivist" view of learning
    - Emphasise statistical and conceptual thinking
    - be data-focussed
    - be less formulaic
    - emphasise graphical concepts and automate calculation
    - foster active learning
  - because “the most effective learning takes place when content (what we want students to learn), pedagogy (what we do to help them learn), and technology reinforce each other in a balanced manner.” (Moore, 1997).
A new approach to statistics Education

• Within the pedagogical paradigm of (social) constructivism permitting:
  – Interaction & collaboration via peer review.
  – Experimentation.
A new approach to statistics Education

• Within the pedagogical paradigm of (social) constructivism permitting:
  – Interaction & collaboration via peer review.
  – Experimentation.

• Responsibility (social control)
  – learning & computing technology.
  – we need to Free Statistics of irreproducible research.
A new approach to statistics
Education

• Within the pedagogical paradigm of (social) constructivism permitting:
  – Interaction & collaboration via peer review.
  – Experimentation.

• Responsibility (social control)
  – learning & computing technology.
  – we need to Free Statistics of irreproducible research.

• www.FreeStatistics.org
Constructivism

Social

Smith, 1998
Constructivism

Social

Individual

Tool Mediation

Individual + Cultural Tool

ACTS ON

Culturally Situated Mathematics

Mathematics

Individual

ACTS ON

Cultural Tool

Mathematical Situation

Smith, 1998
Constructivism

Social

Data Sharing and Peer reviewing via compendiums

Smith, 1998
Compendiums

• Documents that allow us to preserve, reproduce, and re-use the results of data analysis.
Compendiums

- Documents that allow us to preserve, reproduce, and re-use the results of data analysis.
  - Data can be preserved and shared through the internet.
Compendiums

• Documents that allow us to preserve, reproduce, and re-use the results of data analysis.
  – Data can be preserved and shared through the internet.
  – Analysis can be studied and checked by other researchers.
Compendiums

- Documents that allow us to preserve, reproduce, and re-use the results of data analysis.
  - Data can be preserved and shared through the internet.
  - Analysis can be studied and checked by other researchers.
  - New compendiums can be created to communicate new findings.
‘Classical’ vs. RC Compendium

• 'classical' compendium
  – Typically a zip file with
    • data files
    • R scripts
    • Sweave documents ...
‘Classical’ vs. RC Compendium

• 'classical' compendium
  – Typically a zip file with
    • data files
    • R scripts
    • Sweave documents ...

• RC compendium
  – Simple document form (ODF, PDF, .doc..)
    • Containing links to remotely stored computations.
    • Accessed via any browser
Learning System or Educational Laboratory?

BlackBoard

WWW.wessa.net
/lanholliday

Search Engine

Compendium

Query Engine

R Framework

(Virtual) Learning Environment

Process Measurements

Compendium Platform

Blog

Create/Maintain

Reference

Usage

Replicate & Reuse

Usage

WWW.freestatistics.org
Features of the Compendium Platform

• Any computation that is created within the R Framework can be easily archived in the repository
  – there is no need for students to keep track of the data, the model parameters, or the underlying statistical software code;
Features of the Compendium Platform

• Any computation that is created within the R Framework can be easily archived in the repository
  – there is no need for students to keep track of the data, the model parameters, or the underlying statistical software code;

• Any user who visits the unique URL of an archived computation is able to instantly reproduce the computation or reuse it for further analysis
  – only an internet browser (and an active connection) is required to use the repository;
Features of the Compendium Platform

• Any computation that is created within the R Framework can be easily archived in the repository
  – there is no need for students to keep track of the data, the model parameters, or the underlying statistical software code;

• Any user who visits the unique URL of an archived computation is able to instantly reproduce the computation or reuse it for further analysis
  – only an internet browser (and an active connection) is required to use the repository;

• Educators and researchers are able to retrieve data for research purposes.
What Students Do.

Assignment

Reproduce
What Students Do.

- Assignment
- Reproduce
- Investigate
What Students Do.

- Assignment
- Reproduce
- Investigate
- Blog
What Students Do.

- Assignment
- Reproduce
- Investigate
- Report
- Blog
What Students Do.

1. Review
2. Assignment
3. Reproduce
4. Investigate
5. Blog
6. Report

The cycle flow is: Review → Assignment → Reproduce → Investigate → Blog → Report → Review.
Snapshot of a Workshop Assignment Compendium

- Produced in a normal word processor (here I’ve made a PDF).

Snapshot of a Workshop Assignment Compendium

- Produced in a normal word processor (here I’ve made a PDF).
- Shows statistical outputs (graph, tables...)

njqf767w.htm/
Snapshot of a Workshop Assignment Compendium

• Produced in a normal word processor (here I’ve made a PDF).
• Shows statistical outputs (graph, tables…)
• Has links to the blogged analysis.

Snapshot of a Workshop Assignment Compendium

- Produced in a normal word processor (here I’ve made a PDF).
- Shows statistical outputs (graph, tables…)
- Has links to the blogged analysis.

Blogged Computation

- Unique blog URL to Reproducible Content
Blogged Computation

- Unique blog URL to Reproducible Content
- Citeable work – also for students!
Data for the reproduced computations
Can paste in data for new analysis e.g. from excel
Shows the reproduced analysis.
- Shows the reproduced analysis.
- Computation is recomputed externally by wessa.net R servers.
• Shows the reproduced analysis.
• Computation is recomputed externally by wessa.net R servers.
• Enables modification and exploration using controls on the page.
Code is shown and can be modified or re-used in new modules.
• Code is shown and can be modified or re-used in new modules.

• Blogged Analysis reproduced by re-computing.
• Code is shown and can be modified or re-used in new modules.
• Blogged Analysis reproduced by re-computing.
• Changes to analysis computed then blogged.
Computations are “blogged” (not archived)
The scatter matrix plot shows us that all the data has a positive correlation meaning the data is not distributed randomly. When matching the skills variable against the reading variable we can see that there is a high positive correlation. The maths variable against the skills variable has a low positive correlation.

4)

The matrix scatter plot shows us that the data has a high positive correlation. So the data is not distributed randomly. The box plot shows us that the data is normally distributed as the whiskers are not longer on any particular side (such as longer on the bottom). The medians are also relatively similar in the graphs. Looking at the means we and standard deviation above we can see they are also similar as they is not a large difference in values between the variables.


5)
The scatter matrix plot shows us that all the data has a positive correlation meaning the data is not distributed randomly. When matching the skills variable against the reading variable we can see that there is a high positive correlation. The maths variable against the skills variable has a low positive correlation.

The matrix scatter plot shows us that the data has a high positive correlation. So the data is not distributed randomly. The box plot shows us that the data is normally distributed as the whiskers are not longer on any particular side (such as longer on the bottom). The medians are also relatively similar in the graphs. Looking at the means we and standard deviation above we can see they are also similar as they is not a large difference in values between the variables.


Student compendium

- Produced in Word or Oo
- Student’s provide links to blogs to support stats interpretation
Students upload to external review site

External Links

Peer Review
Click [here](#) to access the Peer Review application.

Surveys:
- Click [here](#) to take the Attitudes Towards Thinking and Learning Survey
- Click [here](#) to take the Academic Motivation Survey
- CSUQ+ survey (available soon)
- COLLES survey (available soon)

Some notes:
- **CAUTION**: Multiple tabs within one browser (or multiple browsers open at the same time) should _not_ be used to cross-reference between your reviews.
- The default settings of Internet Explorer are too restrictive to use the Peer Review application. It may be necessary to adjust these settings.
- So far, no difficulties were found in the following browsers: Firefox, Chrome, Safari, Epiphany, SeaMonkey.
- Helpdesk: please, do not hesitate to report any questions, suggestions, or complaints in the Discussion Board.
- Surveys: during the course you will be prompted to submit some surveys. The purpose of these surveys is to help us improve our course offerings. Please be assured that your responses will be treated with the utmost confidence and confidentiality.

Reviewing Rubric Guidelines
review_rubric.doc (245 KB)

Review Deadline Shows in Red
To confirm the announcement at the end of last year regarding the submission of reviews for week 11 Patrick said in red:

"The deadline for the review about the last workshop was set for 09/12/22 (my mistake). However, the system didn't catch it in red but I made sure that this has no impact on the review statistics/reporting whatsoever."
• Students upload to external review site
• We (attempt to!) collect student survey data.
- Students upload to external review site
- We (attempt to!) collect student survey data.
- Provide feedback guidance and support messages
• Students upload to external review site
• We (attempt to!) collect student survey data.
• Provide feedback guidance and support messages
Students upload to external review site

We (attempt to!) collect student survey data.

Provide feedback guidance and support messages
• Student reviews collated and shared anonymously for peer feedback.
• Stats tracked individually
Data captured from students is analyzed within the R framework too.
Data captured from students is analyzed within the R framework too.

This shows per student performance on several metrics e.g. feedback message length.
Exam Results and Feedback Effort

Score by Median Feedback Length

Score

<table>
<thead>
<tr>
<th>Median Feedback Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>[0,100]</td>
</tr>
<tr>
<td>(100,200]</td>
</tr>
<tr>
<td>[200,500]</td>
</tr>
</tbody>
</table>

Experiment on VLE Design

Figure 4. System Design — Year 0

Traditional VLE
Experiment on VLE Design

Figure 4. System Design — Year 0

Figure 5. System Design — Year 1

Traditional VLE
Statistical LE
Effect of VLE DEsign

Feedback messages rate is dominant variable: threshold for pass is 118 in year 1 vs. 57 in year 2 -> large increase in efficiency
Effect of VLE DESIGN

Feedback messages rate is dominant variable: threshold for pass is 118 in year 1 vs. 57 in year 2 -> large increase in efficiency

A gender bias in year 1 is eliminated in the new design
Issues

• Course development takes a lot of effort
  – But a core of material is now available
Issues

• Course development takes a lot of effort
  – But a core of material is now available

• Assessment takes a lot of effort
  – But on-going feedback important feature
Issues

• Course development takes a lot of effort
  – But a core of material is now available
• Assessment takes a lot of effort
  – But on-going feedback important feature
• Student resistance to workload
  – Actually well-matched to course requirement.
Issues

• Course development takes a lot of effort
  – But a core of material is now available
• Assessment takes a lot of effort
  – But on-going feedback important feature
• Student resistance to workload
  – Actually well-matched to course requirement.
• Perceived professional status of SPSS vs. R
  – Point is to learn statistics; open source tools
End of Presentation